SYSTEMATIC REVIEW

Occupational and Non-Occupational Risk Factors for Neck Pain in Dentists: A Systematic Review and Meta-Analysis

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Abstract

Objectives: Musculoskeletal disorders (MSDs), notably neck pain, are important occupational health issues in the field of dentistry. The aim of the present study was to systematically review the literature for significant ris k factors for neck pain in dentists.

Methods: PubMed and Scopus were searched with the following search strategy: (neck AND dentist AND pain). Data regarding the prevalence of each estimated risk factor were extracted, and studies with enough quantitative data were further analyzed using meta-analysis. The last search was done on October 2023. The calculated effect size for each study was based on the odds ratio (OR). All statistical analyses were performed using Comprehensive Meta-Analysis Software (version 2).

Results: In total, 42 cross-sectional studies met our inclusion criteria for the current systematic review, with 34 of them selected for inclusion in the meta-analysis. There was a significant relationship between dentists' neck pain and age (over 40 years old), female gender, working experience (more than 10 years), and height (exceeding 180 cm). Dentists with physical activity (OR=0.2, 95% CI: 0.04-0.9) and stretching (OR=0.6, 95% CI: 0.4-1.0) had a significantly lower risk of neck pain compared to dentists without physical activity and stretching during the week after the treatment session. The use of vibrating tools increased the risk of neck pain among dentists (OR=1.6, 95% CI: 1.1-2.4). The number of compromised and harmful postures was significantly associated with an increased risk of neck pain across studies; however, the data were not enough for running a meta-analysis on this subject.

Conclusion: Poor cervical posture, older age, prolonged working experience, and a larger number of treated patients were identified as significant risk factors associated with neck pain. Ergonomic improvements, regular physical activity, rest breaks, stretching, and indirect vision play a crucial role in mitigating the risk of neck pain.

Level of evidence: III

Keywords: Dentists, Neck pain, Occupational medicine

Introduction

Work-related musculoskeletal disorders (WMSDs) are among the most common occupational diseases, with substantial costs and an impact on quality of life. WMSDs are typically characterized and explored through pain complaints in the neck, shoulder, arm, wrist, hands, upper and lower back, hips, knees, and feet. They are significant concerns in the field of occupational health and have a high prevalence among other occupational diseases in the dental profession.[1] It has been estimated that musculoskeletal disorders (MSDs) have a global prevalence rate of 63% to 93%. The upper extremities and the spine are more susceptible to muscular pain during dental procedures compared to other body regions.[2-4] Neck pain is a prevalent work-related disease in both developed and developing nations, ranging from 17% to 66% among dentists.[5]

Enhanced knowledge of MSDs, ergonomic concerns, and various risk factors within the dental profession have spurred the development of more effective prevention and control strategies and a reduction in the incidence of MSDs among dentists. It has been suggested that deep cervical flexor training and the application of ergonomic

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interventions, including magnification lenses and ergonomic tools, reduce muscle activity and decrease the incidence of neck pain in dentists.[6,7] The aim of the present study was to comprehensively review the literature for significant risk factors for neck pain in dentists.

Materials and Methods

This systematic review was conducted in accordance with the PRISMA statement (www.prisma-statement.org).[8]

Search strategy

PubMed and Scopus were the main databases searched to retrieve the relevant studies. Google Scholar was also searched using cited by features. The last search was done on October 18, 2023. The following keywords were used to search the mentioned databases: (neck AND dentist AND pain). No language or date limit was imposed on the search. The two authors conducted the search independently. Identified records from each database were exported to EndNote reference software (version 11).

Inclusion criteria

All studies that evaluated possible risk factors for work-related neck pain in dentists, including age, gender, working ergonomics, working rest, physical exercise and stretching, and the use of the vibrating tool, were included in the current systematic review. Editorials, reviews, studies with no specific data on neck pain, or unrelated studies were excluded. Study selection was done by two authors independently. Duplicate studies were discussed, and only the most recent reports were included.

Data extraction

Two authors independently extracted necessary data related to study characteristics (title of the study, first author, and country, year of publication, study design, and sample size) and outcome (the prevalence of each risk factor).

Quality assessment

The quality of the studies was evaluated according to the Newcastle-Ottawa scale adapted for cross-sectional studies.[9] This critical assessment aims to gauge both the internal (systematic error) and external validity of the studies, with the overarching goal of mitigating potential biases.

Statistical analysis

All relevant studies were included in the current systematic review, and studies with enough quantitative data were further analyzed by meta-analysis. To be included in the meta-analysis, data regarding the sample size and the number of participants with neck pain were needed for each examined risk factor. The calculated effect size for each study was based on the odds ratio (OR). Considering variation in true effect sizes across different populations (clinical heterogeneity), Der Simonian and Laird's random effects model was applied for the analyses.[9] Cochrane Q-value was used to evaluate the heterogeneity across studies, and $P<0.05$ was considered statistically significant. The I2 index was used to quantify the amount of heterogeneity. All statistical analyses were performed using Comprehensive Meta-Analysis software (version 2).

Results

Studies selection

The PRISMA flowchart illustrates the selection process for included studies [Figure 1]. The initial literature search on PubMed and Scopus yielded 769 articles. Duplicate articles were removed, and the remaining studies were screened based on their titles and abstracts. Following the exclusion of irrelevant articles, the full texts of the remaining studies were assessed by two investigators to identify those eligible for inclusion in the systematic review and meta-analysis. A total of 727 articles were excluded due to missing, insufficient, and/or ambiguous outcome data. Ultimately, 42 cross-sectional studies met the inclusion criteria as the most relevant for the current systematic review, 34 of which were also selected for inclusion in the meta-analysis.

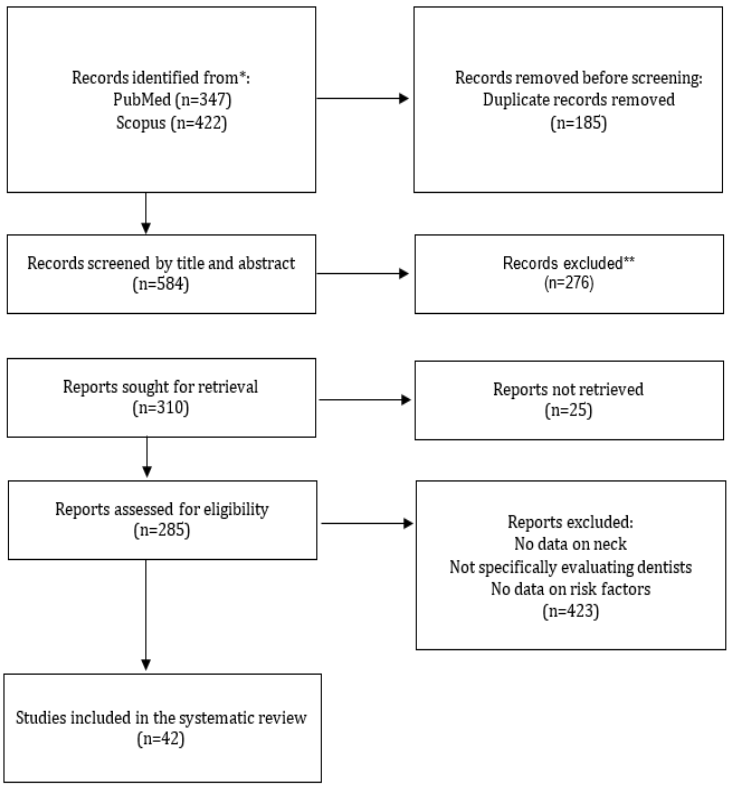

Figure 1. Prisma flowchart

Studies characteristics

The demographic characteristics and qualitative information of the included studies are presented in [Table 1]. Data specific to the studies chosen for meta-analysis are summarized in [Table 2]. The results of the meta-analysis are summarized in [Table 3]. The research included cross-sectional observational studies published between 1998 and 2023. All articles were written in English, except for one that was written in Chinese.

Table 1. Characteristics of the included studies in the systematic review

	Author/ Year Country	Setting	Study population	Sampling method	Tests	Sample size	Occupational risk factors for neck pain	Quality score
1	Zúniga,2023 Japan	Dental University	Dental students	Convenience	Photos and videos were taken to record sitting positions	30	-Harmful neck angle >50% of dentists -Fourth-year students were the only ones who obtained the best acceptable ergonomic score (P-value=0.008)	7
2	Adulyawat,2022 Thailand	Faculty of Dentistry	Endodontics	Convenience	M-DOPAI Borg's CR-10 scale	24	-Harmful neck posture (P-value=0.04) -Treatment duration (P-value=0.005)	8
3	Sulimany,2021 Saudi Arabia	Dental School	Dental interns	Convenience	Self-report surveys	794 females 435 males 359	Multivariate regression: OR (95% CI) -Awareness of posture: 0.80 (0.53-1.22) -Stretching exercises after work (Yes vs. No): 0.83 (0.60-1.15) -Avoid bending or twisting during work: 0.51 (0.37-0.7) -Using magnifying loupes during dental procedures: Yes vs. No: 0.93 (0.69-1.24) -Gender: Female vs. male: 2.03 (1.49-2.74)	6
4	Eyvazlou,2021 Iran	Dental offices	Dental practitioners	Using census	Structured questionnaire, interviews, QEC	0	-Working hours per day (>8 vs. ≤8): β=11.2, t=2.6 (2.7-19.7) -Regular exercise (Yes vs. No): β=-16.4, t=3.1 (6.2-26.5)	8
5	Rabiei,2008 Iran	Private and/ or public dental offices	General dentists and specialists	Convenience	Questionnaire, NMQ, VAS, RULA	92 males 59 females 33	-Age (years): 1.02 (0.87-1.19) -Gender (male): 1.03 (0.29-3.59) -Duration of work (years): 1.02 (0.85-1.21) -Work days in a week: 1.56 (0.71-3.43) -Work hours in a day: 0.90 (0.62-1.32) -Position at work: Standing: 1, Sitting or standing: 1.21 (0.41-3.62) -Vision at work: Indirect: 1, Direct and indirect: 35.34 (1.42-878.4) -Environmental satisfaction: 1.31 (0.61-2.83) -Tabor satisfaction: 1.24 (0.55-2.76) -Unit light satisfaction: 1.11 (0.51-2.42) -Associate satisfaction: 1.23 (0.71-2.12)	8
6	Dantas,2015 Brazil	Dentists practicing	Dentists	Convenience	A self-administered questionnaire	340 males 121 females 219	-Inadequate working position of the torso: P-value=0.005 -Prolonged standing or sitting position: P-value=1 -Upper limbs in strenuous position: P-value=0.5 -Use of the vibrating tool: P-value=0.7	7
7	Rahmani 2013 Iran	University	Dentists	Random	VAS NDI	350 males 215 females 85	P-value -Age: 0.719 -Gender: 0.359 -BMI: 0.083 -Working experience: 0.07 -Exercise: 0.114 -Assistant: 0.036 -Job satisfaction: 0.07	7
8	Kashif 2021 Saudi Arabia	Hospitals	Dentists	Convenience	A self-administered questionnaire and the Modified Nordic questionnaire	200 males 84 females 116	P-value Increased age: 0.019 Gender: 0.584 Working experience: 0.004 Increased working hour/week: 0.007 Posture (flexed/hyper flexed/extended): 0.002	5

Table 1. Continued

9	.Younis et al 2022 Pakistan	College	Dentists	Snowball sampling	A self-administered questionnaire developed for online administration	600 males 312 females 288	Age (mean±SD): 36.3±9.5 Gender (male/female): 58/53 Weight: P>0.001 Height: P>0.001 Working hours/week: P>0.001	6
10	Hodacova 2022 Czech Republic	University	Dentistry students	Convenience	A self-administered questionnaire	73	Multivariate analysis, OR (95% CI) Fifth-year students: -Gender (men): 6.98 (0.65-74.4) -Top-level sport: 21.47 (1.84-250.9) -Regular sporting activities: 0.14 (0.02-0.89) Third-year students: -Top level sport: 5.89 (1.19-29.17)	6
11	Shekhawat 2020 India	Private dentistry	Dentistry practitioners	NA	A self-administered, closed-ended questionnaire	72	Years of practice: P>0.06 Increased number of patients/day: NS	7
12	Prudhvi 2016 India	NA	General and specialist dentists	Convenience	A self-administered previously validated Nordic Musculoskeletal Questionnaire	100 males 70 females 30	- Gender: Male vs. Female: P<0.01 -Increased age: P<0.05 -Increased height: P<0.05 -Increased weight: P<0.05	7
13	Rafie 2015 Iran	NA	General and professional dentists	Criteria	A demographic questionnaire, RULA, NMQ	130	-Gender: men 54% vs. women 57%	6
14	Aminian 2014 Iran	University	General dentists	Convenience	SNQ	male 252 dentists	- Working experience (years) : (0.931-0.984) 0.957	5
15	Botha 2014 South Africa	Web-based	Dentists	Random	NMQ	348 males 232 females 116	-Height increase: 0.962 (CI: 0.938-0.992 95%)	5
16	Memarpour Iran 2013	Faculty of Dentistry	General and specialist dentists	NA	Questionnaire	272 males 134 females 138	-No significant risk factors	5
17	Kumar 2013 India	National conference	Dentists teachers and) (clinicians	Convenience	Self-administered questionnaire survey	536 males 204 females 332	-Time spent rotated/side-bent trunk posture: OR=2.46, P=0.02 -Time spent in wrist-bent postures: OR=2.44, P=0.00 -Time spent in forceful gripping: OR=2.22, P=0.01 -Time spent in overhead arm postures: OR=2.11, P=0.01	6
18	Kierklo 2011 Poland	NA	Specialized dentists	NA	Questionnaire	219	- Increased duration of employment -Working experience	5
19	Harutunian 2011 Spain	School of Dentistry	Dentistry students	NA	Anonymous questionnaire	74	-Gender (female vs. male): P-value<0.05- -Increased number of patients/day: NS-	6
20	Finsen 1998 Denmark	Danish Society for Craniomandibular Disorders	Dentists	Convenience	A questionnaire	99 males 43 females 56	-Age (year): >44 vs. <44: NS -working experience (year): >17 vs. <17 years: NS -Working h/w: >25 h/w vs. <25 h/week: significant -Gender: male vs. female: 0.8 (0.2-2.8)	7
21	Shrestha 2008 Nepal	College of Dental Surgery	Dental surgeons	Convenience	Questionnaires	68 39 males 29 females	-No significant risk factor -Right posture	5

Table 1. Continued

22	Tezel 2004 Turkey	Faculty of Dentistry	Dental students	Convenience	NSQ	221	-Left-handed vs. right-handed: P-value:(P<0.05) -Gender: male (76%) vs. Female (73%)	5
23	Alexopoulos 2004 Greece	Dental Association	Dentists	Random selection	A self-administered questionnaire SNQ	430 males231 females 199	Univariate associations: OR (95%CI) -Repetitive shoulder/hand movements: 1.75 (1.03-2.97) -Low job control: 1.82 (1.17-2.82) -High need for recovery 1.95 (1.24-3.07) -Moderate perceived general health 3.10 (1.98-4.85) Multivariate analysis -Age 50> vs. <40: 2.12 (1.14-3.95) -Gender (female): 2.41 (1.41-4.13)	7
24	Sakly 2022 Tunisia	Dental Medicine University	Dental practitioner	Convenience	Electronic questionnaire	221 males 67 females 154	-Left-handed vs. right-handed: P-value=0.032	6
25	Mohammed 2023 Iraq	College	Dental students, dental practitioners, dental Specialists	Convenience	Questionnaire	150	-Neck pain in standard posture: 27% -Neck pain in excessive neck flexion >20°: 18.1% -Neck pain in excessive flexion with rotation and lateral tilt: 13.6% -Neck pain in switching between postures depending on the case: 40.9% -Gender: 0.5 -BMI: 0.3 -Age: P-value=0.4	5
26	Liu China 2023	General hospital and dental clinic	Dentists	Stratified cluster sampling	An online questionnaire survey	603 males 296 females 307	Univariate analysis -Gender: female vs. male: 2.312(1.663~3.215) -Age >30: 1.989 (1.374~1.996) -Working experience >10 years: 3.019 (2.048~4.451) -Keeping head up or down for a long time: 7.529 (2.258~25.099) -Neck twisting for a long time: 1.551 (1.104~2.179) -Holding head sideways for a long time: 2.816 (1.841~4.306) -Using vibration tools: 1.684 (1.092~2.597) -Sitting spot for a long time: 5.563 (2.947~10.503) -Physical exercise: 1.796 (1.271~2.539)	6
27	Cakir 2022 Turkey	Dental health centers	Dentists	Convenience	Questionnaire	72	-Standing work status: P-value=0.024	5
28	Shetty 2021 India	Institute of Dental Sciences	Postgraduatestudents, private practitioners	Convenience	SNQ	138 males 68 females 70	-No statistically significant risk factor	6
29	Pawar 2023 India	-	Dental professionals	NA	A set of closed-ended questions	499	-Mean work experiencing: 12.4±4.8 y, P-value=0.003 -Mean working hour/day: 6.9±1.9 y, P-value=0.032 -Mean working days/week: 5.6, P-value=0.09 -Mean patients visiting/day:10±3.8, P-value=0.03	5
30	Khair 2023 Pakistan	Dental practitioner	Hospitals	Convenience	Interview VAS NDI	345	-Increased age: P-value<0.001 -Working hours/day: P-value=0.002	8

Table 1. Continued

31	Revankar 2019 India	Clinical practice	Dental surgeons	Convenience	Self- administered questionnaire	150	-No statistically significant risk factor -Increased working experience: P-value=0.7	5
32	Hegde 2018 India	College	Dental professionals	Convenience	Questionnaire	200 males 118 females 82	-Gender: male vs. female: P-value=0.04 -Sitting vs. standing: P-value=0.02 -Working >24 h/w vs. 8-24 h/w: P-value=0.01 -Breaks during treatment: P-value=0.03	5
33	Shadmehr 2014 Iran	Dental association	Dentists	Random selection	SNQ	446 223 males females 219	-Gender: female>male -Working > 20 hours/week: 67% of the dentists with neck pain -10-20 years working experience: 70% of the dentists	6
34	Hodacova 2015 Czech Republic	Department of Dentistry	Dentists	Convenience	SNQ	575 161 males 414 females	Univariate analysis: OR (95% CI) -Gender (Female): 1.67 (1.14-2.46) -Age by year: 1.01 (1.00-1.03) -Working experience: 1.01 (1.00-1.03) -History of serious MSD: 2.02 (1.17-3.48) -More than 20 patients a day: 1.36 (0.96-1.92) -General health satisfactory: 4.01 (2.73-5.91)	5
35	Saxena 2014 India	-	General practitioners and specialists	Convenience	Designed questionnaire	213	Indirect vision: P-value=0.002- Without assistant: P-value=0.013- Gender: 0.9	5
36	Shresta 2008 India	Institute of Health Sciences	Dental surgeon	Convenience	Questionnaire	68 39 males 29 females	-No statistically significant risk factor	5
37	Gandolfi 2021 Italy	-	Dental specialists, practitioners, hygienists	Convenience	Self- administered questionnaire	284 122 males 181 females	-Gender: female>male	6
38	Feng 2014 China	Hospitals	Dentists	Random selection	SNQ	272	Univariate analysis: OR (95%CI) -Age 41-50 y vs. <30: 0.41 (0.18-0.94) -Physical exercise: 0.39 (0.18-0.85) -Working hours/day: 1.34 (1.00-1.79) -Time spent per patient: 1.72 (1.02-2.91) -Gender: male vs. female: 1.19 (0.62-2.29) -Working experience: 0.97 (0.94-1.01)	7
39	Grado 2019 France	Private centers	Dentists	Convenience	Google for questionnaire	1004 622 males 383 females	Univariate analysis: OR (95%CI) -Gender (female): 1.5 -Working experience >15y: 2.5 -Age >45 year and 55 -Mean pain: sitting>both>standing	7
40	Faisal 2014 India	Departments of dental specialties	Post graduate dentistry students	Convenience	Self-administered NQ	306 males 177 females 129	-Gender: female>male	6
41	Camps-Font 2022 Spain	University	Dentistry professors	Convenience	Anonymous survey	43 22 males 21 females	-Age (years): 1.01 (0.95-1.08) -BMI: 1.18 (0.95-1.46) -Working experience: 1.77 (0.50-6.27) -Performing extreme cervical twists or flexions to gain better access to and visibility of the cavity: 3.43 (0.91-12.92) -Performing extreme twists or bends of the back during dental practice: 0.83 (0.23- 3.03) -Performing prolonged static postures: 1.15 (0.23-5.65)	5
42	Lin 2012 Taiwan	Three dental professional groups	Dentists	Convenience	NMQ	197 males 146 females 51	Female>male	5

Table 2. Data of the studies selected for meta-analysis

	Authors, year	Evaluated risk factors for quantitative assessment
1	Sulimany, 2021	***-Avoid bending and twisting: OR: Yes vs. No:*** 0.51 (0.37-0.70) ***-Without physical activity:*** 162/386, with physical activity: 163/255 ***-Male:*** 109/359, ***Female:*** 216/435 ***-Dominant hand: Right:*** 287/703, ***Left:*** 33/78, Both: 5/13 **-BMI:** <18.5: 17/51, 18.5-25: 208/476, 25-30: 71/296, >30: 28/70
2	Rabiei, 2015	***Multivariate analysis: OR (95% CI):*** ***- Male:*** 1.03 (0.29-3.59) ***-Direct vision:*** 35.34 (1.42-878.4) ***-Indirect:*** 1
3	Rahman, 2013	***Number/total number:*** ***-Age:*** <40: 42/125, 41-50: 31/83, 51-60: 23/57, >60: 8/35 ***-Without physical activity:*** 91/204 ***-With physical activity:*** 37/96 ***-Male:*** 71/215, ***Female:*** 33/85 ***-BMI:*** <20: 6/17, 20-25: 27/97, 25-30: 62/156, >30: 8/30 ***-Working experience:*** <10 y: 32/103, 10-20 y: 43/129, >20 y: 29/68
4	Kashif, 2021	***-Flexed:*** 86/152, ***hyper flexed:*** 38/40, ***Extended:*** 8/8 ***-Age:*** 21-25: 40/76, 25-30: 50/76, >30: 42/48 ***-Male:*** 58/84, ***Female:*** 74/116 ***-Working hours/week:*** <20: 4/40, 21-30: 34/54, 31-40: 66/86, >40:12/20 ***-Working experience:*** 1-5: 68/126, 6-10: 28/38, >10: 32/36
5	Younis, 2022	***-Male:*** 58/312, ***Female:*** 53/288 ***-Working hours/week:*** 11-20: 8/54, 21-30: 36/180, 31-40: 55/306, >41: 12/60 ***-Height (cm):*** 130-152: 19/60, 154-178: 71/477, >180: 21/63 ***-Weight (kg):*** 40-50: 1/6, 51-60: 9/93, 61-70: 18/72, 71-80: 20/150, 81-90: 42/222, 91-100: 21/57
6	Hodačová, 2022	***Univariate analysis:*** OR (95% CI) ***-Male:*** 2.57 (0.87-7.62) ***-Dominant hand: Right:*** 1.68 (0.31-8.97)
7	Prudhvi, 2016	***-Age:*** 21-30: 15/38, 31-40: 27/44, 41-50: 11/15, 50-60: 3/3 ***-Male:*** 45/70, ***Female:*** 11/30 ***-Height:*** 151-160: 6/20, 161-170: 21/40, 171-180: 24/34, 181-190: 5/6 ***-Weight (kg):*** 41-50: 4/7, 51-60: 6/15, 61-70: 14/34, 71-80: 21/30, 81-90: 11/14
8	Rafie, 2015	***-Male:*** 45/84, ***Female:*** 26/46
9	Botha, 2014	***-Male:*** 172/232***, Female:*** 86/116
10	Memarpour, 2013	***-Male:*** 36/134, ***Female:*** 50/138
11	Kumar, 2013	***-Age:*** 20-29: 182/241, 30-39: 126/184, 40-49: 78/114, >50: 20/24 ***-Physical activity: Yes:*** 6/54, ***No:*** 400/482 ***-Male:*** 102/204, ***Female:*** 304/332 ***-Dominant hand: Right:*** 384/512, ***Left:*** 22/24 ***-BMI:*** <20: 52/76, 20-24.9: 303/384, 25-29.9: 45/68, >30: 6/8 ***-Working experience:*** <5 y: 178/348, 6-10 y: 65/124, >10 y: 43/64
12	Kierko, 2011	***-Working experience:*** 1-5 y: 10/34, 6-10: 13/34, 11-15:26/68, 16-20:13/31, >20y:41/52
13	Finsen,1998	***OR (95% CI):*** ***-Male:*** 0.8 (0.2-2.8), ***Female:*** 1 ***-Working hours/week:*** >42: 2.8 (0.5-17), 38-42: 1 (0.2-6.2), 33-37: 1.2 (0.2-6.2), <33: 1
14	Shrestha, 2008	***-Break: Yes:*** 35/58, ***No:*** 5/10 ***-Male:*** 20/39, ***Female:*** 20/29 ***-Sitting :***11/18, ***Both:*** 29/50
15	Tezel, 2004	***-Male:*** 101/134, ***Female:*** 64/87 ***-Dominant hand: Left:*** 16/24, ***Right:*** 11/24
16	Alexopoulo, 2004	***Univariate analysis:*** OR, (95%CI) ***-Using vibrating instrument:*** 1.72 (0.90-3.30) ***-Male:*** 1, ***Female:*** 2.41 (1.41-4.13)
17	Sakly, 2022	***-Dominant hand: LH:*** 24/40, 93/181
18	Mohammed, 2023	***-Age:*** 20-30: 57/131, 31-40: 6/15, 40: 3/4 ***-Male:*** 35/84, ***Female:*** 31/66 ***-BMI:*** <18.5: 4/5, 18.5-24.5: 28/70, 25-29.5: 28/61, >30: 6/14 ***-Working experience:*** >10 years: 9/19, <10 y: 57/131 ***-Patients/day:*** >10 per day: 50/118, 5-10: 12/25, 1-4: 4/7

Table 2. Continued		
19	Liu, 2023	***-Break:*** 138/340 ***-Age:*** <30: 73/208, 30:142/274, 40: 49/121 ***-Using vibrating instrument: Yes:*** 227/493, ***No:*** 37/110 ***-Female:*** 165/307, ***Male:*** 99/296 ***-Sitting position: Yes:*** 252/520, ***No:*** 12/83 ***-Working experience:*** <10: 127/351, 10 y: 101/160, 20 y: 36/92
20	Cakir, 2022	***-Age:*** <30: 17/20, 31-40: 20/24, >40: 21/30 ***-Male:*** 16/22, ***Female:*** 42/52 ***-Sitting position:*** 16/20, ***Standing position:*** 47/59
21	Shetty, 2021	***-Age:*** 20-30: 61%,30-40: 51.4%,40-50: 50% ***-Male:*** 36/68, ***Female:*** 42/70 ***-Patients/day:*** 2-5: 47.8%,5-10: 57.9%,>10: 58.6%
22	Pawar,2021	***-Break: Yes:*** 245/499
23	Khair, 2020	***-Age:*** 20-30: 141/275, 31-40: 35/47, 41-45: 22/23 ***-Female:*** 71/253, ***Male:*** 33/92 ***-Working hours/week:*** <6: 48/98, 6-10: 121/211, >10: 29/36
24	Revankar, 2019	***-Working experience:*** 5 years: 16/41, 6-10 y: 38/75, 11-15 y: 12/29, 16-20: 3/20
25	Hedge, 2018	***-Break: Yes:*** 45/154, ***No:*** 28/46 ***-Male:*** 73/118, ***Female:*** 40/82 ***-Working hours/week:*** 8-24: 36%,24-32: 77% ***-Sitting position:*** 46/67, ***Standing position:*** 7/10
26	Shadmehr, 2014	***-Male:*** 141/223, ***Female:*** 144/219 ***-Working hour/week:*** <20: 61.8, >20h/week: 67%,<10y: 186/291, 10-20y: 86/122, >20y: 17/33
27	Hodacova, 2015	***Univariate OR:*** ***-Female:*** 1.67 (1.14–2.46) ***-Sitting:*** 0.7 (0.5-0.99)
28	Saxena, 2014	***-Male:*** 40/118, ***Female:*** 32/95 ***-Direct vision:*** 52/98, ***Indirect:*** 20/115
29	Shrestha, 2008	***-Male:*** 20/39, ***Female:*** 20/29 ***-Sitting:*** 11/18 (61%), ***Both:*** 29/50
30	Gandolfi, 2021	***-Female:*** 111/181, ***Male:*** 72/122
31	Feng, 2014	***Univariate OR:*** ***-Physical activity: No:*** 1, ***Yes:*** 0.39 (0.18-0.85) ***-Male:*** 125/151, ***Female:*** 103/121
32	Faisal, 2014	***-Male:*** 34/117, ***Female:*** 62/129
33	Camps-Font,2022	***-Male:*** 13/22, ***Female:*** 15/21 ***Univariate OR: -Working H/W:*** 1.30 (0.32-5.24)
34	Lin, 2012	***-Male:*** 102/146, ***Female:*** 39/51

Table 3. Results of the meta-analysis

Risk factor		OR (95% CI)	Q-value	I-squared	P-value
Age	> 40 years old	1.16 (0.72-1.87)	19.5	64	
Gender	Female vs. male	1.35 (1.05-1.7)	151.8	81.5	
Working hours/week	>30 h/week	1.24 (0.7-2.18)	2.4	58	
Number of patients/day	>10/day	1.24 (0.66-2.31)	0.22	0	0.6
Working years	>10 years	1.53 (1.06-2.22)	23	70	0.001
Dominant hand	Left vs. Right	1.41 (0.91-2.17)	3.6	18	0.2
Height	>180 cm	2.56 (1.47-4.46)	0.2	0	0.6
Weight	>70 kg	1.96 (0.69-5.54)	4.6	78	0.03
BMI	>25	0.92 (0.59-1.42)	9.3	67	0.02
Physical activity	Yes vs. No	0.2 (0.04-0.97)	44	93	0.0

Table 3. Continued					
Stretching after treatment	Yes vs. No	0.68 (0.46-1.01)	2.7	63	0.0
Vibrating instrument	Yes vs. No	1.69 (1.18-2.43)	0.0	0	0.9
Direct vision	Yes vs. No	3.5 (0.76-16.1)	24	91	0.0

In terms of geographical distribution, 71% of the studies were conducted in Asian countries, with the highest proportion in India (23%), followed by Iran (11%), Saudi Arabia, Turkey, and other nations. Additionally, seven studies were conducted in European countries. The study samples comprised general dentists, specialists in dentistry, and dental students. The adjusted sample size varied from 30 dentists in 2023 to 1,004 dentists in 2019. Across all studies, self-administered questionnaires were the most frequently used survey instrument to assess neck pain risk factors. The average quality scores of the studies ranged from 5 to 9 as per the Newcastle-Ottawa scale [Table 4].

Table 4. Quality assessment of the included studies

	Author Publication Year country	Representativeness of the sample*	Sample size*	Non-respondents*	Ascertainment of the exposure	Confounding factors controlled**	Assessment of outcomes	Statistical test*	Total score
1	Zúniga/2020	-	-	-	**	**	**	*	7
2	Adulyawat/2022	-	*	-	**	**	**	*	8
3	Sulimany/2021	-	-	*	-	**	**	*	6
4	Eyvazlou/2021	*	-	-	**	**	**	*	8
5	Rabiei/2008	-	-	*	**	**	**	*	8
6	Dantas/2015	-	*	*	-	**	**	*	7
7	Rahmani/2013	*	-	*	**	-	**	*	7
8	Kashif/2021	-	-	-	-	**	**	*	5
9	Younis et al./2022	-	-	*	-	**	**	*	6
10	Hodacova/2022	-	-	*	-	**	**	*	6
11	Shekhawat/2020	-	*	*	-	**	**	*	7
12	Prudhvi/2016	-	*	*	-	**	**	*	7
13	Rafie/2015	*	-	-	-	**	**	*	6
14	Aminian/2014	-	-	-	-	**	**	*	5
15	Botha/2014	-	*	-	-	**	*	*	5
16	Memarpour/Iran/2013	-	-	-	-	**	**	*	5
17	Kumar/2013	-	-	*	-	**	**	*	6
18	Kierklo/2011	-	-	-	-	**	**	*	5
19	Harutunian/2011	-	-	*	-	**	**	*	6
20	Finsen/1998	-	-	-	**	**	**	*	7
21	Shrestha/2008	-	-	-	-	**	*	*	5
22	Tezel/2004	-	-	-	-	**	**	*	5
23	Alexopoulos/2004	*	-	*	-	**	**	*	7
24	Sakly/2022	-	-	-	-	**	**	*	6
25	Mohammed/2023	-	-	-		**	**	*	5
26	Liu/2023	*	-	-	-	**	**	*	6
27	Cakir/2022	-	-	-	-	**	**	*	5

Table 4. Continued									
28	Shetty/2021	-	*	-	-	**	**	*	6
29	Pawar/2023	-	-	-	-	**	**	*	5
30	Khair/2023	-	*	-	**	**	**	*	8
31	Revankar/2019	-	-	-	-	**	**	*	5
32	Hegde/2018	-	-	-	-	**	**	*	5
33	Shadmehr/2014	*	-	-	-	**	**	*	6
34	Hodacova/2015	-	-	-	-	**	**	*	5
35	Saxena/2014	-	-	-	-	**	**	*	5
36	Shresta/2008	-	-	-	-	**	**	*	5
37	Gandolfi/2021	-	-	*	-	**	**	*	6
38	Feng/2014	*	-	*	-	**	**	*	7
39	Grado/2019	-	-	-	**	**	**	*	7
40	Faisal/2014	-	-	-	-	**	**	*	6
41	Camps-Font/2022	-	-	-	-	**	**	*	5
42	Lin/2012	-	-	-	-	**	**	*	5

Study outcome measures

Risk factors for work-related neck pain

Forrest plots of the evaluated variables are presented in [Figures 2 and 3].

Age was assessed in 18 studies,[2,10-19] with eight of them providing sufficient data for meta-analysis [Tables 1 and 2].[5, 20-26] The data synthesis of the eight studies indicated that as dentists' ages exceeded 40, the likelihood of neck pain increased by 1.16-fold.[5,20-23, 25-27] However, this finding did not reach statistical significance (95% CI: 0.72-1.87) [Figure 2A]. Among the remaining studies, five showed a significant relationship between an age above 40 and an increased risk of neck pain.[10,12-14,16,19] Two other studies estimated an age above 30 as a significant risk factor of increased neck pain.[17,18]

Of the included studies, 30 assessed the association between gender and neck pain prevalence in dentists, 29 of which provided sufficient data for meta-analysis.[2,5,10-12,14-38] According to the pooled estimation, female dentists had an approximately 1.3-fold higher (95% CI: 1.04-1.7) risk of experiencing neck pain compared to male dentists [Figure 2B].

The relationship between workload (including weekly days and hours of work and the number of visited patients) and the likelihood of neck pain was assessed in 12 of the selected studies. Among these, seven studies specifically focused on weekly working hours.[14,17,19,28,30,34,38] Pooling data from two studies indicated that the likelihood of neck pain in dentists working more than 30 h per week is 1.2-fold higher than in those working less than 30 h per week (OR=1.2, 95% CI: 0.7-2.1)[17,19] [Figure 2D]. In the studies by Shadmehr et al. and Hedge et al., 67% and 77% of dentists working more than 24 h per week reported experiencing neck pain, respectively. This prevalence was significantly higher compared to dentists working less than 24 hours per week.[30,34]

Data on dentists' working hours per day were provided in four studies[2,12,21,39] and days per week in two studies.[2,40] In studies, the incidence of neck pain did not significantly differ between dentists working more than six hours a day and those working less than six hours a day.[2,12,21,39] Pawar et al. found no significant difference in the mean number of working days per week (mean=5.6±0.7, P=0.09) between dentists with and without neck pain.[40]

The number of patients visited per day was assessed in five studies,[24,26,38-40] with only two of them being eligible for inclusion in the meta-analysis.[24,26] The pooled data from these studies revealed that visiting more than 10 patients per day increased the odds of neck pain in dentists by 1.2-fold (95% CI: 0.6-2.3) [Figure 2E]. In the remaining studies, two of them did not find a significant relationship, while one study reported a higher average of neck pain among dentists who saw more than 10 patients per day compared to those who saw less than 10 patients per day.[40]

The relationship between years of working experience and the occurrence of neck pain was assessed in 13 studies,[5,12-14,16,17,22-24,34,41-43] and eight of them met the criteria for inclusion in the meta-analysis.[5,17,22-24,34,42 43] The pooled data indicated that having more than 10 years of working experience increases the odds of neck pain in dentists by 1.5-fold (95% CI: 1.06-2.22) [Figure 2C]. Among the remaining studies, two could not establish a significant association between increased working years and the prevalence of neck pain.[12,14] However, Hodacova et al. found that each additional year of working experience led to a 1% increase in the odds of neck pain.[13,16] Conversely, one study reported a significantly negative association between neck pain and years of working experience in male dentists.[41]

The dominant hand, height, weight, and BMI of dentists were additional variables assessed in five,[15,22,36,37,44] five,[10,15,19,25,28] four,[15,19,25,28] and five studies,[5,22,24,28, 36] respectively.

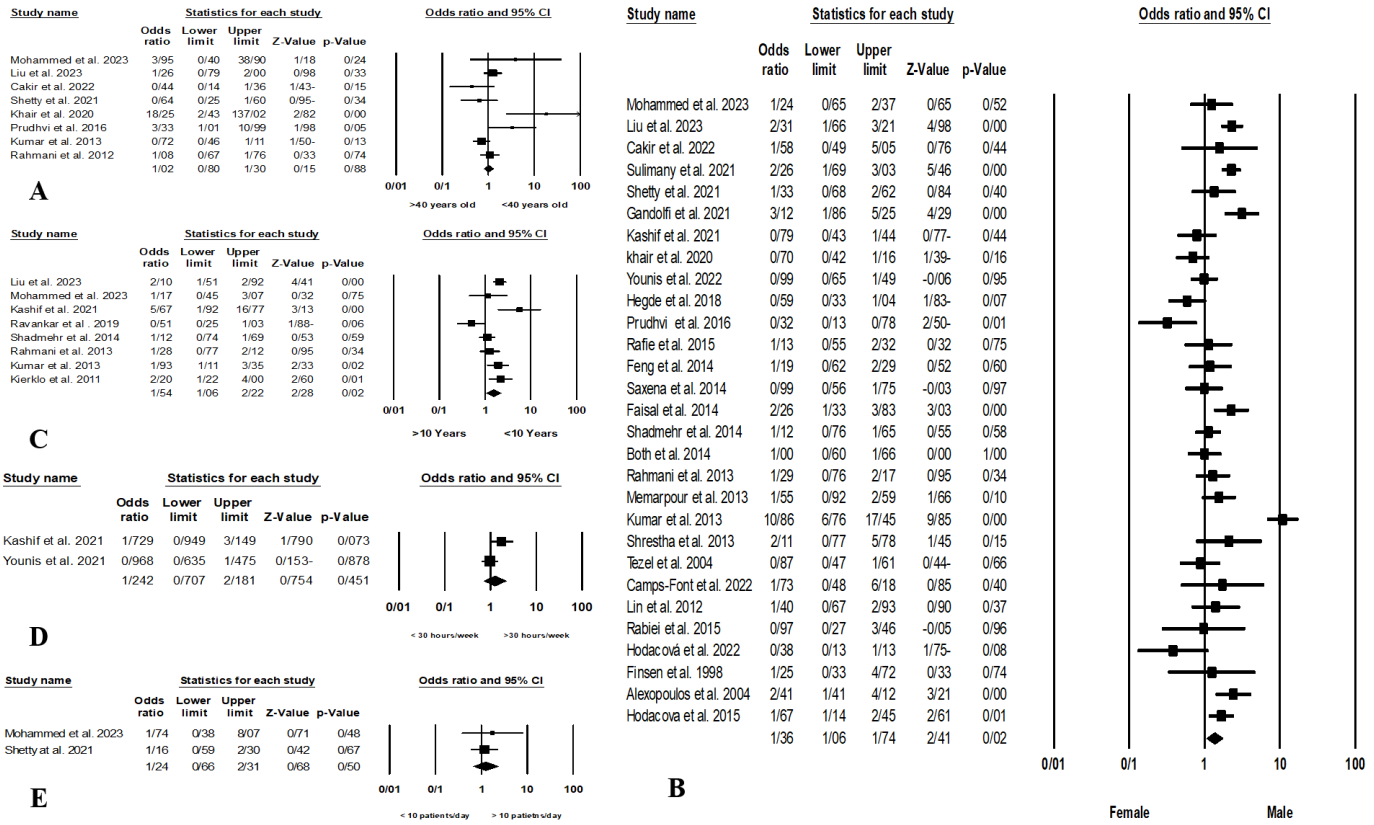

Figure 2. Forrest plot of the age, gender working experience, working hours per week, and patients per day

Concerning the dominant hand, although the risk of neck pain was increased in left-handed dentists by 1.4-fold, it was not statistically significant (95% CI: 0.9-2.1) [Figure 3B]. Pooling data from the four studies on BMI revealed no significant associations between dentists' BMI and the odds of neck pain (OR=0.9, 95% CI: 0.5-1.4) [Figure 3D]. In contrast, when examining height, a 2.5-fold increase in neck pain was detected among dentists with a height exceeding 180 cm (95% CI: 1.4-4.4)[19,25] [Figure 3A]. Although two other studies failed to establish a significant relationship,[10,15] Both et al. reported a 3.8% increase in the risk of neck pain for every centimeter decrease in height among the respondents.[28] In dentists with more than 70 kg of weight, neck pain increased by 1.9-fold; however, the results were not statistically significant (95% CI: 0.6-5.5) [Figure 3C].

Dentists' physical activity and stretching during the work were also evaluated in five [5,12,15,22,36] and four [13,23,36,38] of the studies, respectively. Based on the results, dentists with physical activity (OR=0.2, 95% CI: 0.04-0.9) and stretching (OR=0.6, 95% CI: 0.4-1.0) had a significantly lower risk of neck pain compared to dentists without physical activity during the week and stretching after the treatment session [Figures 3E and F].

The use of vibrating instruments was examined by two studies,[10,23] both showing a statistically significant relationship between the use of vibrating tools and an increased risk of neck pain among dentists (OR=1.6, 95% CI: 1.1-2.4) [Figure 3G]. Three of the included studies proposed a 3.5 increase in the risk of neck pain in dentists with direct vision compared to those with indirect vision (95% CI: 0.7-16.1) [Figure 3F].

Overall, 14 studies assessed the relationship between posture and the risk of neck pain. However, none of these studies provided data eligible for meta-analysis. Based on these studies, the number of compromised and harmful postures is significantly related to an increased risk of neck pain [Table 2]. The effect of sitting or standing for a long time on neck pain has been evaluated in eight of the studies.1,2,13,16,20,23,30,35 In the study of Mohammed et al., the majority of dentists with and without neck pain used to switch between postures depending on the case; however, the results were not significant.24 Harmful neck angle (>45),45,46 bending and twisting during the work,36 poor posture (extended>hyper flexed>flexed, P<0.002),17 time spent in rotated/side-bent trunk posture,22 time spent in wrist-bent postures,22 time spent in forceful gripping,22 sitting or standing positions for a long time,13,20,30 repetitive shoulder/hand movements,10 keeping head up or down for a long time or frequently,23 neck twisting for a long time and holding the head sideways,23 maintaining the same sitting position for a long time,23 and not being free to change postures23 were the awkward positions that increased

dentists' neck pain.

Discussion

MSDs are a prevalent issue within the dental profession, with various risk factors playing significant roles in their incidence. Among these disorders, cervical pain is particularly common among dentists, characterized by a notably high prevalence rate and an array of predisposing risk factors.[47] This literature review presented the effects of various potential risk factors for neck pain among dental professionals.

Multiple risk factors were investigated in the included studies in this review. Among these factors, poor cervical posture emerged as the most prominent and modifiable predisposing element associated with cervical pain and discomfort in dentists. The frequency of adopting compromised and potentially harmful postures during treatment sessions considerably correlates with neck pain experienced by dentists at the end of their treatment sessions. Participants who exhibit attentiveness to their posture during clinical procedures, engage in post-work stretching routines, avoid prolonged fixed positions, or make an effort to minimize excessive bending and twisting demonstrate a significantly reduced likelihood of reporting cervical pain[36] The findings from these studies suggest that enhancing ergonomic conditions, which encompass aspects such as sitting position, clinical settings, workload, work environment, and work-related stress, can effectively reduce the risk of neck discomfort.[17,36,45,46]

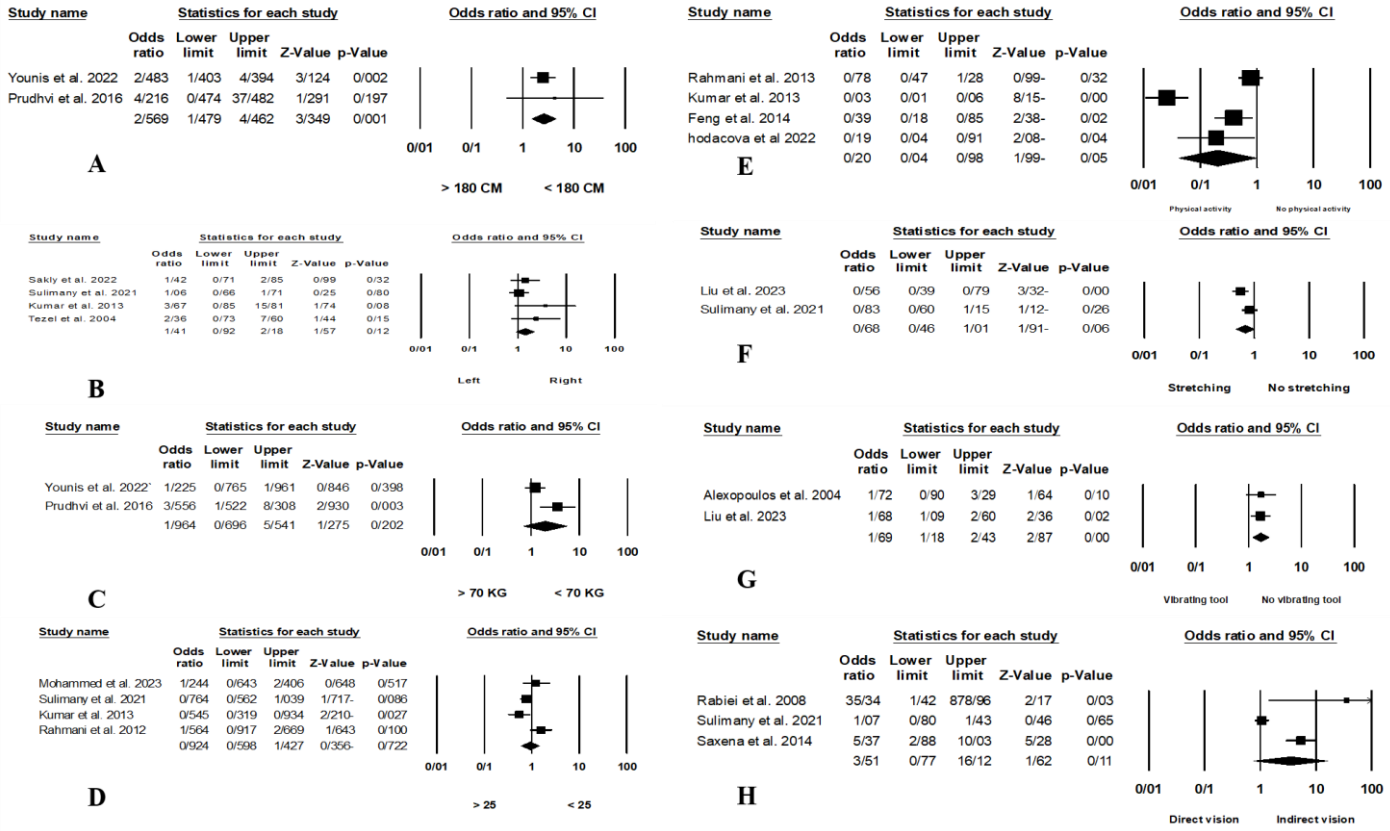

Figure 3. Forrest plot of the dominant hand, height, weight, BMI, physical activity, stretching, vibrating instrument, and direct vision

Regarding age and working experience, our analysis indicated a positive correlation between age and an increased risk of neck pain. However, the detected correlation was not statistically significant, possibly due to the conflicting findings from three of the included studies, which reported a lower percentage of neck pain in dentists over 40 years compared to younger dentists in their study samples.[20,22,26] This discrepancy can be attributed to the possibility that older dentists who experienced severe pain may have left the profession early due to musculoskeletal issues, leading to reduced productivity and early retirement. Consequently, such dentists might not have been included in cross-sectional studies.[48]

In the study by Zuniga et al., early-year dental students exhibited better posture compared to their counterparts in higher academic years. This difference could be attributed to the applied feedback from their instructors and their knowledge of ergonomics, possibly gained from recent academic courses related to the subject.[46]

Consequently, there was no observed correlation between a higher academic year and improved ergonomics.

It can be suggested that age, working years, and the number of treated patients are closely interrelated, with dentists' age and work seniority tending to increase together. One possible explanation for this trend was the expectation that older dentists with more work experience would have less pain compared to younger dentists with less experience. It has been suggested that experienced dentists may be better at adapting their working positions and techniques to prevent musculoskeletal issues, or they may have developed effective strategies for managing pain. However, contrary to expectations, our analysis demonstrated a significant positive association between more working experience and the risk of neck pain in dentists. This implies that, in some cases, experienced practitioners may not effectively control ergonomic conditions, leading to increased neck pain.

While more experienced dentists are generally more knowledgeable about preventive strategies for work-related disorders, our findings revealed a significant association between longer working duration and the likelihood of experiencing neck pain. According to the results of our meta-analysis, the risk of neck pain is 1.5-fold higher in dentists with more than 10 years of working experience. Based on the included studies, it is plausible that older dentists with longer working durations may also tend to have a larger number of treated patients, sustain poor posture, experience increased stress on their musculoskeletal system, and potentially be affected by age-related spine degenerative changes.[49]

Our analysis also revealed a positive correlation between visiting more than 10 patients per day and an increased risk of neck pain, but this association did not reach statistical significance. This could be attributed to the limited number of relevant studies with sufficient data.[26,27] Dentists are required to stay informed about the latest strategies for managing emerging technologies and dental materials. Moreover, having awareness of ergonomics and applying preventive work practices is significantly associated with a reduced likelihood of experiencing symptoms of MSDs. Adulyawat et al. recommended that interventions to reduce neck discomfort should involve efforts to maintain optimal neck posture and apply rest breaks during work.[45] Regular physical activity, taking rest breaks during treatment sessions, and incorporating routine stretching were identified as additional factors positively associated with reducing the risk of neck pain among dentists. Not engaging in regular exercise was linked to a 2.9-fold increase in the likelihood of neck pain. Regular exercise can provide dentists with a break from their demanding workload, aiding in the rejuvenation and strengthening of their bodies while also offering mental relaxation in the face of the high psychosocial demands of their profession. These effects work together to contribute to improved overall health and a reduced risk of musculoskeletal symptoms.[50] Some studies have shown that short rest periods taken at regular intervals during dental treatments have preventive effects on dentists' fatigue and MSDs. These brief breaks help replenish and nourish stressed areas, reducing discomfort in the musculoskeletal and nervous systems.[30,51] Nevertheless, some studies have suggested that there is no significant difference in the occurrence of symptoms among dentists who work with or without scheduled breaks. In our findings, the positive effect of rest breaks on reducing neck pain was detected by 1.6-fold; however, this effect did not reach statistical significance. Therefore, further studies are needed to confirm these results. According to the results of three studies and the meta-analysis, practicing stretching exercises after completing dental work is another factor that can provide immediate relief from musculoskeletal pain for dental professionals. However, the pooled data did not reach statistical significance, which might be due to the limited number of studies.[13,23,36]

In our analysis of the relationship between dentists' dominant hand, weight, height, BMI, and the risk of neck pain, we found that height greater than 180 cm was the only significant risk factor for neck discomfort. Although an increase in weight of over 70 kg was associated with a 1.9-fold increase in the risk of neck pain, this relationship did not reach statistical significance. Conversely, it was observed that dental practitioners taller than or equal to 160 cm had a 42% lower pain level than those in the less than 160 cm group.[52] The relationship between dentists' height and neck injury might be associated with the risk of neck pain.[25]

Direct vision is considered a risk factor for neck pain, as it is commonly used by most dentists and places a significant strain on the neck. It has been suggested that practicing working with indirect vision might be an effective strategy to prevent awkward or forced neck postures.[2,18,36] It is conceivable that improved vision can reduce excessive neck flexion and shoulder elevation. Repetitive movements represent another critical risk factor that could lead to awkward postures when using vibrating instruments. We observed a significant effect of using vibrating tools, which increased the risk of neck pain by 1.6-fold.[10,23] Factors such as incorporating short 50-second micro-breaks between patient treatments and limiting the duration of using vibrating instruments can play a beneficial role in alleviating muscle strain and enhancing the operator's strength capacity.

The studies included in this review had several limitations, including their cross-sectional nature. Conducting prospective studies with standardized data collection will be crucial for examining longitudinal changes. Additionally, the reliance on self-reported information in the majority of these studies may introduce recall bias. Furthermore, these studies only evaluated dental practitioners who were currently working, excluding those who may have left the profession due to work-related MSDs.

Conclusion

This study has shed light on the multifactorial nature of neck pain among dental professionals. Poor cervical posture, older age, prolonged working experience, and a higher number of treated patients were identified as significant risk factors associated with neck pain. Ergonomic interventions, regular physical activity, rest breaks, stretching, and indirect vision are crucial in

mitigating the risk of neck pain. Further studies with a larger sample size are needed to confirm the results. We also emphasize the importance of prospective studies with standardized data collection to monitor longitudinal changes.

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