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ORIGINAL ARTICLE

Dentists have a high occupational risk of neck disorders with impact on somatosensory function and neck mobility

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Abstract

Objectives: Musculoskeletal disorders (MSDs) in the neck and shoulder region may be associated with significant impairment of quality of life and well-being. The study was to determine the prevalence of painful MSDs in Chinese dentists and evaluate somatosensory function and neck mobility compared with non-dental professional controls.

Methods: One hundred dentists (age: 36.5 ± 9.8 years) and 102 controls (age: 36.2 ± 10.0 years) were recruited between September 2019 and December 2020. The Medical Outcome Study 36-item short-form health survey questionnaire and information of MSDs history were recorded. The cervical range of motion (CROM) with and without pain, and the pressure pain thresholds (PPTs) of the facial and neck muscles were tested. Chi-square test, Mann-Whitney U test and multiple linear regression analysis were used to analyze the data. The factors in the multiple linear regression analysis were occupation, working age, and gender.

Results: The prevalence rate of neck pain was significantly higher in dentists (73.0%) compared with the controls (52.0%) ($P = .002$). The regression models of cervical range of posterior extension, lateral flexion and rotation were statistically significant ($P \leq .001$). The regression models of PPTs of the tested facial and neck muscles were statistically significant ($P < .001$).

Conclusion: Dentists are at higher risk of neck pain. The bigger cervical range of left rotation of dentists could be related to the working posture. The lower PPTs in dentists may reflect a hypersensitivity in the facial and neck muscles. Preventive measures are needed to reduce occupational hazards in dentists.

KEYWORDS
dentists, musculoskeletal disorders, neck pain, pain threshold, range of motion

Yanli Zhou and Weina Zhou have contributed equally to the study and co-first authors.

1 | INTRODUCTION

Musculoskeletal disorders (MSDs) are typically characterized by pain and limited function of muscles, bones, and joints, which reduces the ability to work and participate in social life, and has profound implications on psychological status and quality of life.[1,2] According to the 2019 WHO report, MSDs are the leading cause of disability in humans, and it is common not only in the elderly but also in all age ranges.

The prevalence of MSDs was 51.9% in the neck, 33.2% in the shoulder, 33.4% in the chest, 33.7% in the wrist or hand, and 37.3% in the lower back on the basis of reports from 23 studies involving 2,531 Iranian dentists.[3] It was reported that the most common sites of reported MSDs were the neck (59%), lower back (57%), and shoulders (45%)[4] based on the study of 750 dentists in New Zealand in 2008. Also, there were 88% of Chinese dentists who reported at least one MSDs and 83.8% of them suffered from neck pain.[5] According to an Australian study of 285 dentists, more than one third of dentists had received treatment or medical care for MSDs in the past year.[6] It was reported that about 10% of dentists ask for sick leave (an average of 11.5 days per year) or leave their jobs due to MSDs.[6] The above studies suggested that dentists have a high prevalence of neck disorders,[7] which, in its later stages, may seriously interfere with their regular work, social activities, and quality of life.

The MSDs can be evoked by non-ergonomic working postures eg keeping the head rotation, neck bending, shoulder, upper arm abduction,[8] repetitive, constant, and high-intensity static loads on muscles and joints.[9] Besides, psychosocial risk factors and personal characteristics may increase the risk of MSDs. Neck pain and motor dysfunction are usual symptoms of occupational MSDs,[10] which are the leading causes of disability and dysfunction and interfere with the work and life of dentists.[11]

In previous studies, the cervical range of motion (CROM) was used as a primary index for understanding cervical function, and could help to evaluate and monitor the functional status of the neck.[12] It has also been demonstrated that the pressure pain threshold (PPT) test is useful to detect sensitization of deep tissues,[13] and could be used as an indicator for somatosensory dysfunction.[14] Moreover, the reliability, consistency, and repeatability of CROM and PPTs in maxillofacial applications are promising.[15-17]

In the present study, an advanced CROM device and PPT were used to evaluate neck mobility and somatosensory function in dentists and non-dental controls. The purpose of the study was to investigate the prevalence of painful MSD and evaluate the somatosensory function and neck mobility in dentists in comparison with non-dental professional controls.

2 | MATERIALS AND METHODS

2.1 | Study participants

One hundred dentists and 102 controls participated in this comparative cross-sectional study between September 2019 and December 2020 (Figure 1). The inclusion criteria for dentists were as follows: age from 22 to 60 years old, full time working dentists at the forefront of clinical practice for more than half a year, daily working more than 6 hours per day, and 3 days per week. The inclusion criteria for controls were office workers (including accountants, clerks, network managements), age from 22 to 60 years old, full time workers for more than half a year, daily working more than 6 hours per day, and 3 days per week. In order to match the dental group and the control group in terms of age and gender, we included participants in three subgroups according to working age (subgroup A: 1-7 years, subgroup B: 8-14 years, subgroup C: over 14 years).

The exclusion criteria for both groups were: currently suffering any kind of orofacial pain (eg burning mouth syndrome, trigeminal neuralgia, temporomandibular disorders), received treatment related to sports medicine within the last 6 months; experience of surgery or trauma within the last 6 months; mental or psychological conditions or conditions that affect the nervous system or circulatory system, neurological and painful disorders (eg fibromyalgia). Physical labor workers were also excluded from the controls.

2.2 | Study protocol

All participants were requested to fill out personal information. The Medical Outcome Study 36-item short-form (SF-36) health survey questionnaire, intensity and frequency of pain were recorded. The CROM and PPTs of the facial and neck muscles were recorded. All examiners were professionally trained before the experiment and all the instruments were calibrated.

Participants were informed about the experimental procedure and assured that they could leave the study at any time. The Ethics Committee of the State of the Affiliated Stomatology Hospital of Nanjing Medical University approved the study protocol (PJ2019-006-01).

The Chinese version of the SF-36 health survey questionnaire was used. The short self-administrative health questionnaire is spanning eight dimensions: physical function, role physical, bodily pain, general health, vitality, social function, role-emotion and mental health. The SF-36 is a vital outcome measurement tool for health service research and clinical trials, especially for chronic diseases. The Chinese version of the SF-36 questionnaire has produced similar findings concerning reliability, convergent, and discriminant validity tests.[18,19]
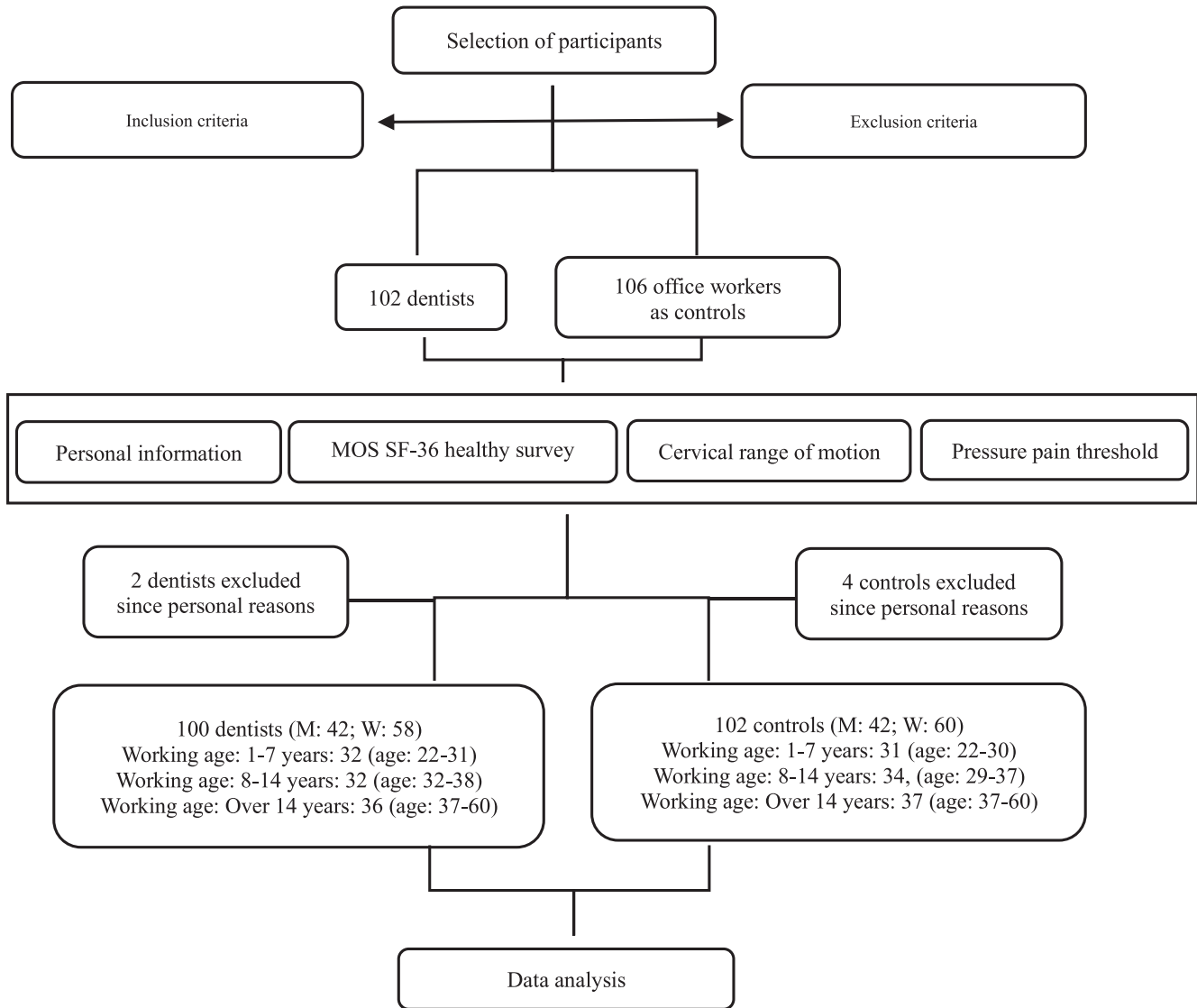
FIGURE 1 Selection process of participants

All participants filled in the necessary information: height, weight, age, gender, occupation, dominant hand, working age, working days per month, working hours per day, cell phone time per day, etc. Some musculoskeletal pains in the past year were recorded, such as headache, neck pain, shoulder pain, lower back pain, and pain area was drawn on paper with a body image and the frequency of pain per month (range from 0 to 30) was recorded, and the intensity of pain was assessed by a numeric rating scale (NRS). The NRS was rate from 0 to 10, where 0 represents no pain, and 10 represents the worst imaginable pain.[20]

The head movement was recorded in 3 directions: sagittal plane, coronal plane, and lateral rotations with the CROM device (Performance Attainment Associates, Roseville, MN, USA) (Appendix Figure S1A), which consists of three fluid-dampened inclinometers secured to a lightweight, plastic frame. The frame fitted on the head like glasses and was secured using hook-and-loop fastening straps. The participants were asked to sit vertically with their eyes parallel to the external auditory canal in the same quiet room. The instrument was attached to the head, and the dial was perpendicular to the ground. The participant´s shoulders were fixed to keep their bodies still, and they were asked to perform anterior flexion and posterior extension on the sagittal plane, left lateral flexion and right lateral flexion on the coronal plane. Then participants wore a magnetic field ring around the neck with the pointer parallel to the field while keeping the upper body still and performed left rotation and right rotation on a horizontal plane.[21] The participants were asked to do the maximum pain-free range of motion and repeated each motion three times with 10 seconds intervals. The CROM was recorded during movement without pain, as well as CROM with pain.

A handheld pressure algometer (Algometer, MEDOC, Israel) (Appendix Figure S1B) was used to measure the PPTs at the right and left anterior portion of temporal muscles, the superficial layer of masseter muscles, sternocleidomastoid muscles, upper trapezius muscles and middle trapezius muscles. When measuring the maxillofacial and neck region, the probe with an area of 1.0 cm^2 was perpendicular to the inspection site, and the measurement rate was set to 30 kPa/s. The participants were instructed to press a switch connected to a computer, once a painless sensation changed to a barely painful sensation, which was defined as the pain threshold rather than the pain tolerance level. Participants were also told that their attention should be focused on the test stimulus because a change in attention has been shown to affect sensitivity and neural responses to peripheral afferent inputs.[22] The applied pressure was shown on a digital display. Each test point was measured three times with an interval of 1 min and the average was used for further statistical analyses.

2.3 │ Data analysis

The Statistical Package for Social Sciences (SPSS 24.0) software was used for statistical analysis. The quantitative data (eg age, working hours, NRS, the results of the SF-36 questionnaire, PPT, CROM) was presented as mean ± standard deviation. Gender and the prevalence rate of pain were presented as absolute (number), and relative frequency (percentage). Before performing the inferential analysis, all quantitative variables were assessed for normal distribution using the Kolmogorov–Smirnov test. The Mann-Whitney U test was used to analyze the difference of non-normally distributed data (such as personal information, the frequency and intensity of pain, the results of the SF-36 questionnaire). A Chi-square test was used to analyze the qualitative data (such as prevalence rate of pain). A multiple linear regression analysis was used to analyze the different outcome parameters of the PPTs and CROM. The factors in the multiple linear regression analysis were occupation (2 levels: dentists and controls), working age, and gender (2 levels: men and women). The difference between the CROM with pain and CROM without pain was analyzed with the paired t-test. $P < .05$ were considered as statistically significant.

3 │ RESULTS

Two hundred eight eligible participants were evaluated, of whom two dentists and four controls did not complete the study for personal reasons. Finally, the study included 100 dentists (age: 22-60 years with mean: 36.5 ± 9.8 years, men: 42, women: 58) and 102 controls (age: 22-60 years with mean: 36.2 ± 10.0 years, men: 42, women: 60). Regarding

to the working age, 32 dentists and 31 controls were in subgroup A; 32 dentists and 34 controls were in subgroup B; 36 dentists and 37 controls were in subgroup C. The demographic and clinical characteristics are summarized in Tables 1 and 2. There were no significant differences in age, gender, body mass index, and working age between the two groups ($P \geq .484$). Self-reported working hours per day and per month, cell phone time were smaller in dentists compared with controls ($P \leq .041$). However, the prevalence rate of neck pain in the dentists (73.0%) was significantly higher than in the controls (52.0%) ($P = .002$). There were no significant differences in the intensity and frequency of neck pain between the groups ($P \geq .628$). There were no differences between the two groups in terms of prevalence rate, intensity and frequency of headache, shoulder pain and back pain.

3.1 │ SF-36 questionnaire

The overall index of the SF-36 questionnaire demonstrated no difference between the dentists and controls ($P = .909$) and none of the eight dimensions revealed any significant difference between the groups (Appendix Table S1).

3.2 │ CROM

The multiple linear regression analysis was used to analyze the influence of occupation, working age, and gender on CROM (Table 3). The controls were taken as the reference

TABLE 1 Descriptive information

	Dentists	Controls	P
Gender			
Men	42 (42.0%)	42 (41.2%)	
Woman	58 (58.0%)	60 (58.8%)	.905
Working age (y)			
1-7	32(32%)	31(30.4%)	
8-14	32(32%)	34(33.3%)	
Over 14	36(36%)	37(36.3%)	.965
Age (y)	36.5 ± 9.8	36.2 ± 10.0	.507
BMI	23.0 ± 3.2	22.8 ± 3.5	.484
Working days (d/mon)	21.8 ± 2.9	22.4 ± 2.5	**.041**
Working hours (h/d)	7.9 ± 0.8	8.3 ± 1.1	**.004**
Working age (y)	13.4 ± 10.0	14.2 ± 10.0	.798
Cell phone time (h/d)	2.8 ± 1.3	3.8 ± 2.6	**.009**

Abbreviation: BMI, body mass index.

Bold indicates statistically significant values.

TABLE 2 Descriptive data for musculoskeletal disorders

	Dentists	Controls	*P*
Prevalence rate			
Head pain	33 (33.0%)	40 (39.2%)	.358
Neck pain	73 (73.0%)	53 (52.0%)	**.002**
Shoulder pain	60 (60.0%)	54 (52.9%)	.312
Back pain	46 (46.0%)	51 (50.0%)	.569
Intensity (0-10)			
Head pain	3.4 ± 1.3	3.6 ± 1.8	.631
Neck pain	3.3 ± 1.4	3.5 ± 1.6	.628
Shoulder pain	3.3 ± 1.4	3.8 ± 1.6	.095
Back pain	3.7 ± 1.7	3.8 ± 1.8	.839
Frequency (0-30)			
Head pain	4.0 ± 5.1	5.2 ± 6.9	.705
Neck pain	5.9 ± 6.8	7.4 ± 8.8	.849
Shoulder pain	6.4 ± 7.6	7.7 ± 7.8	.292
Back pain	8.1 ± 8.4	8.0 ± 8.2	.864

in terms of the occupation and women were the reference in terms of the gender. The linear relationships between independent variables (occupation, working age, gender) and CROM were shown by drawing partial regression scatter plots and studentized scatter plots of residuals and predicted values. The homogeneities of the variance of the residuals were verified by drawing a scatter plot between the studentized residuals and the unstandardized predicted values. The tolerances of regression were greater than 0.1, and there were no multicollinearities. The P-P graph showed an approximate normal distribution of residuals.

The regression models of painless cervical range of extension, lateral flexion and rotation were statistically significant (F ≥ 6.224, $P \leq .001$, adjust $R^2 \geq 0.072$). The influence of occupation could only be demonstrated on the cervical range of left rotation ($P = .009$). The influence of working age on the cervical range of posterior extension, lateral flexion and right rotation was statistically significant ($P \leq .040$). Men showed smaller cervical range of left lateral flexion and rotation than women ($P \leq .041$).

The regression models of painful cervical range of extension, lateral flexion and rotation were statistically significant (F ≥ 8.106, $P < .001$, adjust $R^2 \geq 0.096$). Compared with the control group, the dentists showed greater cervical range of left rotation ($P = .001$). Among the three independent variables included in the study, the influence of working age on the cervical range of posterior extension, lateral flexion and right rotation was statistically significant ($P \leq .033$). Men showed smaller cervical range of extension, lateral flexion and rotation than women ($P \leq .028$).

The paired-samples T test was used to analyze the difference between the CROM with pain and without pain.

The CROM without pain were significantly greater than the CROM with pain in all directions ($P < .001$) (Appendix Table S2).

3.3 | PPT

The PPTs of the tested muscles were converted into normal distributions by log10 transformation. The multiple linear regression analysis was again used to analyze the influence of occupation, working age and gender on PPTs (Table 4).

The regression models of PPTs of the tested facial and neck muscles were statistically significant (F ≥ 20.742, $P < .001$, adjust $R^2 \geq 0.228$). The PPTs of the tested muscles in dentists were lower than those in the control group ($P \leq .044$). The influence of the three independent variables included in the model on PPTs were statistically significant. With the increase of working age, PPTs gradually increased ($P \leq .001$) and men had higher PPTs of the tested muscles than women ($P < .001$).

4 | DISCUSSION

In general, the health status of the dentists was not different from the controls. However, the prevalence rate of neck pain was high among dentists in China. Dentists had a greater range of left rotation compared with the controls, and showed reduced range of bilateral flexion, posterior extension and right rotation with increasing working age. Moreover, the PPTs of facial and neck muscles were significantly lower in dentists compared with the controls, and PPTs gradually increased with the increase of working age. Women had larger CROM and lower PPTs of the muscles compared with men.

4.1 | Study methods

A few studies covering a relatively narrow range of industries have been done in terms of MSDs, and there were few studies on the health status and neck disorders in dentists.[13] In addition, there was no unified standard definition of MSDs, and Nordic Musculoskeletal Questionnaire (NMQ) was mostly used internationally,[23] lacking objective and quantitative standards.

Although magnetic resonance imaging has been recognized as the gold standard for cervical spondylosis, it was not feasible to use imaging as an assessment tool to conduct a large-sample clinical investigation.[17] The CROM was employed to investigate the neck mobility and the PPT test was used to reflect muscle sensitivity and as a measure of somatosensory function in deep tissues. A previous study

TABLE 3 Multiple linear regression analysis for CROM

	Adjust R^2	F	P$_{model}$		Unstandardized coefficients	Standardized coefficients	P$_{coefficients}$
CROM with pain							
Anterior flexion	−0.005	0.641	.590				
Posterior extension	0.072	6.224	**<.001**	Constant	65.090 ± 3.655		
				Occupation	−0.719 ± 2.079	−0.023	.730
				Working age	−0.380 ± 0.104	−0.249	**<.001**
				Gender	−4.067 ± 2.119	−0.131	.056
Left lateral flexion	0.099	8.324	**<.001**	Constant	46.869 ± 2.059		
				Occupation	−0.600 ± 1.171	−0.034	.609
				Working age	−0.253 ± 0.059	−0.290	**<.001**
				Gender	−2.452 ± 1.194	−0.138	**.041**
Right lateral flexion	0.083	7.040	**<.001**	Constant	39.670 ± 1.998		
				Occupation	−0.776 ± 1.137	−0.046	.496
				Working age	−0.239 ± 0.057	−0.285	**<.001**
				Gender	−1.540 ± 1.159	0.090	.185
Left rotation	0.080	6.841	**<.001**	Constant	59.784 ± 2.157		
				Occupation	3.260 ± 1.227	0.180	**.009**
				Working age	−0.077 ± 0.061	−0.085	.214
				Gender	−4.151 ± 1.251	−0.226	**.001**
Right rotation	0.074	6.390	**<.001**	Constant	65.651 ± 2.257		
				Occupation	0.617 ± 1.284	0.033	.632
				Working age	−0.133 ± 0.064	−0.141	**.040**
				Gender	−4.720 ± 1.309	−0.246	**<.001**
CROM without pain							
Anterior flexion	0.019	2.280	.081				
Posterior extension	0.208	18.578	**<.001**	Constant	72.742 ± 2.515		
				Occupation	−0.632 ± 1.431	−0.028	.659
				Working age	−0.404 ± 0.072	−0.358	**<.001**
				Gender	−6.273 ± 1.458	−0.271	**<.001**
Left lateral flexion	0.124	10.495	**<.001**	Constant	47.871 ± 1.783		
				Occupation	0.093 ± 1.015	0.006	.927
				Working age	−0.222 ± 0.051	−0.290	**<.001**
				Gender	−3.181 ± 1.034	−0.204	**.002**
Right lateral flexion	0.096	8.106	**<.001**	Constant	40.839 ± 1.744		
				Occupation	−0.091 ± 0.992	−0.006	.927
				Working age	−0.207 ± 0.050	−0.281	**<.001**
				Gender	−2.237 ± 1.011	−0.149	**.028**
Left rotation	0.115	9.687	**<.001**	Constant	59.908 ± 1.938		
				Occupation	3.772 ± 1.103	0.227	**.001**
				Working age	−0.067 ± 0.055	−0.082	.223
				Gender	−4.331 ± 1.124	−0.257	**<.001**
Right rotation	0.112	9.490	**<.001**	Constant	65.611 ± 2.018		
				Occupation	1.393 ± 1.148	0.081	.226
				Working age	−0.123 ± 0.057	−0.143	**.033**
				Gender	−5.264 ± 1.170	−0.300	**<.001**

Abbreviations: CROM, cervical range of motion; P$_{model}$, Statistical significance of regression model; P$_{coefficients}$, Statistical significance of coefficients.
Bold indicates statistically significant values.

showed that recordings made with the CROM provide a reliable measure of movement directions.[21] Also, the results of studies showed overall good-to-excellent with-session and between-day reliability of PPT measurements on facial and neck muscles.[24]

4.2 | Higher risk of dentists for suffering from MSDs

According to the results of the SF-36 health survey questionnaire, there were no differences between dentists and controls. However, the study showed there was a prominently higher prevalence of neck pain over the past 12 months among the dentists compared with the controls. The neck pain mostly occurred bilaterally, and the prevalence rate was higher than headache, shoulder pain, and lower back pain. Several studies are in line with our results that neck pain is the most prevalent musculoskeletal disorders.[25] Dentists reported to use their mobile phones less and had fewer working hours than the control group, but still had significantly higher prevalence rate of neck pain, which indicated that occupational factors may contribute to the susceptibility of dentists for MSDs.[26] A Swedish survey found that dental hygienists with MSDs were more likely to be associated with long working hours.[27] Also, a French study showed that the prevalence of chronic pain was higher among dentists with 3-15 years of working.[28] Generally, it seems that insufficient training, unsuitable designing of the working facilities, lack of frequent supervision of correct ergonomic working positions, and work-related stress may lead to the adoption of unsuitable positions during work, which could be an important reason for development of MSDs.[3,7]

In order to reduce neck and trunk bending or twisting during working, corrective measures in job postures by the use of ergonomic seats and magnifying facilities are recommended. Further, implementation of ergonomic training courses and physical activity also could benefit dentists in alleviating or even preventing MSDs.[3]

4.3 | Neck mobility

The range of left rotation was significantly larger in dentists compared with the control group. One reason could be related to training and repetitive use of this particular working posture. Most dentists often adopt suboptimal postures such as cervical anteflexion, right lateral flexion, and left rotation of the head which may cause the neck muscles to overstretch. These head postures are related to the need for the dentist to allow direct visual inspection of the oral cavity of the patients during examination and dental procedures. Overstretching of skeletal muscle can initiate an increase in the serial sarcomere

number, respectively.[29] Moreover, active overstretching may trigger serial sarcomere in addition to a greater extent than passive overstretching. This increase in muscle length may have enabled an increased range of left rotation.[29]

In addition, the present results showed decreased cervical range of flexion and posterior extension, left rotation with increasing working age. This finding indicates that the decrease of CROM could be the result of an additive and long-term accumulation of exposures. These results were expected because there is ample evidence demonstrating a reduction in neck movements as the occupational working age increase and this was especially true for dentists.[30] Long-term, repeated and continuous stress concentrated on the intervertebral discs, ligaments, facet joints, muscles and other tissues,[31] can cause muscle fatigue, weakened muscle strength and cervical spine injury.[29] When the pressure reaches a specific threshold the peripheral nerves can be activated by the potentially noxious stimuli and lead to pain localized to the neck and associated with limited activity.[32] In addition, the posterior extension and lateral flexion were restricted preferentially.[33]

Previous studies have shown similar results with women having a greater CROM than men in some directions.[30] The findings may result from a variety of factors, including the anatomical structures eg, men having smaller upper cervical lordosis and greater lower cervical lordosis than women.[34] Furthermore, there remains considerable disagreement over the biological gender effects on the CROM.

4.4 | Muscle sensitivity

The PPTs in dentists were significantly lower in the neck and facial areas, which is consistent with other studies.[16,35] The results of our study indicated a widespread pressure pain hyperalgesia in dentists when compared with healthy controls over the cervical region.[36] Effects of pain on muscle sensitivity in segmentally related areas have been reported previously.[37] Previous studies have found reduced thresholds for measuring the orofacial region in patients with neck disorders.[38]

The PPTs showed an upward trend with the increase of working age in the present study. In a previous study, it was also found that older adults had higher PPTs in their head and neck muscles than younger adults.[39] Long-term occupational exposure, psychological cognitive effects, and degenerative changes in the nervous system such as loss of medullated and myelinated fibers, axonal atrophy, impaired nerve conduction, and neurotransmitter decline could be responsible for the increase in PPTs.[14,22,40]

Women had lower PPTs of muscles than men. The mechanisms by which women are more sensitivity to mechanical stimuli are still not fully understood, but physiological, biological, cultural and psychological differences have been hypothesized.[22]

TABLE 4 Multiple linear regression analysis for PPTs

	Adjust R^2	F	P_{model}		Unstandardized coefficients	Standardized coefficients	$P_{coefficients}$
Right							
Temporal muscle	0.294	28.902	**<0.001**	Constant	2.272 ± 0.050		
				Occupation	-0.081 ± 0.029	−0.168	**0.005**
				Working age	0.007 ± 0.001	0.287	**<0.001**
				Gender	0.202 ± 0.029	0.412	**<0.001**
Masseter muscle	0.281	27.162	**<0.001**	Constant	2.166 ± 0.053		
				Occupation	-0.073 ± 0.030	−0.145	**0.017**
				Working age	0.006 ± 0.002	0.238	**<0.001**
				Gender	0.225 ± 0.031	0.439	**<0.001**
Sternocleidomastoid muscle	0.249	23.231	**<0.001**	Constant	2.165 ± 0.059		
				Occupation	-0.133 ± 0.034	−0.241	**<0.001**
				Working age	0.006 ± 0.002	0.213	**0.001**
				Gender	0.210 ± 0.034	0.375	**<0.001**
Middle trapezius muscle	0.306	30.251	**<0.001**	Constant	2.397 ± 0.050		
				Occupation	-0.057 ± 0.028	−0.120	**0.044**
				Working age	0.009 ± 0.001	0.360	**<0.001**
				Gender	0.184 ± 0.029	0.379	**<0.001**
Upper trapezius muscle	0.228	20.742	**<0.001**	Constant	2.404 ± 0.058		
				Occupation	-0.119 ± 0.033	−0.223	**<0.001**
				Working age	0.077 ± 0.002	0.273	**<0.001**
				Gender	0.169 ± 0.034	0.311	**<0.001**
Left							
Temporal muscle	0.237	21.796	**<0.001**	Constant	2.328 ± 0.055		
				Occupation	-0.125 ± 0.031	−0.247	**<0.001**
				Working age	0.007 ± 0.002	0.265	**<0.001**
				Gender	0.162 ± 0.032	0.316	**<0.001**
Masseter muscle	0.256	24.053	**<0.001**	Constant	2.150 ± 0.058		
				Occupation	-0.088 ± 0.033	−0.161	**0.009**
				Working age	0.007 ± 0.002	0.245	**<0.001**
				Gender	0.223 ± 0.034	0.402	**<0.001**
Sternocleidomastoid muscle	0.270	25.788	**<0.001**	Constant	2.227 ± 0.057		
				Occupation	-0.181 ± 0.032	−0.337	**<0.001**
				Working age	0.006 ± 0.002	0.206	**0.001**
				Gender	0.181 ± 0.033	0.333	**<0.001**

(Continues)

TABLE 4 (Continued)

	Adjust R^2	F	P$_{model}$		Unstandardized coefficients	Standardized coefficients	P$_{coefficients}$
Middle trapezius muscle	0.283	27.243	**<0.001**	Constant	2.387 ± 0.053		
				Occupation	-0.062 ± 0.030	−0.123	**0.042**
				Working age	0.009 ± 0.002	0.343	**<0.001**
				Gender	0.189 ± 0.031	0.367	**<0.001**
Upper trapezius muscle	0.228	20.783	**<0.001**	Constant	2.379 ± 0.059		
				Occupation	-0.102 ± 0.034	−0.187	**0.003**
				Working age	0.008 ± 0.002	0.287	**<0.001**
				Gender	0.178 ± 0.034	0.322	**<0.001**

Abbreviations: PPT, pressure pain threshold; P$_{model}$, Statistical significance of regression model; P$_{coefficients}$, Statistical significance of coefficient.

Bold indicates statistically significant values.

4.5 | Limitations

The present study was a cross-sectional study and most of the participants were recruited in the Nanjing area. The current results have certain limitations and may not be representative of all dentists due to the different working environment and relatively small sample size. A multi-center cohort study with larger sample size and reliable and valid outcome measures including the proposed techniques in the present study are recommended.

5 | CONCLUSION

Our study showed that dentists have more common neck disorders, higher sensitivity of the facial and neck muscles, and abnormal range of motion of the cervical spine in some directions. Therefore, in order to reduce the risk of chronic pain and improve the quality of life, the MSDs caused by dentists' daily work should receive more attention from the society. The implementation of occupational health protection actions and formulation of ergonomic recommendations should be promoted to reduce the prevalence of the MSDs among dentists.

ETHICS APPROVAL STATEMENT

The Ethics Committee of the State of the Affiliated Stomatology Hospital of Nanjing Medical University approved the study protocol (PJ2019-006-01).

DISCLOSURE

Approval of the research protocol: N/A. *Informed Consent*: N/A. *Registry and the Registration No. of the study/Trial*: Chinese Clinical Trial Registry: ChiCTR2000038370.

Animal Studies: N/A. *Conflict of Interest*: The authors declare that they have no competing interests.

AUTHOR CONTRIBUTIONS

All the authors contributed to the study. The study was designed by Kelun Wang and Peter Svensson, and performed by Yanli Zhou, Adila Aisaiti, Bingjie Wang, Weina Zhou, Jinglu Zhang. The data were analyzed by Yanli Zhou, Weina Zhou and Jinglu Zhang. The manuscript was drafted by Yanli Zhou, Weina Zhou, Peter Svensson and Kelun Wang. All the authors helped to revise the manuscript and approved the final version for publication.

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