The Correlation of Time of Cervical Flexion with Cervical Symptoms in Office Workers: A Cohort Study

Zhang Jinlong

Hefei BOE Hospital

Fang Yunyun (✉ cdfk22@tom.com)

Jiangning Hospital of Nanjing Medical University

Gao Lijie

Sichuan University West China Hospital

Chen Jian

China University of Science and Technology

Wang Cheng

China University of Science and Technology

He Hongchen

Sichuan University West China Hospital

Luo Qinglu

Guangzhou Medical University

Research article

Keywords: CFI, office workers, cervical spondylosis, NDI, USP

Posted Date: August 12th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-34223/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background: An increasing number of office workers complain of neck pain after extended smart phone use. We conducted this study to examine the correlation between the time of cervical flexion (CFI) during smart phone use and cervical symptoms of office workers in China.

Methods: In this cohort study, 1791 individuals responded to an on line questionnaire. For our study, we included responses of 498 [27.8%] office workers. Excluded from the study were 1293 [72.9%] individuals including building workers, students, non-office workers, and those who did not complete the questionnaire. Participants completed an online questionnaire survey from May 29, 2019 to April 10, 2020. The (Neck Disability Index) NDI was used to evaluate cervical symptoms. Multivariable logistic regression, threshold saturation effect analysis, t-test, and Pearson's chi-square tests were used to analyze the data.

Results: We analyzed questionnaire results of the 498 office workers. The t-test showed no significant differences among the gender groups for age, working age, and NDI scores ($P>0.05$). Compared with other activities, smart phone use had no positive correlation with NDI scores ($P>0.05$), while low back pain had a strong correlation with NDI scores ($P<0.05$). When adjusting for age, working age, and low back pain covariates, CFI had a positive correlation with NDI scores. In addition, CFI had a curve line correlation with NDI-a monotone increasing relationship; the fold point was 6 ($P<0.05$).

Conclusions: CFI had a positive curve line correlation with the NDI suggesting that office workers should limit CFI to a maximum of 6 hours to decrease cervical symptoms.

Background

An increasing number of office workers are seeing doctors for complaints of neck pain. In our clinic, we have found that the complaints appear to relate to the amount of time that the head is tilted downward while using smart phones or other electrical devices. Cervical spondylosis (CS) refers to the clinical symptoms caused by cervical instability, often due to degeneration of the cervical discs and intervertebral joints, and cervical hyperplasia, which can stimulate or compress the surrounding nerve roots, vertebral arteries, sympathetic nerves, spinal cord, and other tissues [1-3]. In work and in life, there has been a dramatic increase in the use of computers, smartphones, and other electronic devices. Furthermore, studies have shown an increase in work and academic pressures. Many individuals work or study for many hours at a time. This can lead to cervical or other symptoms [4, 5].

The International Labor Organization has classified shoulder and neck pain as occupational diseases since 1960. On July 30, 2019, the Advanced Committee of Healthy China Action announced that diseases such as CS, periarthritis of the shoulder, low back pain, bone hyperplasia, and sciatica are preventable diseases among laborers. Among these diseases, the incidence of CS is the highest. According to the 2015 data released by the European Agency for Safety and Health at Work, the incidence of CS from 2000 to 2012 showed an annually increasing trend, with rates in some countries as high as 46.3% [6]. In

China's modern era of rapid economic development, increasingly more professional office workers have career-related diseases such as CS.

Two region-specific questionnaires for the cervical spine are the Neck Disability Index (NDI) and the Neck Pain and Disability Scale (NPDS) [7]. The NDI is designed to measure activity limitations due to neck pain and disability [8-10], whereas the NPDS measures problems with neck movements, neck pain intensity, effect of neck pain on emotion and cognition, and the level of interference during life activities [11]. NDI is easier for the lay public to understand and considered a responsive measure for neck pain and acute whiplash injury [12], we chose this scale for our analysis.

In order to improve the quality of life among office workers, we sought to investigate the correlation between the time of cervical flexion (CFI) and the NDI among office workers of China, and whether the smart phone use (SPU) had a negative effect on the cervical spine. As far as we know, few scholars pay attention to the relationship between the CFI of SPU and cervical symptoms.

Methods

Data collection

We used the Questionnaire Star (<https://www.wjx.cn/>) to conduct a real-time online cohort survey study. The survey was conducted from May 29, 2019 to April 10, 2020. Respondents came from nationwide; the recruitment target was office workers. The NDI was used to assess the perceived pain and disability related to the cervical spine.

Design and setting

Cohort study.

Statistical methods

In this study, we took a purposive approach with no sample estimation. Data were analyzed using the statistical packages R (R Foundation; <http://www.r-project.org>; version 3.4.3) and EmpowerStats (www.empowerstats.com; X&Y Solutions Inc.). Multivariable logistic regression models, generalized estimated equation model, generalized additive models, threshold saturation effect analysis, *t*-test, and Pearson's chi-square tests were used to analyze the data. The mean $\pm$ standard deviation (SD) and 95% confidence interval (CI) were used to indicate the size of the value. The level of statistical significance was set at $p < 0.05$.

Results

Flow chart of this study

A total of 1791 individuals participated in the online questionnaire survey, with 498 (27.81%) office workers included, and 1293 individuals excluded. Those participants who were excluded were 563 (31.34%) individuals who did not complete the questionnaire, 218 (12.17%) students, 78 (4.36%) building workers, and 434 (24.23%) other non-office workers. The flow chart can be seen in Fig 1.

Sociodemographic and clinical characteristics of the sample.

The baseline characteristics of all patients are shown in Table 1. The results of the *t*-test showed no significant differences among the gender groups for age, working age, and NDI scores ($P>0.05$), and the CFI of males was higher than that of females ($P<0.05$). Pearson's chi-squared test showed that differences in the number of educational degrees in the male and female groups were significant ($P<0.05$). The activities ratio of smart phone use (SPU), using computers (UC), reading books (RB), and using other electronic devices (UOED) was 63.71%/78.07%, 30.65%/18.72%, 1.61%/2.14%, and 4.03%/1.07% in the male and female groups, respectively. Pearson's chi-square tests showed differences were statistically significant ($P<0.05$). The incidence of neck pain (74.19% male, 66.31% female) and the incidence of low back pain (73.39% male, 78.07% female) were high; the difference between males and females was not significant ($P>0.05$).

Crude correlation associations of CFI, covariates, and NDI of the sample

As seen in Table 2, single factor correlation analysis showed that age and working age did not have a correlation with NDI scores for participants ($P>0.05$). CFI had a positive correlation with NDI scores ($P<0.05$). Compared with other activities, SPU had no positive correlation with NDI scores ($\beta=0.83$, 95%CI=-0.07 to 1.73, $P>0.05$), while low back pain had a strong correlation with NDI scores ($P<0.05$).

Multivariate logistic regression model for CFI and NDI of the sample

In a multivariate logistic regression model, covariates were included as potential confounders in the final models if they changed the estimates of NDI by more than 10% or were significantly associated with NDI, according to these protocols, as seen in Tables 1 and 2. Age, gender, working age, and low back pain were selected as covariates. After adjusting for age, working age, and sex covariates, CFI had a positive correlation with NDI scores ($\beta=0.28$, 95%CI=0.13 to 0.43, $P<0.05$), and after adjusting for low back pain CFI had a positive correlation with NDI scores ($\beta=0.26$, 95%CI=0.12 to 0.40, $P<0.05$). (See Table 3)

Curve line correlation between the CFI and NDI of the sample

Generalized additive models were used to visually assess the ToHTD and NDI relationships. We adjusted for age, sex, working age, and low back pain factors. The ToHTD had a curve line correlation with NDI - a monotone increasing relationship. (See Fig 2)

Analysis of threshold saturation effect between the CFI and NDI of the sample

As seen in Table 4, we performed threshold saturation effect analysis between CFI and NDI scores in participants. The logarithmic likelihood ratio test showed that there was a fold point ($K=6$) between CFI and NDI scores, and the differences were statistically significant ($P<0.05$). When CFI was less than 6 hours ($K<6$), the estimated change in NDI was 0.53, 95%CI was 0.26 to 0.81, and the differences were statistically significant ($P<0.05$). When CFI was greater than 6 hours ($K>6$), the estimated change in NDI was -0.03, 95%CI was -0.33 to 0.26, and the differences were not statistically significant ($P>0.05$). The logarithmic likelihood ratio test showed that this fold point was statistically significant ($P<0.05$).

Discussion

With recent rapid socioeconomic development, people are more mindful of their health. Increasingly more individuals who work in the office environment are seeking treatment for pain. In China, outpatients with CS are common in rehabilitation medicine, orthopedics, or traditional Chinese medicine. These patients often complain of neck and back pain, and have occasional complaints of dizziness, limb numbness, walking instability, perineal paresthesia, urinary and fecal incontinence, and sexual dysfunction. Such symptoms can have serious impacts on patients' lives and can result in a sharp decline in the quality of life. In a study conducted at the University Clinical Hospital in Olsztyn, Poland between 2011 and 2015, the most frequent MRI-diagnosed diseases were musculoskeletal diseases (58.0%), cervical disc disorders (12.5%), and spondylosis (4.6%). The authors concluded that the significant number of patients presenting with spinal disorders at young ages (31–40 years) pointed to the necessity of introducing methods in school-aged individuals to prevent disorders of the vertebral column [13]. In the present study, we also found that participants had a high incidence of neck pain syndrome (74.19% for males and 66.31% for females).

Previous research reported that most patients with CS were in occupations that required working long-term at a desk or work station, where it is common to remain for extended periods of time with the head tilted downward [14-16]. The cervical spine has seven vertebrae, and the joints formed by each vertebra are more flexible. The anatomical features of the neck provide a large range of movement. Overloading the neck musculature can lead to cervical tissue damage. Holding the head in a lowered or flexed posture maintains the neck muscles in a tensile state, which may cause muscle strain if the position is held over a long period of time. This forward flexion posture may lead to static imbalance and accelerate degeneration of the intervertebral discs, small joints, and ligaments of the neck, eventually resulting in CS.

The NDI covers 10 dimensions of neck-specific disability: pain intensity, personal care, lifting, reading, headache, concentration, work, driving, sleeping, and recreation [17]. This is closely correlated with cervical spine function [16], which can reflect neck pain intensity [18], and can ultimately be used to evaluate the quality of life [19]. Feng et al. [20] analyzed survey data and found that among ultrasound technicians, lowering of the head for a long period of time led to rates of neck discomfort as high as 93.5%. Gremark Simenson et al. [21] found that the prevalence of CS among ultrasound technicians was 58%, and positively related to the length of time that the technician's head was held in a downward

position while working. These results are consistent with those of our study. We found that CFI was positively correlated with the NDI regardless of unadjusted or adjusted covariates.

Office workers should be mindful of CFI as much as possible. Our study found that there was a fold point ($K=6$) between CFI and NDI, and the differences were statistically significant ($P<0.01$). Many patients with CS have symptoms of neuropathy, however most symptoms are relatively benign and ultimately have a good prognosis [22]. The results of our study suggest that when CFI is greater than 6 hours, participants may adapt to neuropathy symptoms related to neck posture, leading to a decrease in symptoms. Even with this adaptation, cervical syndrome can persist. Therefore, we recommend that office workers limit CFI in order to decrease cervical syndrome.

In the 21st century, the rapid development of technology has resulted in the widespread use of electronic devices, leading to a near-universal presence of computers and smart phones in many countries, including China. One study found active arthritic changes caused by repetitive strain injury from excessive text messaging using smart phones [23]. Another study reported that smartphone use induced a more flexed posture on the neck and trunk than other visual display terminal work [24]. Pain and fatigue worsened with longer smartphone use, and the authors suggested correct posture and breaks of at least 20 minutes when using smartphones [25]. Although our research found that using flexed neck postures to use smart phones and for other activities had no effect on NDI scores, CFI was positively correlated with NDI. We suggest that office workers need to control CFI to reduce cervical symptoms when using smartphones or engaging in other activities that require flexed postures for extended periods of time.

One limitation to our study was the lack of follow-up, therefore, the long-term results of our investigation were unknown. We did not analyze other risk factors associated with NDI such as mental stress, the time of day that people are working, working hours, work pressures, sleep quality, and financial situation. In the future, we hope to conduct further studies and evidence-based research on CFI and NDI.

Abbreviations

CI: Confidence interval

CS: Cervical spondylosis

MRI: Magnetic resonance imaging

NDI: Neck Disability Index

NPDS: Neck Pain and Disability Scale

RB: Reading a book

SD: Standard deviation

CFI: time of cervical flexion

UC: Using computers

UOED: Using other electronic devices

SPU: Smart phone use

Declarations

Ethics approval and consent to participate: All participants filled out the questionnaire in anonymous way, the survey study need not approval by our Ethics Committee of hospital; informed consent was waived due to the nature of this survey study, which coincident with ethical requirements and waiver from the local research ethics committee.

Consent for publication: Not applicable.

Availability of data and materials: The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Competing interests: The authors declare that they have no conflict of interest.

Authors' contributions: JLZ: Conducted the study. Collected, analyzed and interpreted the data. Wrote the manuscript. YYF: Designed the study. Interpreted the data. Edited the manuscript. LJG: Statistical analyzed and interpreted the data. JC and CW: Created and statistical analyzed the data. HCH: Planned the project. Reviewed the manuscript. QLL: Planned the project. Reviewed the manuscript. Final approval of the version to be submitted: JLZ, YYF, LJG, JC, CW, HCH, QLL. The author(s) read and approved the final manuscript

Acknowledgements: We sincerely thank Dechao Xu for collecting and sorting participants' information. We also thank Zeling Tao and Wenxiang Fan for devising the questionnaire using Questionnaire Star. We thank the participants in the study for their time and effort. We thank Edanz Group China (www.liwenbianji.cn/ac), and Editage (www.editage.com) for English language editing for editing the English text of a draft of this manuscript.

References

1. Malige A, Morton PN, Carolan GF, Sokunbi G. The operative treatment of shoulder pain in patients with a concurrent diagnosis of cervical spondylosis and shoulder dysfunction. J Spine Surg. 2019;5(2):207-214.
2. Zheng C, Nie C, Zhu Y, Yu Q, Zhu D, Lu F, Weber R, Jiang J. Changes in central motor conduction time and its implication on dysfunction of distal upper limb in distal-type cervical spondylotic

- amyotrophy. *J Clin Neurophysiol: official publication of the American Electroencephalographic Society*. 2019;36(1):52-59.
3. D MK, B EA. Diagnostic criteria for distinguishing cervical disk herniation from spondylosis in the neural compression syndrome. *Radiol*. 1964;83:67-73.
 4. Woodworth DC, Holly LT, Mayer EA, Salamon N, Ellingson BM. Alterations in cortical thickness and subcortical volume are associated with neurological symptoms and neck pain in patients with cervical spondylosis. *Neurosurg*. 2019;84(3):588-598.
 5. Venosa M, Romanini E, Padua R, Cerciello S. Comparison of high-intensity laser therapy and combination of ultrasound treatment and transcutaneous nerve stimulation in patients with cervical spondylosis: a randomized controlled trial. *Lasers Med Sci*. 2019;34(5):947-953.
 6. Stocks SJ, McNamee R, van der Molen HF, Paris C, Urban P, Campo G, Sauni R, Martinez Jarreta B, Valenty M, Godderis L, et al. Trends in incidence of occupational asthma, contact dermatitis, noise-induced hearing loss, carpal tunnel syndrome and upper limb musculoskeletal disorders in European countries from 2000 to 2012. *Occup Environ Med*. 2015;72(4):294-303.
 7. Cook C, Richardson JK, Braga L, Menezes A, Soler X, Kume P, Zaninelli M, Socolows F, Pietrobon R. Cross-cultural adaptation and validation of the Brazilian Portuguese version of the Neck Disability Index and Neck Pain and Disability Scale. *Spine*. 31(14):1621-1627.
 8. Ackelman BH, Lindgren U. Validity and reliability of a modified version of the neck disability index. *J Rehabil Med*. 2002;34(6):284-287.
 9. Pietrobon R, Coeytaux RR, Carey TS, Richardson WJ, Devellis RF. Standard scales for measurement of functional outcome for cervical pain or dysfunction. *Spine*. 27(5):515-522.
 10. Jovicic MD, Konstantinovic LM, Grgurevic AD, Milovanovic ND, Trajkovic G, Jovicic VZ, Kostic Dedic SI, Hrkovic MK, Draganac SM. Validation of the Neck Disability Index in Serbian patients with cervical radiculopathy. *J Manipulative Physiol Ther*. 2018;41(6):496-502.
 11. Wheeler AH, Goolkasian P, Baird AC, Darden BV. Development of the Neck Pain and Disability Scale. *Spine*. 24(13):1290.
 12. Stefanovitch-Lawbuay N, Amirfeyz R, Lovell R, Bannister G. Reliability and responsiveness of patient-reported outcome measures of neck disability to physical therapy: comparison of the Copenhagen, Northwick Park, and Neck Bournemouth Questionnaires and the Neck Disability Index. *J Manipulative Physiol Ther*. 2019;42(2):104-107.
 13. Kolenkiewicz M, Wlodarczyk A, Wojtkiewicz J. Diagnosis and incidence of spondylosis and cervical disc disorders in the University Clinical Hospital in Olsztyn, in years 2011-2015. *BioMed Res Int*. 2018;2018:5643839.
 14. Lv Y, Tian W, Chen D, Liu Y, Wang L, Duan F. The prevalence and associated factors of symptomatic cervical spondylosis in Chinese adults: a community-based cross-sectional study. *BMC Musculoskelet Disord*. 2018;19(1):325.
 15. Deng YZ, Xu LG, Chen L, Zhou D, Liu Y. Effectiveness of acupuncture in the management of cervical spondylosis: a meta-analysis. *J Biol Regul Homeost Agents*. 2017;31(4):1017-1022.

16. Badhiwala JH, Witiw CD, Nassiri F, Jaja BNR, Akbar MA, Mansouri A, Merali Z, Ibrahim GM, Wilson JR, Fehlings MG. Patient phenotypes associated with outcome following surgery for mild degenerative cervical myelopathy: a principal component regression analysis. *Spine J.* 2018;18(12):2220-2231.
17. Vernon H, Mior S. The Neck Disability Index: A study of reliability and validity. *J Manipulative Physiol Ther.* 1991;14(7):409-415.
18. Breivik H. The Norwegian version of the Neck Disability Index (NDI) is reliable and sensitive to changes in pain-intensity and consequences of pain-in-the-neck. *Scand J Pain.* 2014; 5(1):26-27.
19. Ko S, Choi W, Chae S, Kwon J, Lee Y. Correlation between Short-Form 36 Scores and Neck Disability Index in patients undergoing anterior cervical discectomy and fusion. *Asian Spine J.* 2018;12(4):691-696.
20. Feng Q, Liu S, Yang L, Xie M, Zhang QA-OhooX. The Prevalence of and risk factors associated with musculoskeletal disorders among sonographers in central China: a cross-sectional study. *PloS One.* 2016;11(10):1932-6203 (Electronic).
21. Gremark Simonsen J, Axmon A, Nordander C, Arvidsson I. Neck and upper extremity pain in sonographers – associations with occupational factors. *Appl Ergon.* 2017;58:245-253.
22. Ando T. [Management of Cervical Spondylosis by Neurologists]. *Brain Nerve = Shinkei kenkyu no shinpo.* 2019;71(3):239-248.
23. S U, R R, F AK. Textitis as seen on F-NaF imaging using an Ultra-High-Resolution Positron Emission Mammography Scanner. *J Nucl Med Technol.* 2020;48(2):181-183.
24. JH P, SY K, SG L, HS J. The effects of smart phone gaming duration on muscle activation and spinal posture: pilot study. *Physiother Theory Practice.* 2017;33(8):661-669.
25. SY K, SJ K. Effect of duration of smartphone use on muscle fatigue and pain caused by forward head posture in adults. *J Phys Ther Sci.* 2016;28(6):1669-1672.

Tables

Table 1. Sociodemographic and clinical characteristics of the sample

Sexes	Male	Female	P-value
	Mean±SD/N%	Mean±SD/N%	
N	124	374	
Age, years	32.20 ± 9.30	31.44 ± 7.17	0.699
Working age, years	8.70 ± 7.66	9.10 ± 6.45	0.068
CFI, hours	5.85 ± 3.13	4.74 ± 2.45	<0.001*
NDI	6.17 ± 4.48	5.60 ± 4.49	0.139
Educational degree	<0.001*		
BoB	92 (74.19%)	348 (93.05%)	
MoA	25 (20.16%)	19 (5.08%)	
JSLoB	4 (3.23%)	5 (1.34%)	
HSLoB	3 (2.42%)	2 (0.53%)	
Activities	0.004*		
SPU	79 (63.71%)	292 (78.07%)	
UC	38 (30.65%)	70 (18.72%)	
RB	2 (1.61%)	8 (2.14%)	
UOED	5 (4.03%)	4 (1.07%)	
Low back pain	0.283		
No	33 (26.61%)	82 (21.93%)	
Yes	91 (73.39%)	292 (78.07%)	
Neck pain	0.102		
No	32 (25.81%)	126 (33.69%)	
Yes	92 (74.19%)	248 (66.31%)	

Note: CFI, time of cervical flexion; NDI, Neck Disability Index; JSLoB, junior school level or below; HSLoB, high school level or below; BoB, bachelor's or below; MoA, master's or above; SPU, smart phone use; UC, using computers; RB, reading books; UOED, using other electronic devices; SD, standard deviation; * $P<0.05$.

Table 2. Crude correlation associations of CFI, covariates, and NDI of the sample

Statistics	NDI β (95%CI)	P-value	
Age, years	31.63 $\pm$ 7.76	0.02 (-0.03, 0.07)	0.4169
Working age, years	9.01 $\pm$ 6.76	-0.00 (-0.06, 0.06)	0.9451
CFI, hours	5.02 $\pm$ 2.68	0.28 (0.13, 0.42)	0.0002*
Educational degree			
BoB	440 (88.35%)	0	
MoA	44 (8.84%)	0.68 (-0.71, 2.07)	0.3379
JSLoB	9 (1.81%)	0.25 (-2.71, 3.21)	0.8683
HSLoB	5 (1.00%)	3.96 (0.01, 7.91)	0.0499*
Activities			
Others	371 (74.50%)	0	
SPU	127 (25.50%)	0.83 (-0.07, 1.73)	0.0716
Low back pain			
No	115 (23.09%)	0	
Yes	383 (76.91%)	2.40 (1.49, 3.31)	<0.0001*

Note: ToHTD, time of head tilted downward; NDI, Neck Disability Index; JSLoB, junior school level or below; HSLoB, high school level or below; BoB, bachelor's or below; MoA, master's or above; SPU, smart phone use; UC, using computers; RB, reading books; UOED, using other electronic devices; CI, confidence interval; *P<0.05.

Table 3. Multivariate logistic regression model for CFI and NDI

Exposure	Non-adjusted		Adjust I		Adjust II	
	β (95%CI)	P Value	β (95%CI)	P Value	β (95%CI)	P Value
CFI	0.28 (0.13, 0.42)	0.0002*	0.28 (0.13, 0.43)	0.0002*	0.26 (0.12, 0.40)	0.0003*

Note: Non-adjusted model adjusted for: None; Adjust I model adjust for: age, sex, and working age; Adjust II model adjusted for low back pain; *P<0.05.

Table 4. Analysis of threshold saturation effect between CFI and NDI

Outcome	NDI	
	β 95%CI	P Value
Model χ^2		
A linear regression coefficient	0.26 (0.12, 0.41)	0.0005*
Model χ^2		
Fold point(K)	6	
<K regression coefficient 1	0.53 (0.26, 0.81)	0.0002*
>K regression coefficient 2	-0.03 (-0.33, 0.26)	0.8225
Difference value of regression 2 and 1	-0.57 (-1.06, -0.08)	0.0240*
Predicted value of Y at fold point	6.55 (5.84, 7.27)	
Logarithmic likelihood ratio test	0.023*	

Note: * $P < 0.05$.

Figures

Figure 1

Flow chart and regression tree indicating inclusion and exclusion criteria.

Figure 2

Graph depicting the association between CFI and NDI in participants.