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Prevalence of clinical myelopathic signs and associated factors in neck pain patients: A cross-sectional analytic study

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Abstract

Neck pain symptoms related to cervical myelopathy are commonly assessed by testing for clinical myelopathic signs. These signs could reveal cervical spinal cord irritation or compression. However, there is a paucity of studies related to the prevalence of positive clinical myelopathic signs among neck pain patients. The current study aimed to determine the prevalence of clinical myelopathic signs and associated factors in participants with neck pain. Two hundred eighty participants with neck pain were included to the study; they were aged 20 to 59 years old. Standardized clinical test procedures were undertaken to determine the presence of myelopathic signs. Findings showed the prevalence of clinical myelopathic signs to be: 'biceps reflex 32.5%, patellar tendon reflex 27.14%, inverted supinator reflex 20.36%, triceps reflex 17.86%, Hoffman sign 15%, Tromner sign 13.57%, Achilles tendon reflex 10.36%, finger escape sign 10% and Babinski sign 3.21%'. The current study found out that smart phone usage ≥4 h per day, an education of university or postgraduate level, and neck pain ≥7 score was associated with clinical myelopathic signs with adjusted odds ratio (OR) (95% confidence interval (CI)) of 2.57 (1.52 to 4.36), 3.35 (1.14 to 9.89), and 2.31 (1.07 to 4.99) respectively. The current study highlighted that prolonged smart phone usage may affect the spinal cord. Long duration smartphone use (≥4 h per day) was associated with clinical myelopathic signs. Smartphone users therefore need to keep their duration of smartphone use to less than 4 h per day.

Keywords: Cervical myelopathy, Smart phone used, Flexed neck posture, Clinical myelopathic signs

1. Introduction

Neck pain is widely prevalent around the world; globally, it is one of the top four causes of disability [1]. The broad extent of neck pain ranges between 0.4% and 86.8% (mean 23.1%) in the general population, with point prevalence ranging from 0.4-41.5% (mean 14.4%) and one-year prevalence ranging from 4.8-79.5% (mean 25.8%) [2]. The prevalence of neck pain was 24% in southern Brazil [3], 19.5% in Spain [4], and 20.4% in Greece [5]; these numbers are lower than those found in China (48.7%) [6] and Sri Lanka (56.9%) [7] and higher than those found in the United States (4.4%) [8].

Neck pain seems to be associated with cervical myelopathy, according to the literature reviewed by Tracy and Bartleson et al [9]. One study reported that one-quarter of axial neck pain and/or cervical radiculopathy cases progress into symptomatic myelopathy within a few years [10], while another reported that 35 percent patients with neck pain had cervical spine myelopathy based on magnetic resonance imaging (MRI) [11]. Mild cervical myelopathy is typically present with neck pain and neck stiffness, which may sometimes extend to the upper quarter region or shoulder [12]. It reported that current neck pain had a sensitivity of 93% when screening for patients with cervical myelopathy [11]. From these studies, one can presume that cervical myelopathy is related to neck pain symptoms.

Cervical myelopathy is a neurological injury to the spinal cord [13]; symptoms include gait disturbance, lower limb stiffness, upper and/or lower limb sensory loss, upper and lower limb weakness, urinary incontinence, and so on [3,9]. The term clinical myelopathy is commonly used to infer the presence of myelopathic signs, including any of the following: the Hoffman sign, inverted supinator reflex [11,14-16], hyperreflexia of the patellar tendon [11,16-18], Babinski reflex [11,14-16,18,19], Tromner sign [16], finger escape sign [20,21], altered bicep and tricep reflexes [11,14,15,18], and altered Achilles tendon reflex [14,15].

Most studies state that clinical myelopathic signs in patients with neck pain are the pre-symptomatic condition for cervical myelopathy [10]; further, the presentation of clinical cervical myelopathy has been significantly associated with the minimal narrowing of the cervical spinal canal [22]. Clinical myelopathy signs demonstrate irritation or compression of the cervical spinal cord [23]. According to one systematic review, the sensitivity and specificity of these signs had already been demonstrated in many studies [24]; however, only one study by Rhee et al. (2009) reported the prevalence of clinical myelopathic signs [15]. That study was hospital based, where most patients who had already developed a myelopathic condition, meaning that these findings are not representative of the general population. Consequently, a population-based study is required to clarify the prevalence of clinical myelopathic signs in patients with neck pain in the general population.

A previous study reported that age is a consideration; the percentage of positive inverted supinator reflex in neck pain patients under 40 years of age was higher than in neck pain patients over 40 years of age [25]. Gender is also a factor to consider; Glaser et al. reported that females appear to have a higher rate of positive clinical myelopathic signs and thus a higher incidence of positive clinical myelopathic signs [26]. In contrast, but still in relation to gender, it stated that clinical myelopathic signs are more significant in males than females [16]. However, others have reported no significant differences in the proportion of males and females with clinical myelopathic signs [25]. Thus, previous studies have reported conflicting results regarding the association between gender and clinical myelopathic signs [16,25] and a general lack of knowledge about factors associated with clinical myelopathic signs besides aging.

Prolonged smartphone use of more than 4 h per day has been shown to have negative effects on cervical proprioception and dynamic balance [27]. Park et al. reported that heavy smartphone usage could place stress on the cervical spine and result in the changing of the cervical curve [28]. As people are both using their smartphones more and spending longer periods using them these days, the authors wonder if this could have a negative effect on patients with neck pain, for example, as demonstrated by clinical myelopathic signs. However, no studies on the association between prolonged smartphone use and clinical myelopathic signs in patients with neck pain have been conducted to date.

Further, there are possible influential factors that have been reported to be associated with neck pain in the general population. A neck flexion posture, commonly adopted by smartphone users when looking at their smartphone visual display terminals for prolonged periods, is a potential risk factor for musculoskeletal problems [28-31]. Chen et al. reported that smoking accelerated the process of cervical disc degeneration, meaning patients present with more severe neck-shoulder pain than non-smoking patients [32]. According to their studies, these factors were highly associated with neck pain. However, these factors have not been studied among patients with neck pain who have clinical myelopathic signs.

There may yet be other factors related to clinical myelopathic signs in the general neck pain population, so the purpose of the current study was to investigate the prevalence of clinical myelopathic signs in patients with neck pain in the general population. This study also aimed to determine factors associated with commonly used clinical myelopathic sign tests among neck pain patients. The hypothesis is that prolonged smartphone use is associated with clinical myelopathic signs in patients with neck pain. The results of the current study would yield significant information for exploring associations between clinical myelopathic signs and the occurrence of neck pain, and we anticipate the findings may be used to support preliminary preventions and health promotion to address the risk of positive clinical myelopathic signs in this population.

2. Materials and methods

2.1 Study design

The current study employed a cross-sectional analytic design. Data collection was conducted between December 2018 and May 2019 in Myanmar, where patients with neck pain were recruited from the general population in Mandalay city.

2.2 Sample size calculation

The sample size was calculated while considering the primary outcome of the study, the "prevalence of clinical myelopathic sign(s)," with the highest prevalence (biceps reflex) being 0.51 from [9]. An initial sample size of 267 was required via calculations according to the formula.

$$n = \frac{\left(Z\frac{\alpha}{2}\right)^2 P(1-P)}{e^2} \tag{1}$$

where we set $Z\frac{\alpha}{2} = 1.96$, and e = 0.06. At least 280 participants were required to be recruited in this study.

2.3 Study population-recruitment and screening

Between December 2018 and May 2019, patients from Myanmar with neck pain were recruited in Mandalay city, Myanmar. A two-stage cluster method was used to recruit study participants. Mandalay city has seven divisions, each of which has quarters. First, cluster sampling was used to randomly select two quarters from each division in Mandalay city. In each quarter, data collection commenced from residences situated within the southeast corner of each quarter in a clockwise direction. After getting 20 neck pain participants according to the inclusion and exclusion criteria in a quarter, data collection moved on to other quarters until participants were selected from all 14 quarters.

Screening for inclusion and exclusion criteria was conducted by the physiatrist. Patients were eligible for inclusion if they (i) were aged between 20-59 years, (ii) reported neck pain defined as low-grade neck dysfunction where individuals have recurrent flare-ups of neck pain but have not yet sought regular treatment [33], and (iii) experienced pain duration of more than 3 months [34]. Participants were excluded if they had a number of conditions. These conditions included positive jaw jerk, positive Spurling tests, history of previous cervical spine surgery, concurrent suffering from other locomotor disorders, a history of brain trauma, comorbid neurological diseases (such as cerebral infarction or neuropathy), the consumption of any sedative drugs or alcohol within the past 48 h, or pregnancy.

Of the 456 participants included, 12 participants had positive jaw jerk, 18 participants had a positive Spurling test, 113 participants with neck pain were concurrently suffering from locomotor disorders, 16 participants had a history of brain trauma and comorbid neurological diseases (such as cerebral infarction or neuropathy), 9 participants were pregnant, and 8 participants had consumed alcohol within the past 48 h. Thus, a total of 176 participants were excluded, and 280 participants were included in the current study. The flow diagrams representing the study's procedure are shown in Figure 1.

2.4 Procedure

Recruited participants completed an interviewer-administered questionnaire that included (1) demographic data (e.g., questions relating to sex, age, weight, height, education, occupation, and habit of smoking), (2) use of the computer (e.g., usage time), (3) smartphone usage data (e.g., usage time and neck posture during use), and (4) severity of neck pain that was assessed using a visual analog scale (VAS), which was a continuous horizontal line with 10 cm in length anchored by two adjectives: zero represented no pain in the left anchor, and 100 or 10 represented worst imaginable pain at the right anchor [35]. This process was completed by the physiotherapist, who had three years of clinical experience.

Clinical examination was undertaken for the following myelopathic signs: Hoffman sign, Tromner sign, inverted supinator reflex, finger escape sign, and Babinski sign, as well as the abnormal tendon reflexes of the biceps, triceps, patellar tendon, and Achilles tendon. The evaluation was conducted by a blinded assessor (M.M. H.L), a physical therapist with 18 years of experience as a clinician and extensive training in spinal screening, who did not know the other participant data. For this process, standard test procedures, as shown in Appendix 1, were used [11,16,24]. The sensitivity and specificity of each test are shown in Appendix 1 [11,14-16,21,36]. The results were examined to determine whether these reflexes were positive or negative. The order of clinician examination was randomized for each participant. To evaluate intra-rater variability, 10 patients with neck pain were reassessed by the same observer Mental Hygiene Law (MHL) one day after the first assessment. The intra-rater reliability for clinical myelopathic signs was evaluated using kappa analysis. The intra-rater reliability of these signs was moderate to excellent, ranging from 0.62 to 1.00 (Table 3).

2.5 Statistical analysis

Descriptive statistics were used to analyze participant characteristics and clinical myelopathic signs. The reliability of examining for clinical myelopathic signs was assessed using kappa coefficients for dichotomous variables (signs and reflexes). Continuous variables were analyzed by the mean and standard deviation (SD). Categorical variables were considered in terms of frequency and percentage. Each of the variables was categorized into an ordinal scale for further logistic regression analysis.

Univariate logistic regression was used to determine the association between factors and four groups of positive clinical myelopathic signs. The variable that reached $p < 0.2$ in the univariate logistic regression analysis was included in the multiple logistic regression model. The backward elimination process was applied for multivariate logistic regression analysis; variables with $p < 0.05$ were considered to be statistically significant. Data were analyzed using the statistical (STATA) program version 10 (STATA, College Station, TX, USA).

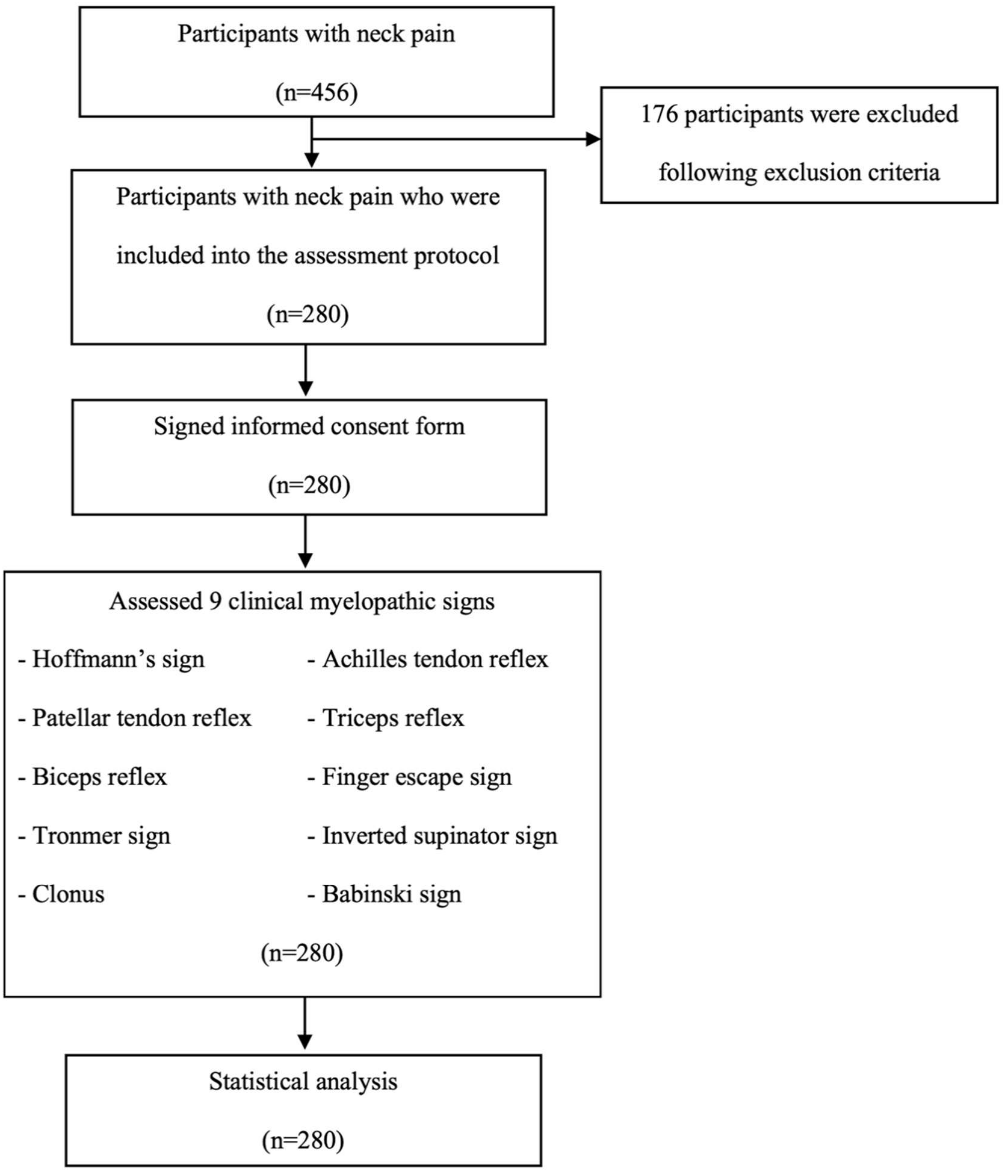

Figure 1 Flow diagram of the participants throughout the study.

3. Results

Two hundred and eighty participants with neck pain were included in the current study. General participant characteristics are presented in Table 1. Their average age was 38.85±10.63 years. There were 57 males (20.36%) and 223 females (79.64%). The mean body mass index (BMI) was 24.47±4.48 kg/m. No history of smoking was reported by 95.36% of participants.

The prevalence of clinical myelopathic signs is shown in Table 2. The prevalence of positive signs from high to low was biceps reflex at 32.5%, patellar tendon reflex at 27.14%, inverted supinator reflex at 20.36%, tricep reflex at 17.86%, Hoffman sign at 15%, Tromner sign at 13.57%, Achilles tendon reflex at 10.36%, finger escape sign at 10%, and Babinski sign at 3.21%, respectively. Next, participants were grouped according to the number of positive clinical myelopathic signs; these were divided into four groups, where participants showed (i) ≥ 1 positive signs, (ii) ≥ 2 positive signs, (iii) ≥ 3 positive signs, and (iv) ≥ 4 positive signs (Table 2). The grouping revealed the largest group to be positive, with ≥ 1 of any clinical myelopathic sign.

Table 1 Baseline demographic characteristics of neck pain participants (n=280).

Factors	n (%)	Mean ±SD	Range
Age (years)		38.78±10.63	20 to 59
• 20-40	152 (54.29)		
• 40≥ 59	128 (45.71)		
Sex			
• Female	223 (20.36)		
• Male	57 (79.64)		
Body mass index (kg/m^2)		24.74±4.48	13.6 to 40.06
• Normal (<25)	162 (57.86)		
• Overweight (≥25)	118(42.14)		
Smoker			
• No	267 (95.36)		
• Yes	13 (4.64)		
Education level			
• Primary to High School	46 (16.43)		
• University to Postgraduate	234 (85.57)		
Occupation			
• Sedentary Worker	226 (80.71)		
• Others	54 (19.29)		
Laptop usage (h per day)			
• <4	207 (73.93)		
• ≥4	73 (26.07)		
Smartphone usage (h per day)			
• <4	195 (69.64)		
• ≥4	85 (30.36)		
Severity of neck pain (VAS)			
• <7	240 (85.71)		
• 7≥10	40 (14.29)		
Neck posture while using smart phone			
• Neutral position	34 (12.14)		
• Flexion	213 (76.07)		
• Extension	33 (11.79)		

Table 2 Prevalence of clinical myelopathic signs in patients with neck pain (n=280).

Name of Signs	Numbers of positive signs	Percentage of positive signs
Hoffman reflex	42	15.00
Tromner sign	38	13.57
Finger escape sign	28	10.00
Inverted supinator reflex	57	20.36
Babinski sign	9	3.21
Biceps reflex	91	32.50
Triceps reflex	50	17.86
Patellar tendon reflex	76	27.14
Achilles tendon reflex	29	10.36
Any **(**≥ 1**)** Myelopathic sign	119	42.5
Any **(**≥ 2**)** Myelopathic sign	109	38.93
Any **(**≥ 3**)** Myelopathic sign	89	31.79
Any **(**≥ 4**)** Myelopathic sign	63	22.50

Table 3 The intra-rater reliability of clinical myelopathic signs.

Clinical myelopathic signs	Agreement	Kappa value
Hoffman sign	90	0.62
Tromner sign	90	0.62
Finger escape sign	90	0.62
Inverted supinator reflex	90	0.74
Babinski sign	100	1.00
Biceps reflex	100	1.00
Triceps reflex	90	0.74
Patellar tendon reflex	90	0.78
Achilles tendon reflex	100	1.00

The univariate regression analyses between the four groups of participants with positive clinical myelopathic signs and associated factors are shown in Table 4. Six factors reached a $p < 0.2$. They were smartphone usage >4 h per day, age ≥ 40 years, smoking, adopting a neck flexion posture during smartphone use, university to postgraduate education level, and neck pain score ≥ 7. These factors were then analyzed using multivariate regression analyses.

Table 5 shows three factors associated with the four groups of patients with positive clinical myelopathic signs using a process of backward stepwise elimination. They were smartphone usage > 4 h per day, university to postgraduate education level, and neck pain score ≥ 7 with a difference-adjusted odds ratio (OR) threshold.

Table 4 Clinical myelopathic sign and associated factors in univariate analysis

Factors	≥One sign Crude OR (95%CI)	≥Two signs Crude OR (95%CI)	≥Three signs Crude OR (95%CI)	≥Four signs Crude OR (95%CI)
Smart phone usage				
• < 4 h per day	1.00	1.00	1.00	1.00
• ≥ 4 h per day	2.43 (1.44 to 4.09)*	2.65 (1.57 to 4.48)*	2.46 (1.44 to 4.19)*	2.25 (1.26 to 4.02)*
Age				
• <40 (years)	1.00	1.00	1.00	1.00
• ≥40 (years)	0.68 (0.42 to 1.11)*	0.62 (0.38 to1.01)*	0.64 (0.38 to 1.07)*	0.56 (0.31 to 1.01)*
Sex				
• Female	1.00	1.00	1.00	1.00
• Male	0.82 (0.45 to 1.48)	0.74 (0.40 to 1.36)	0.72 (0.37 to 1.38)	0.90 (0.44 to 1.83)
Smoker				
• No	1.00	1.00	1.00	1.00
• Yes	2.25 (0.72 to 7.06)*	1.89 (0.62 to 5.77)	1.90 (0.62 to 5.83)	1.57 (0.47 to 5.27)
Neck Posture				
• Other	1.00	1.00	1.00	1.00
• Flexion	1.71 (0.96 to 3.05)*	1.54 (0.86 to 2.76)*	2.06 (1.07 to 3.95)*	1.64 (0.80 to 3.37)*
Body mass index (kg/m)				
• Normal (<25)	1.00	1.00	1.00	1.00
• Overweight (≥25)	1.05 (0.65 to 1.70)	0.94 (0.58 to 1.54)	1.03 (0.62 to 1.72)	1.13 (0.64 to 1.99)
Education level				
• University to	1.00	1.00	1.00	1.00
Postgraduate	1.32 (0.69 to 2.53)	1.77 (0.88 to 3.53)	1.83 (0.86 to 3.89)	3.54 (1.22 to 10.29)*
• Primary to High School				
Occupation				
• Sedentary	1.00	1.00	1.00	1.00
• Others	1.00 (0.55 to 1.83)	0.74 (0.40 to 1.39)	0.70 (0.36 to 1.38)	0.64 (0.29 to 1.39)
Severity of neck pain				
• <7	1.00	1.00	1.00	1.00
• 7≥10	0.89 (0.45 to 1.75)	0.93 (0.47 to 1.86)	1.35 (0.67 to 2.70)	1.83 (0.88 to 3.80)*

*Significant at p <0.2 level was included into the model of multiple logistic regression.
OR =odds ration; CI=confidence interval.

Table 5 Clinical myelopathic sign and associated factors in multivariate analysis.

Factors	≥One sign Adjusted OR (95%CI)	≥Two signs Adjusted OR (95%CI)	≥Three signs Adjusted OR (95%CI)	≥Four signs Adjusted OR (95%CI)
Smartphone usage				
< 4 h per day	1.00	1.00	1.00	1.00
≥ 4 h per day	2.33 (1.38 to 3.94)*	2.57 (1.52 to 4.36)*	2.33 (1.36 to 4.00)*	2.26 (1.23 to 4.13)*
Education level				
Primary to High School				1.00
University to Postgraduate				3.35 (1.14 to 9.89)*
Severity of neck pain				
<7				1.00
7≥10				2.31 (1.07 to 4.99)*

*Significant at p <0.05 level.

4. Discussion

The purpose of the current study was to investigate the prevalence of clinical myelopathic signs in patients with neck pain. The results showed that the biceps reflex had the highest prevalence followed by the patellar tendon reflex, inverted supinator reflex, tricep reflex, Hoffman sign, Tromner sign, Achilles tendon reflex, finger escape sign, and Babinski sign.

The prevalence of hyperreflexia in the deep tendons of biceps, triceps, patellar, and Achilles was 32.5%, 17.86%, 27.14%, and 10.36%, respectively. In our study, most participants with clinical myelopathic signs had more than one positive sign. Ten participants (3.57%) had only one positive myelopathic sign. Thirty-two participants (11.43%) had four positives clinical myelopathic signs, the highest number of signs in the current study. Cook et al. (2010) reported that a combination of three or four myelopathic signs may be useful in screening for cervical myelopathy in patients with neck pain [14]. In the current study, participants with neck pain also had a combination of clinical myelopathic signs. Neck pain may be associated with spinal cord pathology because clinical myelopathic signs represent a pathological spinal cord condition [22].

The prevalence of the inverted supinator reflex in the current study was 20.36%. This result is consistent with the prevalence reported by Rhee et al. in their study (19%) [15]. Both studies involved participants with neck pain. However, the setting was different; the study by Rhee et al. was hospital based. In our study, neck pain participants were outpatients who went to either the hospital or clinic to get treatment. The inverted supinator reflex represents cervical cord dysfunction, especially at the C5-C6 level. Therefore, neck pain with inverted supinator reflex may be a risk factor for cervical spinal cord dysfunction at the C5-C6 level.

The current study found that the prevalence of the Hoffman sign was 15%, which is similar to the prevalence of the positive Hoffman sign in the study by Rhee et al. [15]. The average mean age of participants in the current study was 38.78±10.63 years, while the average mean age of those in Rhee et al.'s study was 48 years. These findings are very similar. In contrast, the prevalence of a positive Hoffman sign (1.7%) in the general population was significantly lower than in the present study [18]. This difference may be because Nagata et al. tested an older normal population with an average age of 67 years. In older adults, exaggerated reflexes are uncommon, as reflexes may be reduced by peripheral neuropathy or other causes [18]. Therefore, age is important, as different age groups have different prevalences of myelopathic signs.

The prevalence of the Tromner sign in the current study was 13.57%, in contrast to Chiyamongkol et al [16], who reported a much higher prevalence of 71% (in an axial neck pain group). The difference in results could be accounted for by two factors. First, their participants had a confirmed diagnosis of cervical spondylosis with axial neck pain, and second, the number of participants in the axial pain group was small (n=14).

In the current study, the prevalence of finger escape signs was 10%. The prevalence of finger escape signs in the study by Wang et al [21] was 55%. The higher prevalence in their study may be due to the fact that all the participants were included from a hospital-based study, and all of them had already been diagnosed with cervical myelopathy by MRI.

This study found that nine (3.12%) participants had a positive Babinski sign, which is higher than that reported in Rhee et al [15]'s study at 0%. The number of participants included in the current study was 280, and the larger number of participants in our study may have enabled the finding of positive Babinski signs.

The current study also aimed to determine associated factors among neck pain participants. In this study, age was not associated with clinical myelopathic signs in patients with neck pain. Among the elderly, clinical myelopathic signs are not uncommon and can be caused by peripheral neuropathy or various other causes [37]. In their study, the prevalence of myelopathic signs in elderly participants was only 4.9%. In our study, participants were aged less than 60 years on average [37]. Therefore, as expected, age was not associated with clinical myelopathic signs in patients with neck pain.

In this study, smartphone usage of ≥ 4 h per day was associated with ≥1-4 (≥1, ≥2, ≥3, and ≥4) clinical myelopathic signs. When participants using a smartphone for more than 4 h per day had at least two positive clinical signs, they had the highest adjusted OR 2.57 (95% CI: 1.52-4.36) (Table 4). The participants who had ≥4 clinical myelopathic signs were also associated with university to postgraduate-level education and an OR of 3.35 (95% CI: 1.14-9.89), and pain score ≥7 on the VAS scale with an OR of 2.31 (95% CI: 1.07-4.99). In our study, approximately 80% of participants reported using their smartphones in a flexed position. A longer length of smartphone use reportedly leads to a higher neck flexion angle [38,39]. Neck flexion causes lengthening of the cervical spinal cord [40,41]; it also causes the narrowing of the anteroposterior cord diameter [42,43]. These indicate that neck flexion positions can indirectly affect the cervical spinal cord. Ligamentous edema in the cervical spine can occur in patients with clinical myelopathic signs [25]. From our results, we suggest that smartphone usage of more than 4 h per day could not only indirectly affect the cervical spinal cord but also cause ligamentous edema in the cervical spine, and this may produce positive clinical myelopathic signs. Having more than one, two, or three clinical myelopathic signs may arise from prolonged smartphone use through aggravation of the spinal cord in the cervical spine. According to these results, the current study highlighted that prolonged smartphone usage may affect the spinal cord. Long durations (≥4 h per day) of smartphone use were found to be associated with clinical myelopathic signs. Therefore, smartphone users need to keep their duration of smartphone use to less than 4 h per day. Although >1 sign got the adjusted OR 2.43, we caution against the use of an isolated test for the diagnosis of cervical myelopathy in patients with neck pain [25,44]. Therefore, >2 positive signs are the recommendation from this study.

Participants with university or postgraduate level education had a greater risk of developing cervical myelopathy by up to 3.35 times (95%CI: 1.14-9.89) when they have ≥ 4 positives clinical myelopathic signs. According to Mohammadyari et al [45], the higher the education level, the more likely the person will use technologies like computers and the internet. Research has proven that with an increase in education level, the perceived ease of use also increases. Thus, the postgraduate education level was associated with clinical myelopathic signs.

The last factor associated with ≥ 4 positive clinical myelopathy signs was a pain score ≥ 7 on the VAS scale with an OR of 2.31 (95%CI: 1.07-4.99). At present, most spinal researchers state that mechanical compression is not the main cause of spinal and referred pain, for example, lumbago and leg pain; instead, chemical stimulation plays a key role [46]. Peng et al. studied 17 patients with discogenic lower back pain and reported that the nucleus pulposus of the outer ring of fibers along the intervertebral disc fissures, where there is a vascular granulation tissue region, has an abnormal abundance of substance P, prostaglandin E2, and bradykinin, which can lead to pain [47]. It also found a variety of inflammatory regulators in the discogenic lower back pain of the intervertebral discs, such as carbon albumin matrix metalloproteinase, prostaglandin E2, tumor necrosis factor, and various cytokines, which have been found in degenerative intervertebral discs. Nitric oxide synthase was also reported in the spinal fluid of these patients [48]. For these reasons, concomitant with an increasing pain score, one might expect that ligamentous edema will occur in the cervical spine.

The current study has some limitations. First, we did not measure cervical flexion angle, and second, our sample consisted of a low number of smokers; the crude OR in smokers was high. All the participants had no MRI information to confirm they had cervical cord compression. However, we cannot establish the association between clinical myelopathic signs and smoking in our final model due to the low number of smokers. In future studies, it would be useful to study a specific smoker-only sample to confirm this finding. Third, there was an unequal gender ratio. Fourth, our study did not ask about other electronic device usage, such as tablets, personal computers, etc. Our study method was useful as a starting point to determine clinical myelopathic signs and associated factors in smartphone users with subclinical neck pain. In our study, we selected only one time period in only one area of the country. In the future, it would be interesting to repeat our study after providing health education about smartphone usage hours. Further studies should aim to determine the sensitivity of clustered clinical myelopathic signs in smartphone users to rule out false positives of these myelopathic signs because most of them occur together.

5. Conclusion

In this study, most (11.43%) of the neck pain patients had clusters of clinical myelopathic signs (up to four clinical myelopathic signs). Prolonged smartphones use ≥ 4 h per day, a higher education level, and severe neck pain were found to be associated with clusters of clinical myelopathic signs. The current study highlighted that prolonged smartphone usage may affect the spinal cord, as evidenced by the altered reflexes. Smartphone users should take care, particularly with respect to the duration of use. Clinicians treating smartphone users should give postural education and recommend reduced smartphone use time to less than 4 h per day. Severe neck pain (VAS ≥ 7) can occur with a cluster of clinical myelopathic signs. Therefore, as a diagnostic criterion of cervical myelopathy, the severity of neck pain should be considered. Neck pain within a postgraduate education level cohort has to be aware of the pain’s development into myelopathy.

6. Ethical approval

The study design was approved by the three following ethics review boards: Khon Kaen University Ethics Committee (Khon Kaen, Thailand, 28 November 2018), University of Medical Technology, Ethical Review Committee (Mandalay, Myanmar, 21 September 2018) and University of Public Health (Yangon, Myanmar, 30 November 2018). In addition, this study was approved for registration with the Thai Clinical Trial Registry (TCTR20190121003). Before assessing the study participants, the investigators gained informed written consent.

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