Cervical Proprioception in a Young Population Who Spend Long Periods on Mobile Devices: A 2-Group Comparative Observational Study

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Abstract

Objectives: The purpose of this study was to evaluate if young people with insidious-onset neck pain who spend long periods on mobile electronic devices (known as "text neck") have impaired cervical proprioception and if this is related to time on devices.

Methods: A 2-group comparative observational study was conducted at an Australian university. Twenty-two participants with text neck and 22 asymptomatic controls, all of whom were 18 to 35 years old and spent ≥4 hours per day on unsupported electronic devices, were assessed using the head repositioning accuracy (HRA) test. Differences between groups were calculated using independent sample *t*-tests, and correlations between neck pain intensity, time on devices, and HRA test were performed using Pearson's bivariate analysis.

Results: During cervical flexion, those with text neck (n = 22, mean age ± standard deviation [SD]: 21 ± 4 years, 59% female) had a 3.9° (SD: 1.4°) repositioning error, and the control group (n = 22, 20 ± 1 years, 68% female) had a 2.9° (SD: 1.2°) error. The mean difference was 1° (95% confidence interval: 0–2, *P* = .02). For other cervical movements, there was no difference between groups. There was a moderately significant correlation (*P* ≤ .05) between time spent on electronic devices and cervical pain intensity and between cervical pain intensity and HRA during flexion.

Conclusion: The participants with text neck had a greater proprioceptive error during cervical flexion compared with controls. This could be related to neck pain and time spent on electronic devices. (J Manipulative Physiol Ther 2018;41:123-128)

Key Indexing Terms: *Neck Pain; Proprioception; Cervical Vertebrae*

Introduction

The term "text neck" has been used to describe neck pain occurring in people who spend long periods using unsupported mobile electronic devices.[1] Seventy-five percent of the world's population spends time each day reading small unsupported screens of electronic devices such as cell phones, iPads, laptops, electronic readers, and video game consoles.[1] Spending longer than 20 hours a week on unsupported electronic devices is linked to the development of cervical spine musculoskeletal disorders.[2] Despite text neck becoming an increasingly common problem, as more and more time is spent on unsupported electronic devices, there has been little research to date describing the characteristics of people with this problem. Research is needed to assess and identify any deficits in this population so appropriate interventions and treatment can be recommended.

Previous research has indicated that proprioceptive deficits occur in people with traumatic neck pain such as whiplash injury,[3-8] as well as in those with insidious-onset neck pain.[5,9-11] However, as these studies were conducted mostly on older populations (mean age ± standard deviation [SD] ranging from 30 ± 9 years[5] to 56 ± 9 years[11]), it is not known if some of these proprioceptive deficits are age related. Teng et al compared head repositioning accuracy (HRA; as a measure of cervical spine proprioception) between a group of middle-aged participants with neck pain (59 ± 6 years), a middle-aged group without neck pain (55 ± 5 years), and a young asymptomatic group (age 22 ± 4 years).[12] As the repositioning errors were greater in both older groups, they concluded that age had an effect on cervical proprioception.[12,13] Studies of younger cohorts are required, as they are spending more time on mobile devices and are, thus, more likely to develop text neck. A survey of students at an Australian university found that students

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spent 4.1 ± 1.9 hours per day on mobile devices, with 66% of students reporting headache and 53% neck pain in the past year.[14] If deficits in proprioception are found in this young population with neck pain, they could be treated, which should lead to deceases in pain and disability. Previous research has indicated that patients with neck pain who undergo retraining of proprioceptive deficits report a reduction in symptoms.[10,15,16] Jull et al used a 6-week exercise regime of either proprioceptive training or craniocervical flexion training and found both groups had better proprioception and less pain.[15] Similar results were reported by Humphreys and Irgens following a 4-week rehabilitative exercise program of eye-head-neck coordination exercises.[10]

People using smartphones spend, on average, 2 to 4 hours a day bent forward to use mobile electronic devices; this can put stress on their cervical spines, which could be linked to neck pain. Studies have found that as the head goes more into flexion, the weight of the head on the cervical spine increases.[17] Hansraj found that the adult head weighs 10 to 12 pounds in the neutral position.[17] However, as it tilts forward, the forces in the neck increase to 27 pounds at 15°, 40 pounds at 30°, 49 pounds at 45°, and 60 pounds at 60°.[17]

The purposes of this study were (1) to evaluate if young people with neck pain who spend more than 4 hours a day on mobile devices differ in cervical spine proprioception from those without neck pain and (2) to assess any correlations between the amount of time spent on mobile devices and neck pain and proprioception.

Methods

Design

This study was a comparative observational study of 2 groups of young adults (<35 years old) who all spend more than 4 hours a day on mobile electronic devices. One group had cervical pain (n = 22) and the other group was asymptomatic (n = 22). The study was approved by the Human Research Ethics Committee at the Australian Catholic University under Approval No. 2013-334N. Informed consent was obtained in writing from the participants after the procedures were explained to them.

Participants

Forty-four participants (22 with neck pain and 22 asymptomatic controls) were recruited at an Australian university from January 2014 to May 2014 via posters and e-mails requesting volunteers. All participants (both groups) had to have spent ≥4 hours per day, over the past 2 years, on unsupported electronic devices such as phones, laptops, and iPads.[2,18] All participants were between ages 18 and 35 years. Additionally, to be in the neck pain group, participants were required to have neck pain ≥20 mm on a 100-mm visual analogue scale (VAS) for at least 3 months.[19] An inclusion criterion for the control group was absence of current or previous cervical spine pain.

Exclusion criteria for all participants in both groups were traumatic neck injuries, inflammatory joint disease, cervical spine infection, bony disease or marked osteoporosis, marked cervical spine disc protrusion, foramen nerve blockage, cervical spine cancer, cervical spine fracture/dislocation in the last 3 months, surgery to the cervical spine, severe migraines, vestibular disorders, and vertebrobasilar insufficiency.

Measurements

Questionnaire. All participants included in the study completed a questionnaire detailing age, sex, whether cervical spine pain was present, average time spent on unsupported electronic devices a day (in the past 2 years) and checking exclusion criteria. Participants with cervical spine pain completed a VAS to record intensity of cervical spine pain on a 100-mm line, ranging from "no pain" to "worst cervical spine pain experienced," averaged over the past week.

Head Repositioning Accuracy. Four cervical spine movements (flexion, extension, left rotation, and right rotation) were assessed using the HRA test as described by Revel et al.[20] A laser was attached to a lightweight headband (Fig 1) positioned on the participant's head. The laser was projected at a bull's-eye target (90 cm in front of the participant) that converts HRA values from centimeters to degrees based on the formula angle = $\tan^{-1}$[error distance/90 cm].[21] This target reading is accurate to ±0.5.[21] Participants were instructed to keep their eyes closed.

Procedure

Participants were seated with their heads in a natural straight-ahead position that they were asked to focus on and memorize. Each cervical spine movement (flexion, extension, right rotation, left rotation) was demonstrated to the participant, and they were allowed 1 practice movement.

Participants were then asked to keep their eyes closed and perform the movements in a slow, controlled manner. The participants were asked to move to half the reported normal range of motion (flexion = 30°, extension = 35°, right rotation = 40°, left rotation = 40°)[22] to avoid any potential end-range pain or stretch provocation. This range of movement was standardized by the researcher using a CROM device (Performance Attainment Associates, St Paul, Minnesota) (Fig 1). They were then instructed to return slowly to their starting position and indicate verbally when there. The difference between the starting and relocation positions was recorded. Each movement was performed 3 times and averaged. All participants were given the same instructions, and no feedback was given about their performance. Ten seconds of rest time was allowed between attempts of the same movement and 1 minute between different cervical spine movements.

Data and Statistical Analysis

Power sampling was calculated by an independent statistician using previous studies that assessed HRA.[5,9] It was estimated that at least 18 participants were required for each group based on the number of degrees on the HRA test that is clinically relevant.[23]

Statistical analysis was conducted with SPSS Version 22.0 (IBM, Armonk, New York). Alpha was set at .05. Baseline characteristics (such as age and time spent on unsupported electronic media per day) for the neck pain and control groups were compared using independent sample *t*-tests for equality of means. Differences in the baseline characteristic of sex proportions between the 2 groups were analyzed using a χ^2-test. The mean and standard deviation of the HRA for both the neck pain and control groups, for each of the 4 cervical spine movements (flexion, extension, right rotation, left rotation), were calculated using each group's 22 individual participant averages. Mean differences between the neck pain and control group for the HRA tests of the 4 movements were then analyzed using independent sample *t*-tests.

Correlations were performed using Pearson's bivariate analysis (1) between intensity of cervical spine pain (measured with a VAS) and time spent on unsupported electronic media and (2) between intensity of cervical spine pain (VAS) and HRA during each of the 4 cervical spine movements.

Results

Baseline Data

In total, 44 participants entered this study. Twenty-two participants (13 females, 9 males; mean age ± SD: 21 ± 4 years; range: 18-33 years) were in the text neck pain group, and 22 participants (15 females, 7 males; 20 ± 1 years; range: 18-23 years) formed the control group (Table 1). There were no significant differences in age or sex between groups (Table 1). The average time spent on unsupported mobile devices per day was 5.4 hours (SD: 1.4) for the neck pain group compared with 4.8 hours (SD: 0.8) for the control group. There was a trend (P = .08) for the pain group to spend more time on unsupported electronic media than the control group (Table 1).

Head Repositioning Accuracy

When HRA was assessed for cervical spine flexion, the participants with text neck had a 3.9° (SD: 1.4°) error, and the control group had a 2.9° (SD: 1.2°) error. The mean difference was 1° (95% confidence interval: 0-2; P = .02).

Fig 1. *Example of patient in test setting.*

For the other 3 cervical spine movements (extension, right rotation, left rotation), there was no difference in HRA between the 2 groups (Table 2).

Correlations

There was a moderately significant correlation (P < .05) between the amount of time spent on unsupported electronic media and intensity of cervical spine pain (VAS) (Table 3). There was also a moderately significant correlation ($P \leq$ .05) between intensity of cervical spine pain (VAS) and HRA with cervical spine flexion (Table 3).

Discussion

This study assessed HRA in a subcategory of young adults with insidious-onset neck pain, believed to be text neck. Participants with neck pain were less accurate in returning their head from flexion to neutral than those without neck pain. As the study found that the more time spent daily on unsupported electronic media, the greater was the intensity of cervical spine pain, we can expect that as the use of mobile devices increases in the general population, text neck will be an increasingly common problem.

When compared with the symptomatic group with cervical spine flexion, participants in this study exhibited deficits during HRA, but not during the other 3 cervical movements assessed. This could be because cervical spine

Table 1. *Comparison of Groups at Baseline*

Demographic	Neck Pain Group (n = 22)	Control Group (n = 22)	df	P [a]	Mean Difference [95% CI]
Age (y) [b]	21.0 (3.5)	20.1 (1.2)	26.3	.26	0.91 [–0.71, 2.52]
Sex [c]				.75	
Female	13 (59.1)	15 (68.2)			
Male	9 (40.9)	7 (31.8)			
Time spent on unsupported electronic media, h/d [b]	5.4 (1.4)	4.8 (0.8)	33.8	.08	0.61 [–0.07, 1.3]
VAS for cervical spine pain, mm [b]	47.9 (21.4)	0 (0)			
Time since onset of pain, mo [b]	26.3 (22)	0 (0)			

CI, confidence interval; *df,* degrees of freedom; *VAS,* visual analogue scale.
[a] Comparison of means between groups (significant at $P < .05$).
[b] Mean (standard deviation).
[c] Number (%).

Table 2. *Comparison of Head Repositioning Accuracy in the Neck Pain and Control Groups*

Cervical Spine Movement (°)	Neck Pain Group [a]	Control Group [a]	df	P [b]	Mean Difference [95% CI]
Flexion	3.91 (1.44)	2.95 (1.17)	42	.02	0.96 [0.16 to 1.76]
Extension	3.98 (1.85)	3.35 (1.46)	42	.21	0.64 [–0.38 to 1.65]
Right rotation	4.27 (1.49)	3.95 (1.34)	42	.42	0.32 [–0.54 to 1.18]
Left rotation	4.48 (1.84)	3.62 (1.57)	42	.10	0.86 [–0.18 to 1.90]

CI, confidence interval; *df,* degrees of freedom.
[a] Mean (standard deviation).
[b] Comparison of means between groups (significant at $P < .05$).

flexion was the position in which most time (>4 hours a day) was spent.

The finding that participants with neck pain had reduced HRA during cervical spine flexion, compared with the control group, has been reported in another study of participants with nontraumatic neck pain and in studies of patients with whiplash.[4,7,9] It is unknown whether the participants in these other studies also spent long periods with the neck in sustained flexion.

Informing Clinical Practice

These results indicate a cervical spine proprioceptive deficit in participants believed to have text neck, which could indicate the need for targeted advice and treatment. As more and more people spend increasing amounts of time on mobile electronic devices, proprioceptive deficits may require treatment to prevent progression and symptoms. There is evidence from previous research that a 4 to 6 weeks of proprioceptive retraining will improve proprioception and decrease neck pain. Because the laser method used to measure HRA is a simple method that is economical and easily performed, it can be used clinically to assess and treat patients with this problem.[20,24,25]

Although this study was conducted on young students, there may be similar deficits in other groups of people who spend long periods in sustained flexion, such as dentists, graphic designers, and seamstresses. The correlation between time spent in flexion and increased neck pain suggests advice should be given to patients to spend less time on unsupported mobile devices or, when using them, to hold the head in a less flexed position. They should be advised to lift the device so it is closer to eye level by placing a support such as a pillow under the arms, or to look down with the eyes but not the head. Several phone apps are available for detection of the angle of the head. The app Text Neck Indicator LITE in Google Play Store (Android phones) detects poor head posture and sends an alert to lift the head. Forward Head Posture is another useful app that allows you to take a picture of your cervical spine posture and measure the angle of your head.

Limitations

A confirmed diagnosis of text neck may be difficult to standardize as other confounding factors may contribute to the neck pain. The method used in this study may also have been compromised, as the participants were not blindfolded to eliminate visual feedback and, instead, were given instruction to keep their eyes closed. In this study, 3 repetitions for each movement were performed, as suggested by Feipel et al.[7] Another study suggested that at least 6 trials are required for reliability of HRA.[14] However, in a previous study, Rix and Bagust conducted 10 repetitions for each movement of the HRA test and concluded that the decrease in HRA between groups occurred on the first attempt, with little significant variation with subsequent repetitions.[7,9]

Strengths and Future Research

A strength of the study is the young age range of participants (18-33 years), which should avoid possible age-related proprioceptive deficits suggested by Teng et al.[12] Another strength of this study was relocating to a

Table 3. *Correlations: Intensity of Cervical Spine Pain to Time Spent in Flexion, Intensity of Cervical Spine Pain to HRA During Movements, Time Spent in Flexion to HRA During Movements, and HRA During Movements to Each Other* [a]

	Pearson's Correlation Coefficient *r* (*P* Value)					
	VAS for Cervical Spine Pain	Time (h)	Flexion	Extension	Right Rotation	Left Rotation
VAS for cervical spine pain		0.371 [a] (.013)	0.380 [a] (.011)	0.08 (.62)	0.19 (.23)	0.27 (.08)
Time, h	0.371 [a] (.013)		0.10 (.53)	0.10 (.54)	–0.05 (.75)	–0.21 (.89)
Flexion	0.380 [a] (.011)	0.10 (.53)		0.388 [b] (.009)	0.340 [a] (.024)	0.21 (.18)
Extension	0.08 (.62)	0.10 (.54)	0.388 [b] (.009)		0.05 (.77)	0.09 (.54)
Right rotation	0.19 (.23)	–0.05 (.75)	0.340 [a] (.024)	0.05 (.77)		0.27 (.08)
Left rotation	0.27 (.08)	–0.21 (.89)	0.21 (.18)	0.09 (.54)	0.27 (.08)	

HRA, head repositioning accuracy; *Time,* time spent on unsupported electronic media; *VAS,* visual analogue scale.
[a] Correlation is significant at the .05 level (2-tailed).
[b] Correlation is significant at the .01 level (2-tailed).

straight-ahead position, as this has been reported to be the most accurate method of detecting cervical spine proprioceptive deficits.[5] In addition, participants were instructed to perform cervical spine movements to half the normal expected range of motion to avoid increased pain and the stimulation of afferent inputs at end of range.[9] Finally, to avoid stimulation of the vestibular system during head movement, participants were instructed to rotate their head slowly.[12,26,27] Future studies could be conducted assessing the effect of a tailored sensorimotor retraining program for this group with text neck that has been reported to be beneficial for proprioceptive deficits in other neck pain groups.[10,15,16]

Conclusion

The results indicate that there is a difference in HRA in cervical flexion between young participants with text neck pain who spend extended periods in sustained cervical flexion and asymptomatic controls. Spending longer time on unsupported electronic media resulted in higher intensity of cervical spine pain. The greater the cervical spine pain experienced, the greater was the decrease in HRA during cervical spine flexion.

Practical Applications

- This study found significant correlation between time spent on electronic devices and cervical pain intensity.
- The study also found a correlation between cervical pain intensity and HRA during flexion.

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Contributorship Information

Concept development (provided idea for the research): S.A.R.
Design (planned the methods to generate the results): S.A.R.
Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): S.A.R.
Data collection/processing (responsible for experiments, patient management, organization, or reporting data): A.P., S.A.R.
Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): A.P., S.A.R.
Literature search (performed the literature search): A.P.
Writing (responsible for writing a substantive part of the manuscript): A.P., S.A.R.
Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): A.P., S.A.R.

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