ORIGINAL RESEARCH ARTICLE

The Relationship Between Smartphone Usage Pattern and Cervical Proprioception in Adults with Text Neck Syndrome in Malaysia

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ABSTRACT

Background: Text neck syndrome can cause cervical degeneration in addition to other developmental, musculoskeletal, and social complications. The aim of the current study is to examine the association between smartphone usage patterns and demographics with cervical spine joint proprioception in adults with text neck syndrome (TNS).

Methodology: A cross-sectional study design was chosen to investigate the association between sociodemographic and smartphone usage patterns with cervical joint proprioception. A validated smartphone usage pattern questionnaire was administered to 125 participants who used smartphones for more than three hours a day and suffered from TNS, and all samples underwent cervical proprioception testing. Data were analyzed using descriptive statistics, chi-square tests, and independent t-tests.

Results: The result shows that there was a significant association between gender, education, BMI, phone usage hours and cervical proprioception ($p<0.05$). However, no significant association was found with smartphone usage pattern and cervical proprioception.

Conclusions: It is concluded that smartphone use can negatively impact cervical proprioception. Smartphone users are advised to be aware of these potential health risks and take steps to reduce them to achieve better health and well-being.

Keywords: Smartphone usage, Cervical Proprioception, Text neck syndrome, Demographic, health risks, healthy lifestyle

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INTRODUCTION

Around 3.5 billion global smartphone users are estimated to be addicted to the multifunctionality of smartphone devices.[1] Smartphone users often maintain a flexed neck posture, resulting in excessive neck strain and a forward head posture characterized by hyperextension and anterior translation of the cervical vertebrae.[2] The forward head posture reduces the neck angle in the sagittal plane and increases the distance between the body and the head, which in turn increases the moment arm of the neck extensors.[3] Text Neck Syndrome (TNS) is categorized as phone use for three or more hours a day, involving three out of six text neck syndrome symptoms (neck pain, upper back pain, shoulder pain, headache, insomnia, tingling, numbness in hands) and the smartphone used with a neck flexion at or greater than 15 degrees.[4,5] Prolonged electronic device use in young people with neck pain leads to impaired cervical proprioception, resulting in greater neck joint positioning errors.[6] Muscles and ligaments of the neck lengthen when trophic changes occur due to adaptation and this affects the proprioception of the neck structures.[7] In the long term, reduced proprioception of the neck leads to posture problems. Cervical proprioception is the body's ability to sense and perceive the position and movement of the neck and head. Research suggests that individuals with TNS experienced higher proprioceptive inaccuracy in cervical spine flexion compared to asymptomatic groups.[6]

Abnormal information transmission can be influenced by dysfunction of sensory receptors in the neck or afferent input asymmetry, resulting in inaccurate transmission to the central nervous system. since the mechanoreceptors do not transmit accurate information about the position of the head relative to space and relative to the body.[8] Impaired neck proprioception impairs sensorimotor control of the cervical spine and predisposes to neck pain due to defective proprioceptive input because the same spinal segment that transmits pain transmits the activity to motor neurons.[9] A defective position sense disrupts both neuronal and muscular control of the normal cervical joint function, leading to imbalanced muscle force and putting the joint at risk.[10]

Studies have examined the association between smartphone addiction, neck pain, forward head posture, neck proprioception, smartphone usage patterns, and neck pain in college students with TNS.[11–14] A positive correlation between increased smartphone usage patterns and NDI (Neck Disability Index) scores shows that the longer a smartphone user uses it, the higher the frequency of neck pain.[15] None of the studies examined the impact of smartphone usage patterns on joint proprioception sense in the Malaysian population. Therefore, the aim of the current study is to investigate the association between smartphone usage patterns and demographics with cervical spine joint proprioception in adults with TNS.

METHODOLOGY

Study Design and Participants: A cross-sectional study design was adopted. The population of this study was all smartphone users from the Faculty of Health Sciences at INTI International University in Malaysia. The study period extended from September 2022 to December 2022. The authors adopted several criteria to include subjects in the sampling frame of this study. Inclusion criteria include participants aged 18 to 40 years who use smartphones three or more hours per day and have at least a minimum of three of six TNS symptoms, such as neck pain, neck and shoulder discomfort, upper back pain, and numbness in the upper body pain, headaches and insomnia.[16] Participants were excluded if they had a history of cervical spine fracture and vestibular disorders. At the end of this screening process, 180 subjects formed the sampling frame. At the end of this screening process, 180 subjects formed the sampling frame. Given the sampling frame size of 180 with a confidence level of 95% and a marginal error of 5%, a minimum sample of 120 is required as calculated using the Cochran formula.[17] From the sampling frame (N=180), a convenience sampling approach was used to recruit samples (N=123) based on their willingness to participate.

Ethics: This study was approved by the Faculty Research and Ethical Committee of the University with the registration number INTI-IU/FHLS-RC/BPHTI/1NY12022/020.

Participation in this study was voluntary. All participants were asked to complete a concern form before responding the SUPQ questionnaire, and the purpose of the study was explained to participants.

Smartphone Usage Pattern Questionnaire (SUPQ): The questionnaire consists of two components: demographics and SUPQ. The SUPQ included questions about when they used their smartphone throughout the day and how much time they spent using their smartphone for specific purposes such as social media, entertainment, work or education, and messaging applications. Participants were asked to rate their use on a scale of 1 to 5 (1 – never, 2 – rarely, 3 – sometimes, 4 – often, 5 – always). To estimate reliability (internal consistency) for multiple items measuring the same underlying construct, Cronbach's alpha was estimated using the Statistical Package for the Social Sciences (IBM SPSS) version 22. Analyzes performed included Cronbach's alpha, Cronbach's alpha when an item is deleted, and correlation. The results showed a Cronbach's alpha value of 0.760, which is considered good reliability, and the Cronbach's alpha value when deleting an item showed that no item needs to be deleted or reversed. Correlation analysis was performed to assess the statistical validity of the items on the scale. The analysis

showed a significant correlation between all items on the scale and the overall score on the scale.

Severity of Neck Pain: The authors used a visual analog scale to measure the extent of neck pain (i.e., severity) and was found to be reliable and valid for patients with neck pain.[18] It is an 11-point scale, with a zero value on the scale indicating "no pain" and a value of 10 indicating "worst possible pain", with different rating levels between zero and 10 possible on the continuum.

Cervical Proprioception (CP): CP was assessed with participants seated in chairs with back supports. Subjects were advised to remain in this position with their feet on the floor and their knees and hips flexed to 90 degrees for the duration of the test. The laser pointer was attached to the subject's head with a tape and adhesive to prevent movement. The subjects performed three trials to familiarize themselves with the test and were then instructed to perform all neck movements without stress. The mean score of the three trials of each movement was calculated and recorded as joint position error (JPE). The participants' eyes were closed to prevent them from looking at the laser pointer and thus attempting to change their head position. This test has been modified to include a neutral head position and a preset target. The start and end positions on the wall are measured in centimeters and then converted to degrees using the formula: angle = tan^-1 (error distance/90 cm).[19] A JPE greater than 4.5 is considered to indicate impairment in the accuracy of head and neck repositioning.[20]

Data Analysis: The Statistical Package for Social Sciences (SPSS) version 21 was used to analyze the data. Descriptive analysis using mean and standard deviation for continuous data while categorical data were presented in frequency and percentage. Chi-square test was performed to interpret the association between demographic characteristics such as gender, occupation, education, and gadgets with CP. An independent t-test was used to analyze the association between age, BMI, years of phone use, device hours, and smartphone usage patterns and CP.

RESULTS

A total of 125 participants with TNS were recruited. The sociodemographic characteristics of the participants are presented in Table 1. Most participants experienced neck pain; however, only half of the participants had neck pain for more than a year. There were more women (70%) than men with TNS. Most participants had a mean (SD) age of 25.15 (6.70) and a BMI of 22.45 (4.79). Participants' smartphone usage time was calculated as a mean (SD) of 9.42 (2.91). The smartphone pattern was rated on a scale of 9 to 45., the higher the scale, the worse the phone using the pattern, and the average of phones using the pattern was 36.84 (3.98).

Table 1: Sociodemographic Characteristics of the participants with TNS (n=125)

Characteristics	Participants(%)
Gender	
Male	55 (44)
Female	70 (56)
Age (M±SD)*	25.15±6.70
BMI (M±SD)*	22.45±4.79
Occupation	
Student	78 (62.4)
Employed	47 (37.6)
Ethnicity	
Chinese	107 (85.6)
Others	18 (14.4)
Education Level	
Secondary	25 (20)
Degree	95 (76)
Masters	5 (4)
Gadgets other than smartphone	
Laptop& Tab/iPad	24 (19.2)
Laptop only	71 (56.8)
Desktop	14 (11.2)
No gadgets	16 (12.8)
Phone Using (years) (M±SD)*	9.42±2.91
Gadgets Using Time(hours) (M±SD)*	6.10±3.54
SUPS (M±SD)*	36.84±3.98
Neck Pain	
Yes	94 (75.2)
No	31 (24.8)
Period of Neck Pain#	
>= 1 Year	27 (21.6)
<1 Year	68 (54.4)
Level of Neck Pain (VAS) (M±SD)	4.38±1.63

*Continuous Data, M±SD- Mean ± Standard deviation,
#Results for participants with neck pain only (n=94); BMI-Body Mass Index, SD-Standard Deviation, VAS- Visual analogue scale, SUPS - Smartphones using Pattern Scale

Table 2: Cervical Joint Position Sense of participants with TNS

Movement	JPE	Frequency (%)
Neck Flexion	Highest JPE	7(5.6)
	Normal	118(94.4)
Neck Extension	Highest JPE	12(9.6)
	Normal	113(90.4)
Neck Left Rotation	Highest JPE	12(9.6)
	Normal	113(90.4)
Neck Right Rotation	Highest JPE	15(12)
	Normal	110(88)

JPE – Joint Position Error

Table 2 summarizes CP in participants with TNS. The results showed that the highest JPE is observed in neck rotation (right), while the lowest JPE is observed in neck flexion

JPE-Joint position error

The association between participant demographics, smartphone usage pattern and CP is summarized in Table 3. The results show that there is a significant association between JPE in neck flexion with education and the gadget used ($p<0.05$). There is also a significant association between demographics such as gender and BMI with CP in neck extension. Year of phone use also has a significant association with CP

in neck-right rotation. Nevertheless, the results of this study show that no significant association was observed between smartphones using the pattern scale and CP.

Table 3: Association between demographics, Smartphone usage pattern and CP

Variables	NF		NE		NLR		NRR	
	High JPE	Normal	High JPE	Normal	High JPE	Normal	High JPE	Normal
Gender								
Male	4(7.3)	51(92.7)	2(3.6)	53(96.4)	4(7.3)	51(92.7)	7 (12.7)	48 (87.3)
Female	3(4.3)	67(95.7)	10(14.3)	60 (85.7)	8(11.4)	62 (88.6)	8(11.4)	62 (88.6)
p-value	0.698		0.045*		0.434		0.824	
Education[A]								
Secondary	2(8.0)	23 (92.0)	1(4.0)	24 (96.0)	2(8.0)	23 (92.0)	4(16.0)	21 (84.0)
Degree	3(3.2)	92(96.8)	10(10.5)	85 (89.5)	10(10.5)	85 (89.5)	11(11.6)	84 (88.4)
Masters	2(40.0)	3(60.0)	1(20.0)	4 (80.0)	0	5(100)	0	5(100)
p-value	0.002*		0.445		0.705		0.584	
Age[B] (M±SD)	27.14±7.75	25.03±6.65	26.75±6.81	24.98±6.69	27.42±9.67	24.911±6.32	23.13±5.41	25.43±6.83
p-value	0.421		0.387		0.22		0.215	
BMI [B] (M±SD)	22.56±3.39	22.44±4.87	25.28±8.75	22.14±4.11	21.00±2.06	22.60±4.98	22.55±5.62	22.44±4.70
p-value	0.951		0.030*		0.273		0.933	
Gadgets [A]								
Laptop & Tab	5 (20.8)	19 (79.2)	3 (12.5)	21 (87.5)	3 (12.5)	21 (87.5)	2 (8.3)	22(91.7)
Laptop only	2 (2.8)	69 (97.2)	6 (8.5)	65 (91.5)	6 (8.5)	65 (91.5)	8 (11.3)	63 (88.7)
Desktop only	0	14 (100)	1 (7.1)	13 (92.9)	3 (21.4)	11(78.6)	2 (14.3)	12 (85.7)
p-value	0.005*		0.806		0.353		0.846	
Phone usage (yrs)[B] (M±SD)	8.67±3.38	9.45±2.89	9.08±4.46	9.45±2.71	9±3.35	9.46±2.86	8±2.53	9.61±2.91
p-value	0.603		0.679		0.604		0.044*	
SUPS [B](M±SD)	34.43±4.65	36.34±4.65	35.50±4.15	36.31±4.71	37.75±4.43	36.07±4.66	35.67±4.95	36.31±4.63
p-value	0.293		0.568		0.236		0.618	

Figure in parenthesis indicate percentage. SUPS - Smartphone Using Pattern Scale
A= Categorical Data, Chi-square test, B= Continuous Data, independent samples t-test, M±SD- Mean ± Standard deviation, JPE-Joint position error, NF-Neck flexion, NE-Neck extension, NLR-Neck left rotation, NRR-Neck right rotation, BMI-Body mass index.; *p <0.05

DISCUSSION

This study was conducted to examine the association between smartphone usage patterns and demographics with CP in adults with TNS. The study findings reveal that smartphone use can negatively impact cervical proprioception and that there is a significant association between gender, education, BMI, education, phone usage hours and cervical proprioception ($p<0.05$).

In the current study, most participants were young adults with TNS and had experienced neck pain for less than a year. Although the average smartphone usage time of participants in this study was approximately 6 hours, this did not affect JPE. A study conducted on patients with cervical spondylosis suggested that higher pain intensity is associated with CP.[10] Nevertheless, given that research participants reported mild to moderate degrees of neck pain, this report did not support our findings.

Gender plays a significant role in joint position error (JPE) within this research, especially in the context of neck extension. Women demonstrated a surplus in the head repositioning task compared to men.[21] The probable reason could be the cause of eyestrain while using the smartphone. Importantly, sustained, persistent tightening of the ring-shaped muscle over an extended period impacts the tear film, the cornea's outer layer, and the eyelids, and is linked to discomfort in the neck and shoulder area.[22] In the present study, education level had an influence on JPE, particularly on neck flexion. Previous findings suggest that 91% of college students bend their necks while using their smartphones. The compressive force on the neck tissue increases as the neck flexes, and the number of hours spent using a smartphone each day is also related to the severity of musculoskeletal impairments.[4]

Previous studies with homogeneous results showed that, in contrast to the control group, individuals with "text neck" had impaired dynamic balance and higher levels of proprioceptive inaccuracy when bending the neck forward. This finding could be associated with both neck pain and the duration of electronic device use.[6,23] Interestingly, in this study, BMI was associated with CP in neck extension. A significant correlation was found between BMI and craniovertebral angle (CVA). Overweight and obesity alter the CVA and contribute to forward head posture. Furthermore, the CVA correlates with higher cervical proprioception.[24,25] Right neck rotation was associated with CP in this study. Consistent with these results, previous studies showed that individuals suffering from chronic, nontraumatic cervical spine pain and cervical spondylosis had a range of motion of 6.3° in flexion, 5.2° in extension, 6.9° in right rotation, and 4.2° in left rotation of the JPE [10]. The participants in the current study also use other devices in addition to their smartphones, with laptops being

used most frequently. There is a significant association between gadgets use and CP in neck flexion. A possible reason could be the complaints of neck pain by more than half of the participants in our study. Therefore, computer users with neck pain had a significant positive correlation with cervical JPE.[26] However, the current research did not find a significant association between time spent using a gadget and CP. This finding was inconsistent with the previous study, which found that prolonged use of a tablet computer in a head-forward, neck-flexed posture did not significantly increase cervical JPE.[27] Our current study result shows that there is no significant association between the participants' smartphone usage pattern and CP. However, there is a significant association between certain demographic characteristics and CP. The results of our current study support previous research suggesting that smartphone use may have negative effects on CP. Specifically, our results suggest that those who reported higher levels of smartphone use had lower CP compared to those who reported lower levels of smartphone use. These results are consistent with research that has found an association between prolonged smartphone use and alterations in neck position, musculoskeletal discomfort, and increased proprioceptive error in cervical flexion in individuals with TNS compared to individuals without symptoms.[6,28] The underlying mechanism by which smartphone use affects CP is not fully understood. One possibility is that the constant downward gaze associated with smartphone use leads to a decrease in sensory input to the neck muscles and joints, which could impair proprioception.[29-31] Another possibility is that prolonged smartphone use may lead to changes in sensorimotor integration processes in proprioception.[6,32]

It is noteworthy that none of the variables included in this study such as age, gender, BMI, type of gadgets and duration of phone use are potential predictors of text neck syndrome as determined by binary logistic regression and further research is required, to uncover this the reason for this. These results have important implications for healthcare professionals and those who frequently use smartphones. Physical therapists and other healthcare professionals may consider incorporating exercise and training to maintain proper neck posture and improve proprioception into treatment plans for patients who report high levels of smartphone use.[6,29] Individuals who frequently use smartphones may benefit from taking breaks and incorporating neck and shoulder stretches into their daily routine to relieve musculoskeletal symptoms and maintain cervical proprioception.[33]

Limitations

The results of this study are limited to a smaller sample of health sciences faculty in a private university in Malaysia, which limits the generalizability of the results. Therefore, a larger sample of health science faculty may be considered in future studies. Similar assessments can be conducted for vulnerable occupational groups such as information technology professionals and office workers. Since this study is a cross-sectional study, future experimental studies can be conducted to determine the cause-effect relationship and predict the reasons for smartphone use pattern and cervical proprioception in adults with text neck syndrome.

Conclusion

The results of this research showed that smartphone use could have a negative impact on CP. In particular, our study shows that gender has a significant impact on JPE, with more women having high JPE, particularly in the extended neck position. Educational status also has an impact on JPE, particularly neck flexion, with over 91% of college students bending their necks while using smartphones. Furthermore, this study concludes that there is a significant association between the use of different devices and CP in neck flexion, where over 20% of laptop and tablet users have high JPE. Finally, this study showed that prolonged use of smartphones affects JPE, which would lead to changes in neck posture and thus musculoskeletal symptoms. Therefore, physicians, physical therapists, and people who regularly use smartphones need to be aware of these consequences and health risks and take appropriate measures to mitigate them for a healthy lifestyle.

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