

Factors Associated with Neck and Shoulder Pain in Volunteers

Keiji Nagata¹⁾, Yuyu Ishimoto²⁾, Shinichi Nakao¹⁾, Shoko Fujiwara²⁾, Toshiko Matsuoka²⁾, Tomoko Kitagawa²⁾, Masafumi Nakagawa²⁾, Masakazu Minetama²⁾ and Mamoru Kawakami²⁾

1) Department of Orthopedic Surgery, Wakayama Medical University, Wakayama, Japan

2) Spine Care Center, Wakayama Medical University Kihoku Hospital, Wakayama, Japan

Abstract:

Introduction: The aims of the present study were 1) to examine the association between neck and shoulder pain (NSP) and lifestyle in the general population and 2) to examine if sagittal spino-pelvic malalignment is more prevalent in NSP.

Methods: A total of 107 volunteers (mean age, 64.5 years) were recruited in this study from listings of resident registrations in Kihoku region, Wakayama, Japan. Feeling pain or stiffness in the neck or shoulders was defined as an NSP. The items studied were: 1) the existence or lack of NSP and their severity (using VAS scale), 2) Short Form-36 (SF-36), 3) Self-Rating Questionnaire for Depression (SRQ-D), 4) Pain Catastrophizing Scale (PCS), 5) a detailed history consisting of 5 domains as being relevant to the psychosocial situation of patients with chronic pain, 6) A VAS of pain and numbness to the arm, and from thoracic region to legs. The radiographic parameters evaluated were also measured. Participants with a VAS score of 40 mm or higher and less were divided into 2 groups. Association of SF-36, SRQ-D, and PCS with NSP were assessed using multiple regression analysis.

Results: In terms of QoL, psychological assessment and a detailed history, bodily pain in SF-36, SRQ-D, and family stress were significantly associated with NSP. A VAS of pain and numbness to the arm, and from thoracic region to legs, was significantly associated with NSP. There were no statistical correlations between the VAS and radiographic parameters of the cervical spine. Among the whole spine sagittal measurements, multiple logistic regression analysis showed that sacral slope (SS) and sagittal vertical axis (SVA) were significantly associated with NSP.

Conclusion: In this study, we showed the factors associated with NSP. Large SS and reduced SVA were significantly associated with NSP, while cervical spine measurements were not.

Keywords:

cervical spine, lifestyle, neck and shoulder pain, sagittal spino-pelvic alignment, sacral slope, cervical sagittal vertical axis

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Introduction

Neck and shoulder pain (NSP), which is a common symptom among the general population, is a very prevalent problem in adults. Among European and North American populations, two-thirds of people experience neck pain at some point during their lives¹⁾. In Japan, a comprehensive survey reported that NSP was the most common symptom in Japanese women and men²⁾. Although Iizuka et al.³⁾ have reported that NSP is associated with some factors, including age, sex, psychological stress, and musculoskeletal pain at other anatomic sites, the pathogenesis and mechanisms of NSP have not been analyzed in depth. In order to effectively treat neck pain, it is important to understand the underlying

medical condition causing the pain. However, there continues to be little information available regarding the epidemiology and clinical characteristics of NSP in healthy subjects. It has been reported that most neck pain has some postural component related to the etiology⁴⁾. Postural retraining has traditionally been a principal part of physiotherapeutic intervention and treatment of spinal pain disorders. In recent years, many authors have emphasized the importance of spinal sagittal balance and investigated those parameters in healthy participants⁵⁻⁷⁾. Sraivshet et al.⁸⁾ reported the impact of cervical sagittal alignment parameters on neck disability in preoperative patients with cervical spine disease. Tsunoda et al.⁹⁾ showed an association between sagittal postural alignment and NSP using a Spinal Mouse[®] in a cohort study.

Corresponding author: Keiji Nagata, keiji_nagata@hotmail.com

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However, the Spinal Mouse can only assess thoracic kyphosis and lumbar lordosis (LL); thus, it cannot evaluate cervical and pelvic sagittal alignment. Currently, evidence from epidemiological studies has not clarified an association between NSP and total sagittal spinal/spino-pelvic parameters using whole spine radiographic assessment. The aim of this observational cohort study was to examine if specific patterns of total spinal and sagittal spino-pelvic alignment are more prevalent in NSP in healthy participants.

Methods

Participants

A total of 136 healthy participants (mean age, 63.7 years) were included in this survey from listings of resident registrations in the town of Katsuragi and the city of Hashimoto, Wakayama, Japan (the Kihoku region). The criteria for inclusion were as follows: (1) age 40 years or older at the time of evaluation, (2) no contraindication for radiographic exposure (e.g., pregnancy and tumor), and (3) no assessment at a medical facility for a neck complaint or treatment at an osteopathic institute in the previous year. All study participants provided informed consent, and the study was reviewed and approved by the appropriate ethics review boards. Among the 136 participants, those who could not undergo radiography were excluded. In total, 107 participants (mean age, 64.5 years) who underwent whole spine radiographs were included in this study. Anthropometric measurements, including height (cm), body weight (kg), and body mass index (BMI, kg/m²) were recorded for each participant. The items studied were: 1) the existence or lack of NSP and their severity (using VAS scale), 2) Short Form-36 (SF-36), 3) 6 items assessing masked depression (Self-Rating Questionnaire for Depression [SRQ-D]), 4) catastrophic thoughts and feelings about pain (Pain Catastrophizing Scale [PCS]), 5) a detailed history consisting of 5 domains as being relevant to the psychosocial situation of patients with chronic pain: work (stress, interpersonal relations, and satisfaction); family (support); sleep (falling asleep, wakefulness, and use of sleep aids), mental health (depression and anxiety); and pain-related quality of life (QoL; effects of pain on daily life and social life) reported by Nikaido et al¹⁰. The VAS ranges from 0 to 100 mm, with higher scores indicating more severe symptoms. This has proved to be a valid index of experimental, clinical, and chronic pain¹¹. For the mental health and pain-related QoL domains, subscales already developed for the Medical Outcomes SF-36 were used¹². The SF-36 measures 8 concepts: general health (GH), physical function (PF), role physical (RP), bodily pain (BP), vitality (VT), social function (SF), mental health (MH), and role emotional (RE). The SRQ-D includes many questions concerning depression-related physical symptoms and is suitable for evaluating masked depression. The SRQ-D score ranges from 0 to 36, with higher scores indicating higher severity. A score of 10 points or

less could be regarded as being in the normal range, a score of 10 to 15 being suggestive of the depression, and a score of 16 points or more indicating the probable presence of mild depression¹³. The SRQ-D has been found to have reliability and validity^{14,15}. The PCS score ranges from 0 to 52, with higher scores indicating more frequent catastrophizing when experiencing pain. The PCS has been shown to have sufficient internal reliability, including the Japanese version¹⁶.

Radiological measurements

Participants were asked to maintain a horizontal gaze in a relaxed standing position during the radiological examination, which consisted of neural lateral radiography of the cervical spine. Radiographic measures of the cervical spine were as follows (Fig. 1)¹⁷⁻¹⁹: cervical lordosis (CL), C2-C7 tilt, the distance from C2 to C7, T1 tilt, the distance from C1 to C7, and the atlantoaxial angle (AAA) were obtained. All participants also underwent lateral radiography with their neck in the neutral position. These radiographic views were obtained with a 1.5-m distance between the vacuum tube and the radiograph for all participants. Whole spine lateral plain radiographs were also performed. Radiograph measures were as follows: thoracic kyphosis (TK, T1-12), the angle of LL, pelvic incidence (PI), pelvic tilt (PT), sacral slope (SS), and the C7 cervical sagittal vertical axis (SVA) were obtained (Fig. 2)²⁰⁻²². Whole spine lateral radiographs were taken in a standing position, in which the participant's elbows were fixed with fists resting on the clavicles. All images were transferred to a computer as Digital Imaging and Communications in Medicine (DICOM) data.

Definition of NSP

NSP was defined as the symptoms of muscle stiffness, tension, pressure, or dull pain extending from the neck to the scapular arch^{23,24}. A schematic drawing showing the localization of NSP is presented in Fig. 3. NSP data for each participant were collected according to the definition of the Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ)²⁵.

Statistical Analysis

Univariate analysis (Mann-Whitney U test) was used to compare characteristics between men and women. Association of SF-36, SRQ-D, and PCS with NSP strength was assessed using multiple regression analysis. Participants with a VAS score of 40 mm or higher and less than 40 mm were classified as the groups A (severe NSP) and B (mild or nil NSP), respectively, as described previously^{26,27}. Univariate analysis (Mann-Whitney U test) was used to analyze the 2 groups in terms of the presence or absence of NSP and the aforementioned variables. Radiographic parameters were compared between groups A and B. In addition, in order to determine the association of the detailed history and each radiographic parameter with NSP, logistic regression analysis was used after overall adjustment for age, sex, BMI, and

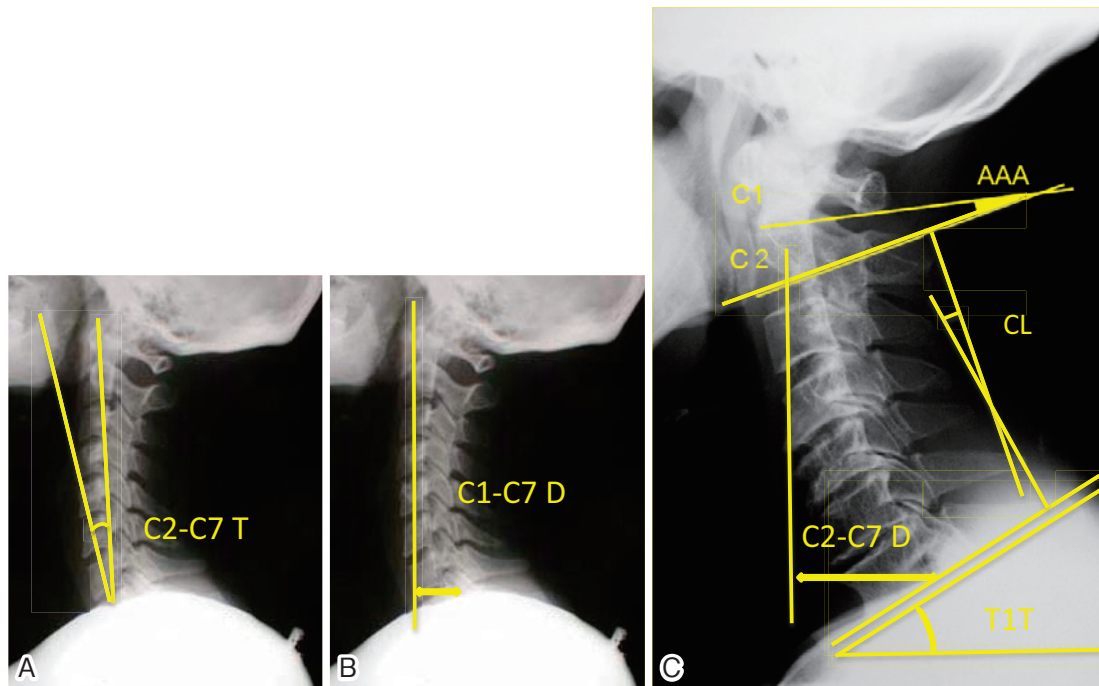


Figure 1. (A), (B), and (C) depict the measurement of the various cervical spine parameters discussed in this manuscript.

(A) C2-7 tilt: the angle from centroid of C2 to lower end of C7, to perpendicular line of C7 lower end.

(B) C1-7 distance: the distance from the posterior superior corner of C7 to the plumb line from the C1 anterior arch.

(C) Atlantoaxial angle (AAA): measured by the angle subtended between a line connecting the inferior edges of the posterior and anterior arches of C1 and the inferior endplate of C2.

C2-7 distance: the distance from the posterior, superior corner of C7 to the plumb line from the centroid of C2.

Cervical lordosis (CL): the angle subtended by lines drawn along the posterior vertebral bodies of C2 and C7.

T1 tilt: the angle from the horizontal to the upper end, plate of the T1 vertebra.

other significant variables. All statistical tests were performed at a significance level of 0.05 (two-sided) and were not adjusted for multiple testing. Data analyses were performed using JMP version 8 (SAS Institute Inc., NC). To evaluate the interclass coefficients of the parameters, 30 randomly selected radiographs were measured by the same observer at more than 1 month after the first reading. Thirty other radiographs were also scored by 2 experienced radiographic technologists (KN and MN) using the same atlas for interclass coefficients. The 12 estimated intraclass coefficients were in the high range (ICCs > 0.80) and the interclass coefficients were higher than 0.84.

Results

Characteristics of the participants

The characteristics of the participants, including data for anthropometric measurements, are shown in Table 1. The participants' heights were 167.8 ± 5.3 cm for men and 154.2 ± 6.2 cm for women. The participants' weights were 66.7 ± 9.4 kg in men and 54.5 ± 9.0 kg in women. The mean VAS for NSP was not significantly higher in women (28.2 ± 27.5) than in men (18.7 ± 23.5). The severe NSP

(group A) was observed in 31 participants (29%). There were 31 individuals in group A (men:women = 8:23) and 76 in group B (men:women = 43:33) ($p = 0.09$). In SF-36 category, PF and RP were significantly higher in men than in women, while not BP, GH, VT, SF, RE, and MH. There was no association of SRQ-D and PCS with NSP in men and women.

Association of SF36, SRQ-D, and PCS with NSP

Table 2 shows that association of SF36, SRQ-D, and PCS with NSP using multiple regression analysis after adjustment for age, sex, BMI, and all other explanatory variables. NSP was significantly associated with decreased BP, but not with PF, RP, GH, VT, SF, RE, and MH. SRQ-D was significantly associated with NSP, while PCS was not.

Factors associated with NSP

A VAS of pain and numbness to the arm ($p < 0.001$) and a VAS of pain and numbness from thoracic region to legs ($p < 0.001$) were significantly associated with NSP (Table 3). NSP was significantly associated with reduced extension and right rotation of the cervical spine (Fig. 4). In terms of lifestyle, family stress (41% for individuals with NSP vs. 18% for individuals without NSP) and waking up in the middle

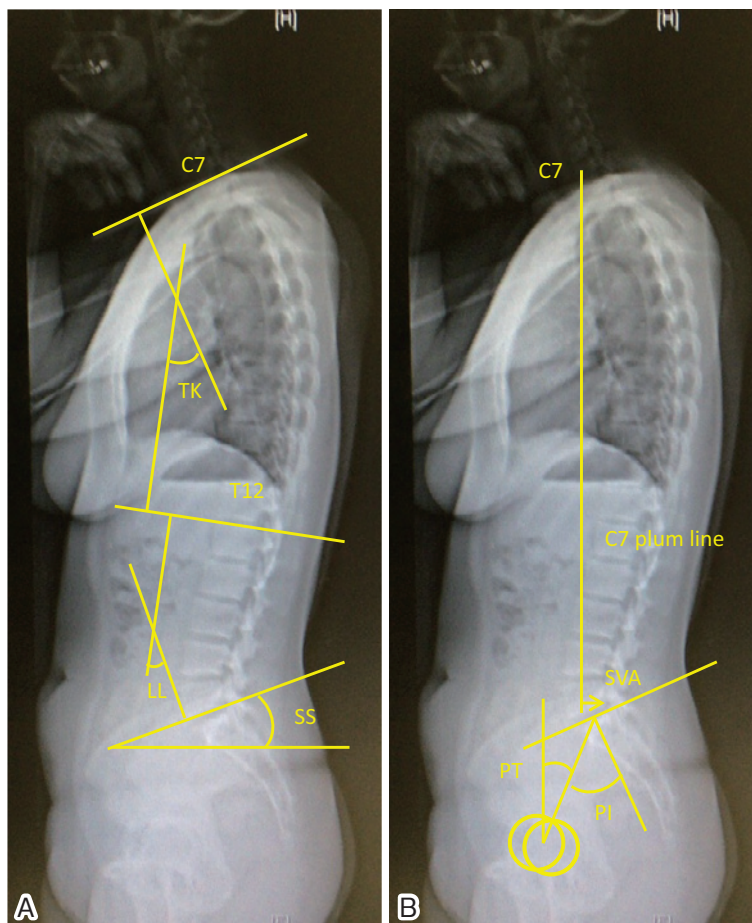


Figure 2. (A) and (B) depict the measurement of the various spino-pelvic parameters discussed in the manuscript.

(A) Thoracic kyphosis (TK): the angle subtended by lines drawn along the posterior vertebral bodies of T1 and T12.

Lumbar lordosis (LL): the angle from the upper endplate of L1 to the upper end plate of S1.

Sacral slope (SS): the angle between the superior endplate of S1 and a horizontal axis.

(B) C7 sagittal vertical axis (SVA): defined as the horizontal distance between the C7 plumb line and the posterior superior corner of the superior margin of S1.

Pelvic tilt (PT): the angle between the line connecting the midpoint of the sacral plate to the axis of the femoral heads and the vertical axis.

Pelvic incidence (PI): the angle between the perpendicular to the sacral plate at its midpoint and the line connecting the point to the middle axis of the femoral heads.

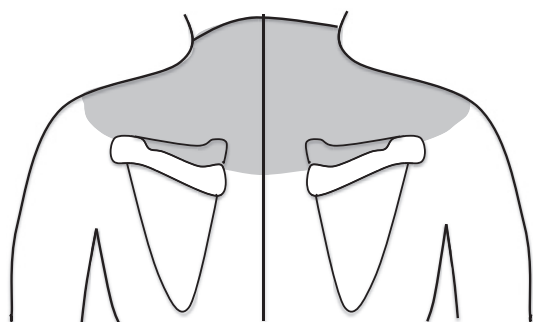


Figure 3. The defined area of neck shoulder pain.

of the night (48% vs. 26%) were significantly associated with NSP.

Differences of sagittal spine parameters between groups A and B

There were no statistically significant correlations between NSP and radiographic parameters of the cervical spine (Table 4). Among whole spine sagittal parameters, sacral slope (group A: 30.7 ± 5.3 , group B: 26.1 ± 10.4 ; $p = 0.0078$) and SVA (group A: -0.85 ± 20.7 , group B: 18.0 ± 30.8 ; $p = 0.0035$) were significantly associated between the

Table 1. Characteristics of Men and Women Participating in the Present Study.

	Men	Women
N	41	66
Age	64.4±9.4	64.5±7.9
Height, cm	167.8±5.3*	154.2±6.2
Weight, kg	66.7±9.4*	54.5±9.0
Body mass index, kg/m ²	23.6±2.6	22.8±3.1
Visual analog scale for neck shoulder pain, mm	18.7±23.5	28.2±27.5
SF-36		
Physical function	90.4±12.8*	84.8±16.6
Role physical	93.8±13.5*	86.6±17.4
Bodily pain	77.5±20.9	71.7±19.8
General health	67.0±15.4	62.8±14.0
Vitality	72.0±14.9	64.7±19.7
Social function	94.5±11.2	89.8±16.8
Role emotional	93.1±13.4	87.9±19.0
Mental health	79.4±12.5	77.0±16.3
SRQ-D	5.8±3.0	6.0±3.0
PCS		
Rumination	8.4±6.6	8.9±5.8
Helplessness	4.7±4.8	4.4±4.6
Magnification	2.9±2.8	3.3±3.1

Significantly different from women by Mann–Whitney U test (*p<0.05).

Values are the mean±standard deviation (SD). N=number

Table 2. Association of SF36, SRQ-D and PCS with NSP Strength.

	Beta	p value
SF-36		
Physical function	0.11	0.40
Role physical	-0.05	0.75
Bodily pain	-2.0	0.038
General health	0.09	0.37
Vitality	-0.20	0.14
Social function	-0.10	0.36
Role emotional	0.12	0.43
Mental health	-0.07	0.33
SRQ-D	0.38	0.0006
PCS		
Rumination	0.002	0.11
Helplessness	0.11	0.43
Magnification	-0.012	0.92

NSP, neck and shoulder pain; SF-36, Short-Form 36; SRQ-D, Self-Rating Questionnaire for Depression; PCS, Pain Catastrophizing Scale

Beta values are shown using multiple regression analysis after adjustment for age, sex, BMI, and all other variables.

2 groups (Table 4). On sub-analysis, Pearson's correlation coefficient revealed that sacral slope was significantly associated with LL ($r = 0.31$, $p = 0.002$) and pelvic tilt ($r = -0.35$, $p = 0.0002$).

Factors associated with NSP using logistic regression analysis

In addition, logistic regression analysis was used to estimate the association of meaningful items with NSP after adjustment for age, gender, BMI, and other significant variables. As an overall result, a VAS of pain and numbness to the arm, a VAS of pain and numbness from thoracic region to legs, family stress, a large SS, and reduced SVA were significantly associated with NSP (Table 5).

Discussion

Altogether, our results demonstrate that NSP is significantly associated with family stress, as well as pain and numbness in the arm and thoracic region to the legs. QoL and psychological assessments were significantly associated with NSP. A relationship between NSP and back pain or pain in the upper limbs has been previously reported^{24,28}. In particular, Takasawa et al showed that pain in the upper extremities was independently associated with NSP. In our study, we also showed that NSP was associated with pain in other parts of the body. However, the mechanism underlying this relationship remains unclear. Pain symptoms may be caused by systemic disease such as fibromyalgia, which is characterized by widespread musculoskeletal pain, as well as fatigue and sleep, memory, and mood issues²⁹. In our study, we also found an association between NSP and family stress, bodily pain, and SRQ-D. Psychological stress, including systemic disease, may also trigger NSP. However, we were unable to further characterize the causal relationship

Table 3. Factors Associated with NSP.

	Group A (Severe NSP)	Group B (Mild or nil NSP)	p value
A VAS of pain and numbness to the arm	23.9±25.3	6.6±12.6	<0.001
A VAS of pain and numbness from thoracic to legs	24.5±26.8	7.5±11.9	<0.001
<i>Work</i>			
Are you satisfied with your work environment?	52	46	0.86
Are you satisfied with your work?	61	77	0.22
Are you satisfied with your interpersonal relations at work?	70	61	0.21
Do you enjoy your job?	73	78	0.8
Are you satisfied with your income?	50	31	0.24
Can you yourself decide the order or procedure of your work?	81	70	0.63
Have you ever taken a day off of work because of pain?	27	22	0.79
<i>Family</i>			
Do family problems cause you stress?	41	18	0.015
Do you enjoy spending time with your family?	90	97	0.12
Does anyone in your family require nursing care?	10	13	0.73
Does anyone else in your family suffer from the same type of pain that you have?	30	16	0.23
<i>Sleep</i>			
Do you often have difficulty falling asleep?	33	26	0.56
Do you often wake up early and have difficulty falling back asleep?	29	27	0.88
Do you often wake up in the middle of the night?	48	26	0.027
Do you use sleep aids?	19	8	0.088

Significantly different by Mann-Whitney U test. NSP, neck and shoulder pain

For categorical data, Pearson correlation coefficient was used.

Values are the mean±standard deviation (SD). Otherwise, values are percentage of each group.

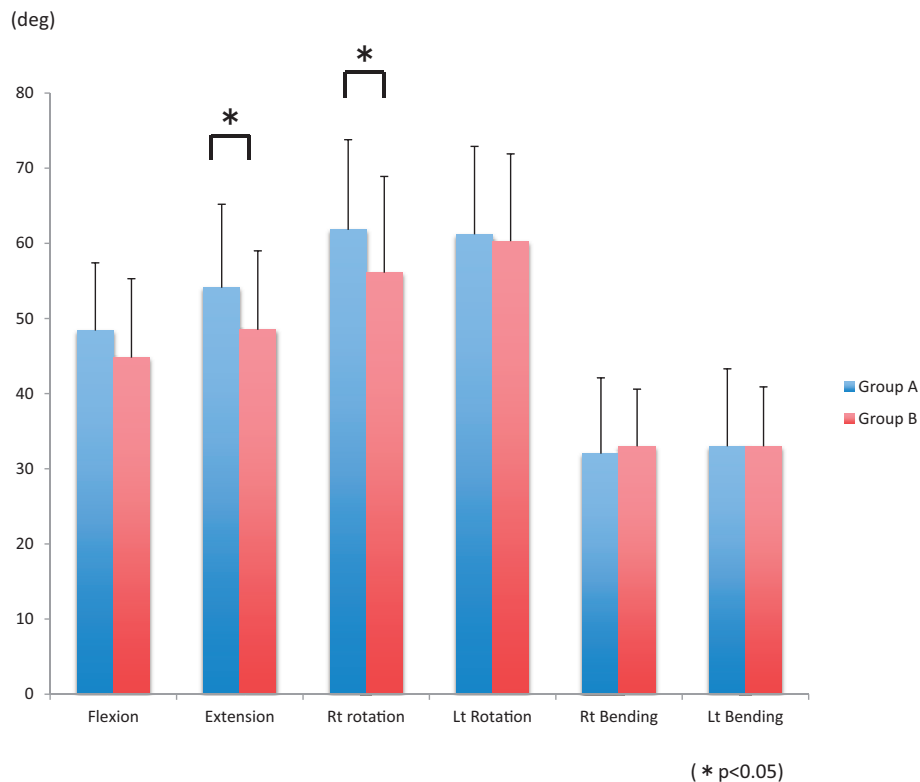


Figure 4. The association between NSP and cervical ROM.

between NSP and SRQ-D because of the cross-sectional design of our study.

To our knowledge, this is the first study to investigate the association between NSP and spino-pelvic alignment using

whole spine radiographs in healthy participants. We identified a significant association between NSP, and pelvis anteversion and reduced SVA; cervical spine and thoracic parameters were not significantly associated with NSP, however. Although the pathogenesis and mechanisms of NSP have not been elucidated, previous studies have identified factors associated with NSP^{1,3,4,7-9,23,30-32}. Associations between NSP and sagittal spinal alignment have yet to be adequately elucidated. Furthermore, Okada et al.³⁰ concluded that there was no correlation between stiff shoulders and sagittal alignment of the cervical spine. Tsunoda et al.⁹ reported that NSP was not associated with thoracic kyphosis. In our study, we also found that NSP was not associated with either cervical or thoracic sagittal alignment. Our data support previous reports pertaining to cervical and thoracic sagittal alignment. Conversely, Straker et al.³¹ and Tsunoda et

al.⁹ reported that lordosis angles were significantly larger in the NSP group than in the non-NSP group. Straker et al.³¹ determined that sagittal alignment via the photographic analysis of visual markers placed on bony landmarks, whereas Tsunoda et al.⁹ measured sagittal alignment using the Spinal Mouse. However, neither of these studies evaluated precise sagittal parameters from the cervical spine to the pelvis. To our knowledge, our study is the first to investigate the specific association between NSP and SS in healthy volunteers. In addition, SS was correlated with LL, which was expected, because LL may result from large SS that causes pelvic anteversion. Although pelvic angle anteversion can alter the alignment of the body trunk, we did not observe a shift of SVA in participants with NSP. This might show that the increased sacral slope could produce back and neck stress to maintain SVA in the upright posture. However, the causal relationship remains unclear as this was a cross-sectional study. Further longitudinal study will be needed to confirm causality.

Table 4. Association between NSP and Spine Parameters on Radiograph.

	Group A (Severe NSP)	Group B (Mild or nil NSP)	p value
Age	62.5±9.0	65.3±8.2	0.13
Gender (male/female)	8/23	33/43	0.09
<i>Cervical Spine</i>			
Cervical lordosis (°)	9.8±8.5	12.3±9.8	0.23
C2–C7 tilt (°)	-6.6±6.1	-8.0±7.1	0.37
C2–C7 distance (mm)	6.0±15.1	6.9±18.3	0.80
T1 tilt (°)	23.4±7.3	25.2±7.1	0.25
C1–C7 distance (mm)	-3.1±11.8	-1.8±11.6	0.60
Atlantoaxial angle (°)	29.3±7.8	27.6±6.0	0.23
<i>Whole Spine</i>			
Thoracic kyphosis (°)	38.6±10.2	38.0±9.6	0.66
Lumbar lordosis (°)	43.7±8.4	40.0±11.7	0.14
Pelvic incidence (°)	48.6±7.5	47.0±10.1	0.71
Pelvic tilt (°)	17.8±7.0	21.0±8.0	0.12
Sacral slope (°)	30.7±5.3	26.1±10.4	0.0078
C7 SVA (mm)	-0.85±20.7	18.0±30.8	0.0035

Significantly different by Mann–Whitney U test. NSP, neck and shoulder pain; SVA, sagittal vertical axis
Values are the mean±standard deviation (SD).

The results of our study will also help to better understand the relationship between sagittal alignment and NSP. Whole spine sagittal alignment can be further used to assess patients with NSP, identify problematic neck issues, and help tailor specific neck treatments.

Study limitations

We acknowledge that the study has several limitations. First, we were unable to determine whether family stress, pain in other sites, and masked depression represent specific risk for NSP. The causal relationship between radiographic parameters and NSP could also not be characterized further, because of the cross-sectional design of our study. Second, this study only included participants who were aged above 40 years. Peak age of NSP was reported to be 30-40 years in women. Therefore, age above 40 years is not appropriate when examining the healthy population²³. Degenerative features, such as osteoarthritis, should also be taken into consideration. Consequently, these results cannot be generalized to all age groups, because our study may have incurred selection bias in favor of relatively healthy participants.

Table 5. Factors Association with NSP Using Logistic Regression Analysis.

	OR	95% CI	p value
A VAS of pain and numbness to the arm (+10 mm)	1.95	1.14–4.21	0.036
A VAS of pain and numbness from thoracic to legs (+10 mm)	1.88	1.19–3.38	0.015
Extension of cervical spine (+1 degree)	0.94	0.86–1.00	0.090
Right rotation of cervical spine (+1 degree)	0.97	0.91–1.02	0.25
Family stress (vs. no)	5.8	1.21–34.4	0.027
Wake up in the middle of night (vs. no)	1.6	0.30–8.6	0.57
Sacral slope, degree (+1 degree)	1.20	1.07–1.41	0.0009
C7 SVA, mm (+1 mm)	0.96	0.91–0.99	0.024

OR, odds ratio; CI, confidence interval; N, number; NSP, neck and shoulder pain; SVA, sagittal vertical axis

†OR was calculated by multiple logistic regression analysis after adjustment for age, sex, BMI, and other significant variables.

Conclusion

In this study, we showed that NSP was significantly associated with family stress, as well as pain and numbness to the arm and from the thoracic region to the legs. BP and SRQ-D were significantly associated with NSP. Furthermore, to the best of our knowledge, this is the first study to investigate the specific association between NSP and spino-pelvic alignment in healthy participants. Our data revealed that a large SS and reduced SVA were significantly associated with NSP. However, cervical spine measurements were not significantly associated with NSP. Collectively, these results suggest that NSP is caused by an anterior pelvic tilt from compensatory musculoskeletal changes to maintain an upright posture.

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Author Contributions: Mamoru Kawakami designed the study. Keiji Nagata wrote the initial draft of the manuscript and contributed to analysis and interpretation of data. All other authors have contributed to data collection and interpretation, and critically reviewed the manuscript. All authors approved the final version of the manuscript, and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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