Cover Story

Prevention and rehabilitation of musculoskeletal disorders in oral health care professionals

A systematic review

Shawn C. Roll, PhD, OTR/L, RMSKS, FAOTA; Kryztopher D. Tung, PhD; Heng Chang, OTD; Tina A. Sehremelis, OTD; Yoko E. Fukumura, BM; Samantha Randolph; Jane L. Forrest, EdD, BSDH

ABSTRACT

Background. The authors' objective in this systematic review was to describe the evidence for preventive and rehabilitative interventions for musculoskeletal disorders in oral health care.

Types of Studies Reviewed. The authors conducted systematic search, screening, and eligibility processes to identify experimental, quasiexperimental, observational, and survey research studies in which the investigators either directly evaluated or predicted the effects of preventive or rehabilitative interventions on the reduction of musculoskeletal symptoms in oral health care professionals.

Results. The authors identified and screened 3,571 unique abstracts, assessed 256 full-text articles for eligibility, and included 34 articles in the review. Investigators in 17 experimental studies described the results of preventive or rehabilitation interventions and in 17 survey research studies predicted or correlated preventive or protective techniques to a reduction in musculoskeletal symptoms. The primary techniques evaluated in the studies included equipment modification, ergonomic training, and physical exercise.

Conclusions and Practical Implications. The evidence suggests that magnification loupes and indirect-vision techniques have a positive effect on the reduction of musculoskeletal symptoms. In terms of evaluating intervention efficacy, other techniques have mixed evidence or are limited by low-level study design.

Key Words. Ergonomics; injury prevention; musculoskeletal disorders; dentists; dental hygienists.

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Work-related musculoskeletal disorders (MSDs) are a common occupational hazard for dentistry professionals. The nature of the work requires repetitive motion of the arms, wrists, and hands while adopting awkward static trunk, neck, and shoulder postures for extended periods.[1] Tasks requiring repeated high hand forces applied at the fingertips and requiring prolonged awkward postures generate significant biomechanical stress and can promote distal upper extremity injuries such as carpal tunnel syndrome.[2,3]

Authors of a review article determined the prevalence of MSD symptoms in the neck and shoulders to be, respectively, 17% to 73% and 20% to 65% in dentists, 54% to 83% and 27% to 76% in dental hygienists, and 38% to 62% and 62% in dental assistants.[4] In a 2017 study, 81.4% of the dentists surveyed experienced MSDs, mostly in the neck, lower back, or shoulders.[5] In another study, the investigators used the Nordic Musculoskeletal Questionnaire and found that 76.2% of male dentists experienced symptoms of MSDs in the lower back, neck, or shoulders.[6]

Authors of a 1993 study found the loss of income for dentistry professionals owing to musculoskeletal pain was greater than $40 million per year.[7] In addition to financial costs, MSDs are associated with poor quality of life and mental distress.[8] MSDs also are associated with factors that reduce the efficiency and quality of work, such as falling asleep during normal activity, stiffness, and loss of strength.[9]

Although results from extensive research and systematic reviews indicate a high prevalence of MSDs among oral health care professionals worldwide, there is a lack of research on antidotal measures. Our objective in this systematic review was to identify the consensus on preventive and rehabilitative interventions for MSDs for oral health care professionals.

METHODS

Databases searched

We searched PubMed, Cumulative Index to Nursing and Allied Health Literature, BIOSIS, and PsycINFO by using a combination of the Medical Subject Headings and key terms *dental hygienist*, *dentist*, or *dental assistant* and *human engineering*, *ergonomics*, *wound*, *injury*, *sprain*, *strain*, *stress*, or *musculoskeletal*. We limited searches to studies published in the English language between January 1, 1990, and September 15, 2018. In addition to the systematic database search, we conducted a hand search by reviewing the references of all included articles and the tables of contents of the journals of oral health care professional societies published within this time frame. We included the following journals: *International Journal of Dental Hygiene*, *International Dental Journal*, *The Journal of the American Dental Association*, *Journal of Dental Education*, and *Journal of Dental Hygiene*. We also searched the tables of contents in *Applied Ergonomics* and *WORK: A Journal of Prevention, Assessment & Rehabilitation* because of many articles appearing in the full-text review and the existence of a special issue dedicated to dentistry, respectively.

Inclusion criteria

Once we removed duplicate records, at least 2 raters (H.C., T.A.S., Y.E.F., or S.R.) screened the remaining abstracts to narrow the list of studies for inclusion. We screened abstracts to identify records focused on interventions for the rehabilitation or prevention of MSDs in oral health care professionals that had an experimental, quasiexperimental, observational, or survey design. We did not include conference abstracts, educational articles, nonsystematic reviews, editorials, and expert opinion manuscripts. In addition, we did not include articles about psychological stress versus MSDs or on patient injury instead of injuries in oral health care providers.

We assessed the full text of any record identified as meeting the broad inclusion criteria by either rater for eligibility. Final inclusion required meeting the following criteria: the study population was oral health care professionals (that is, dentists, dental hygienists, dental assistants, or students within these professions), the study investigators evaluated a preventive or rehabilitative intervention, and the study investigators measured an outcome related to musculoskeletal discomfort or dysfunction. We excluded intervention studies that were purely laboratory based or in which the investigators evaluated changes in tissue morphologic or physiological aspects, postures, or participant preference without any measure of MSD outcomes. We included retrospective, observational, or cross-sectional survey studies if the investigators used statistical analyses to correlate or predict the relationship of preventive or protective interventions or activities to musculoskeletal outcome measures. We did not include surveys or cross-sectional studies in which the investigators reported only descriptive data.

ABBREVIATION KEY

CAM:	Complementary and alternative medicine.
DASH:	Disabilities of the Arm Shoulder and Hand.
MSD:	Musculoskeletal disorder.
NA:	Not applicable.
NPDS:	Neck Pain and Disability Scale.
STROBE:	Strengthening the Reporting of Observational Studies in Epidemiology.
U:	Unable to determine.
VAS:	Visual analog scale.

Study evaluation

Two raters independently reviewed all full-text articles for eligibility (Y.E.F., S.R., or K.T.), and they discussed discrepancies with a third rater to achieve consensus on final eligibility (S.C.R.). We coded included studies as either cross-sectional or prospective intervention studies. We assessed the quality of reporting of cross-sectional studies by using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist,[10] and we evaluated the quality of methodological design of the intervention studies by using the Cochrane Risk of Bias assessment.[11] We extracted data regarding intervention type, outcome measures, and study results. We conducted qualitative synthesis and interpretation of the findings through an iterative process among the authors (Y.E.F., S.R., K.T., S.C.R., J.L.F.).

RESULTS

We identified 3,939 abstracts from PubMed (n = 2,950), Cumulative Index to Nursing and Allied Health Literature (n = 413), BIOSIS (n = 359), and PsycINFO (n = 217). We identified 22 additional studies through the hand search. After removing duplicates, we screened 3,571 abstracts

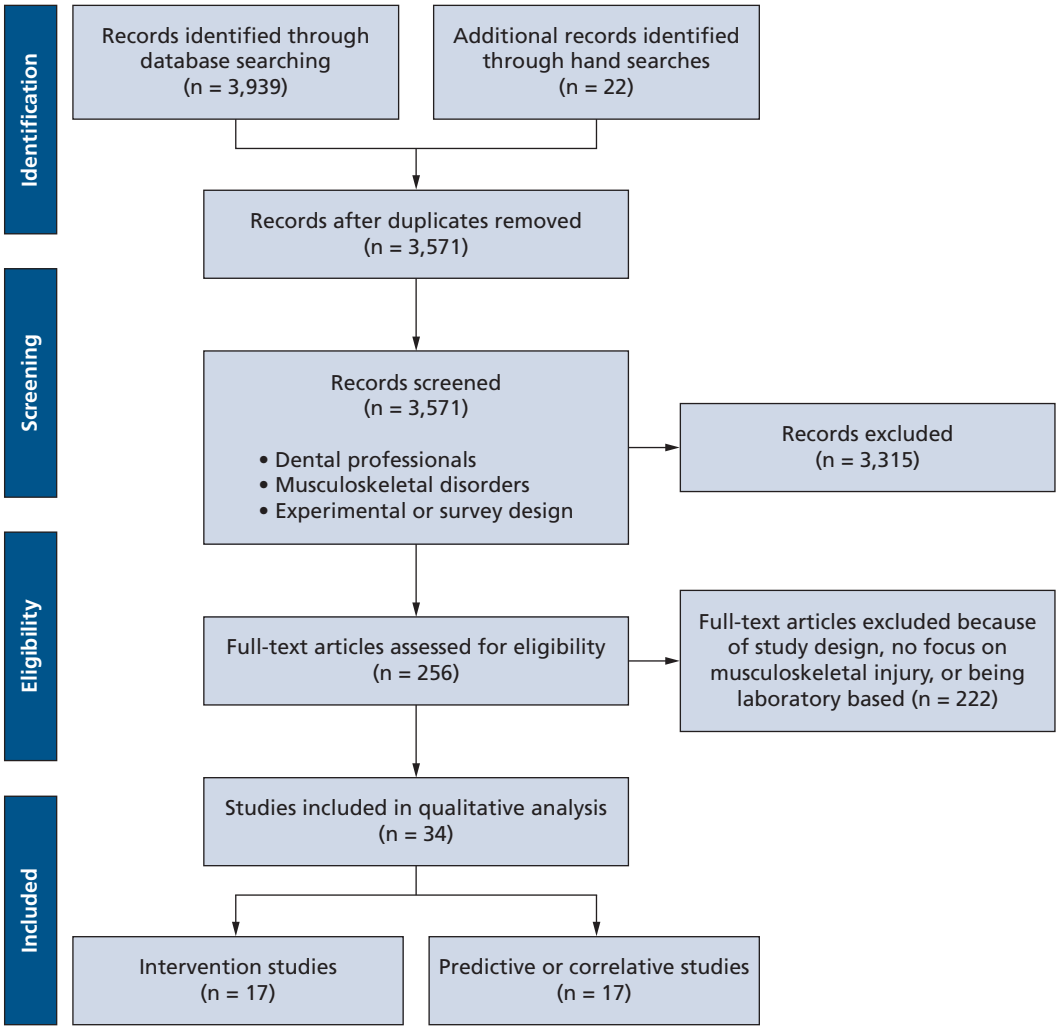

Figure. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of study inclusion.[11]

and read 256 full-text articles to determine eligibility. After screening articles and completing an eligibility review, we included 34 studies in the final qualitative analysis (Figure).[11] Across all included articles, 3 general categories emerged based on the type of interventions used to reduce the effect of MSDs. The most common type of intervention was physical activity, such as exercise or rehabilitative therapy techniques. Second, study investigators evaluated the effect of modifying the equipment being used by dental practitioners, such as the type of instrument handles and loupes. The final category was various methods of providing direct training to oral health care professionals regarding ergonomic practices, proper posture, and other behavioral modifications to their practice patterns. For ease of reporting and interpretation, we organized the included studies as either cross-sectional or prospective intervention trials.

Cross-sectional studies

Seventeen of the included articles involved predictive, correlational, or comparative statistical analyses of potential preventive or protective techniques within a cross-sectional survey or observational study design (Table 1).[10,12-28] The investigators evaluated 3 primary topics across these 17 studies, with investigators in some articles evaluating multiple topics, which included physical activity (n = 13), ergonomic training (n = 6), and equipment modification (n = 4). We assessed the quality of presentation of these data by using the STROBE checklist.[10] Overall, presentation quality across the studies ranged from 17 through 22 on the basis of the 22-item checklist. The primary criteria not met were not acknowledging funding sources, potential sources of bias, or limitations of the study.

Table 1. Retrospective, observational, or cross-sectional survey studies in which the investigators correlated or predicted the relationship of preventive or protective interventions or activities to musculoskeletal outcome measures in dental professionals (N = 17).

STUDY	LOCATION	SAMPLE	INTERVENTIONS			OUTCOME MEASURES	FINDINGS	STROBE SCORE*
			Physical Activity	Ergonomic Training	Equipment Modification			
Marshall and Colleagues,[12] 1997	New South Wales, Australia	353 dentists	No	Yes	No	Prevalence of musculoskeletal pain and 4-handed dentistry	Increased pain with 4-handed dentistry ($P < .05$)	21 No discussion of limitations
Rucker and Sunnell,[13] 2002	British Columbia, Canada	421 dentists	No	Yes	Yes	Prevalence of musculoskeletal pain and ergonomic training	Decreased low back pain with ergonomic education in dental school ($P = .05$) Decreased low back pain with surgical magnification tool ($P = .034$) Decreased leg pain with lumbar supports ($P = .007$)	21 Potential sources of bias not discussed
Rising and Colleagues,[14] 2005	San Francisco, California	271 dental students	Yes	No	No	Prevalence of musculoskeletal pain and weekly physical activity	No statistically significant decrease in pain with different frequency, duration, or intensity of physical exercise	19 Potential sources of bias not discussed No discussions of limitations No interpretation of results
Hayes and Colleagues,[15] 2009	Ourimbah, New South Wales, Australia	126 dental hygiene students	Yes	No	No	Prevalence of musculoskeletal pain and weekly physical activity	Increased low back pain with no regular weekly exercise (OR,† 4.88; 95% CI,‡ 1.75 to 14.00).	20 Potential sources of bias not discussed Funding source (or lack of funding) not acknowledged
Harutunian and Colleagues,[16] 2011	Barcelona, Spain	54 dental students, 20 faculty dentists	Yes	No	No	Prevalence of musculoskeletal pain and preventative measures	No statistically significant decrease in low back pain from stretching ($P > .05$)	19 Potential sources of bias not discussed No explanation of study size Funding source (or lack of funding) not acknowledged
Kierklo and Colleagues,[17] 2011	Bialystok, Poland	219 dentists	Yes	Yes	No	Prevalence of musculoskeletal pain and frequency of physical activity	No statistically significant decrease in pain from physical activity or ergonomic training Dentists who did not take rest breaks experienced more hip pain ($P = .004$).	18 Participant selection not discussed Potential sources of bias not discussed No explanation of study size Funding source (or lack of funding) not acknowledged
Hayes and Colleagues,[18] 2012	Ourimbah, New South Wales, Australia	560 dental hygienists	No	No	Yes	Prevalence of musculoskeletal pain, type of scaler, and magnification loupes	Decreased shoulder ($P < .01$) or wrist ($P < .01$) pain with loupes	19 Potential sources of bias not discussed No descriptive data of study participants Funding sources (or lack of funding) not acknowledged

* STROBE: Strengthening the Reporting of Observational Studies in Epidemiology. Scores range from 0 through 22. Refers to items that were lacking from the STROBE criteria.[10] † OR: Odds ratio. ‡ CI: Confidence interval. § CAM: Complementary and alternative medicine.

Table 1. Continued

STUDY	LOCATION	SAMPLE	INTERVENTIONS			OUTCOME MEASURES	FINDINGS	STROBE SCORE*
			Physical Activity	Ergonomic Training	Equipment Modification			
Kumar and Colleagues,[19] 2013	Mangalore, India	536 dentists	Yes	No	No	Prevalence of musculoskeletal pain and level of physical activity	Physically active dentists experienced pain in the upper back (59.25%), wrist or hand (22.22%), and low back (14.81%) Physically inactive dentists experienced pain in the neck (82.96%), wrist or hand (78.83%), and low back (78.42%)	19 Potential sources of bias not discussed No discussion of limitations Funding source (or lack of funding) not acknowledged
Rahmani and Colleagues,[20] 2013	Tehran, Iran	300 dentists	Yes	No	No	Prevalence of neck pain and frequency of physical activity	Decreased pain with presence of assistant and good general health ($P < .05$)	20 Potential sources of bias not described No discussion of limitations
Yi and Colleagues,[21] 2013	Sichuan, China	288 dental students	Yes	No	No	Prevalence of musculoskeletal pain and weekly physical activity	Decreased pain with 6 to 8 hours of exercise per week (OR, 0.53; 95% CI, 0.30 to 0.94) Increased pain with less than 1 hour of exercise per week (OR, 1.83; 95%, CI 1.13 to 2.95)	22
Feng and Colleagues,[22] 2014	Guangzhou, China	272 dentists	Yes	No	Yes	Prevalence of musculoskeletal pain and frequency of physical activity	Decreased neck pain with regular physical activity (OR, 0.37; 95% CI, 0.14 to 1.00) Incorrect tool selection associated with shoulder pain (OR, 1.43; 95% CI, 1.03 to 1.98) and wrist or hand pain (OR, 2.47; 95% CI, 1.15 to 5.32)	22
Saxena and Colleagues,[23] 2014	Madhya Pradesh, India	213 dentists	Yes	No	Yes	Prevalence of musculoskeletal pain, visual positioning training, and physical activity	Increased low back ($P < .001$) and neck ($P = .002$) pain with direct vision Increased low back pain without physical activity ($P < .001$)	21 Potential sources of bias not discussed
Gupta and Colleagues,[24] 2015	Eastern India	877 dentists	Yes	No	No	Prevalence of musculoskeletal pain and CAM[§] therapies	Higher physical functioning with CAM (OR, 1.51; 95% CI, 1.1 to 3.1)	19 No discussion of limitations No interpretation of results Funding sources (or lack of funding) not acknowledged
Koneru and Tanikonda,[25] 2015	Mumbai, India	220 dentists	Yes	No	No	Prevalence of musculoskeletal pain and type of physical activity	Prevalence of musculoskeletal pain: Yoga: 10.5% Other type of physical activity: 21.7% No regular physical activity: 45.6% Decreased pain with yoga or physical activity compared with no physical activity ($P < .05$)	20 Potential sources of bias not described Funding source (or lack of funding) not acknowledged

Table 1. Continued

STUDY	LOCATION	SAMPLE	INTERVENTIONS			OUTCOME MEASURES	FINDINGS	STROBE SCORE*
			Physical Activity	Ergonomic Training	Equipment Modification			
Shirzaei and Colleagues,[26] 2015	Zahedan, Iran	120 dental students	Yes	Yes	No	Prevalence of musculoskeletal pain and level of physical activity	Decreased pain with exercise ($P < .05$) According to their Rapid Entire Body Assessment scores, 84% of 5th- and 6th-year students were in the medium- to high-risk level for musculoskeletal disorders. Decreased musculoskeletal pain in students aware of posture compared with that in students unaware of posture ($P = .046$)	22
Thanathornwong and Suebnukarn,[27] 2015	Bangkok, Thailand	16 dentists	No	Yes	No	Prevalence of musculoskeletal pain and ergonomic training	Statistically significant decrease in neck and upper back extensions with participants who received feedback in posttest ($P < .05$)	21 Potential sources of bias not discussed
Pejčić and Colleagues,[28] 2017	Serbia	356 dentists	Yes	Yes	No	Prevalence of musculoskeletal pain, postural education, chair design, use of magnification devices, presence of assistants, dentist health status, massage therapy, and exercise	Increased pain with physical activity ($P < .01$) Decreased pain with in-session body posture changing ($P < .05$) and focus on ergonomics ($P < .01$) Increased pain with chairs without lumbar support ($P < .01$) or without armrests ($P < .05$)	17 Lacks description of setting Potential sources of bias not discussed No explanation of study size Lacks discussion of participants No discussion of limitations

In most of the studies that focused on physical activity interventions, the investigators concluded that implementing regular physical activity reduced the frequency of musculoskeletal pain.[20-22,25,26,28] Investigators in 1 study found a significant decrease in pain with 6 to 8 hours of physical activity per week.[21] Investigators in another survey study found that physical activity and massage were the most effective preventive measures for musculoskeletal pain.[28] Compared with walking, jogging, or other forms of aerobic exercise, yoga seemed to decrease musculoskeletal symptoms the most.[25] Similarly, stretching decreased musculoskeletal pain in dental students, and a lack of regular weekly exercise correlated with increased low back pain.[15,26] In contrast, investigators in 2 other studies found no significant relationships between stretching or physical activity with musculoskeletal pain.[16,17] There was no significant relationship between the duration, frequency, or intensity of physical exercise and musculoskeletal pain.[14] Investigators in 1 study on complementary and alternative medicine (CAM) therapies found that these therapies correlated with higher physical functioning but that the CAM therapies used were inconsistent.[24]

Of the 6 studies in which the investigators addressed ergonomic education and training, investigators in 4 studies found that it can decrease musculoskeletal symptoms and pain.[13,17,26,27] According to results from 1 study, dentists who received ergonomic education during dental school were less likely to experience low back pain later in their career.[13] Similarly, investigators in another study concluded that an increased awareness of ergonomic posture when working was linked to a lower risk of developing musculoskeletal pain.[26] In-session body posture adjusting and focusing on ergonomics was correlated with less pain, and chairs without lumbar support and

armrests were associated with more pain.[28] However, dentists who practiced 4-handed dentistry reported more frequent pain; they also reported longer work hours before taking breaks.[12] Investigators in another study found that dentists who did not take rest breaks experienced significantly more hip pain.[17] Lastly, dentists who received postural feedback and recommendations had improvements in neck and upper back extensions during subsequent dental tasks.[27]

Investigators in 3 of the 4 studies focused on equipment modifications, specifically tool and visual modifications, found suggestive evidence that such modifications decreased musculoskeletal pain and symptoms.[13,18,23] In 1 study, dentists experienced decreased leg pain with use of surgical magnification tools and lumbar supports.[13] Findings in another study in which the investigators compared direct and indirect vision indicated that dentists who worked without visual modifications had significantly higher rates of musculoskeletal pain.[23] Investigators in 1 study found that, although there was a decrease in musculoskeletal pain with use of magnification loupes, there was an increase in pain with use of ultrasonic and hand scalers.[18] In addition, investigators in 1 study noted an increase in musculoskeletal symptoms with incorrect tool size; however, there was a nonsignificant finding between extent of symptoms and tool diameter.[22]

Intervention studies

Investigators in the remaining 17 articles described results of prospective intervention studies for the prevention or rehabilitation of MSDs in oral health care professionals (Table 2).[18,29-44] We categorized interventions evaluated as physical activity (n = 6), ergonomic training (n = 6), and equipment modifications (n = 7). We completed quality and bias assessment for these studies by using the Cochrane Risk of Bias assessment (Table 3).[11,18,29-44] Only 2 studies were randomized controlled trials with the opportunity to meet all the criteria, with the remaining intervention trials failing to meet most of the criteria for rigor. Across the studies, common limitations included a small sample size and the use of convenience sampling.

Investigators in the 6 articles focused on physical activity, including various types of physical therapy and stretching, concluded that physical activity had a positive effect on reducing musculoskeletal pain and symptoms.[32,34,37,38,42,44] Investigators in 1 pretest-posttest study compared the outcomes of deep cervical flexor training and isometric training and concluded that both produced significant improvements in the Neck Disability Index and visual analog scale scores.[37] These investigators also found that deep cervical flexor training produced significant improvement in forward head posture.[37] Findings from another study indicated that combining medication and rehabilitation, such as electrotherapy, massage, kinesiotherapy, and home programming, decreased pain and dysfunction more effectively than did medication alone.[38] In addition, investigators in a quasiexperimental study found that 2.5 hours of mid- to high-intensity physical activity per week decreased upper extremity pain.[33] In 1 randomized controlled study, the dentists performed 5 finger stretches before starting scaling and root planing.[44] This intervention successfully reduced the decrease in pinch strength after the dentists performed scaling and root planing.[44] Investigators in another randomized controlled trial implemented an ergonomic training intervention that included stretches, and they found a significant decrease in musculoskeletal pain as measured by using the Nordic Musculoskeletal Questionnaire.[45]

Investigators in 6 studies measured the effect of ergonomic training, including education, analysis, and posture, and found a positive effect on the reduction of musculoskeletal pain and symptoms.[29,30,32,34,40,42] Investigators in 1 case report implemented Global Postural Reeducation combined with Global Active Stretching and found a significant reduction in pain and dysfunction, indicating that a combination of postural education, regular stretching, and physical activity has a positive effect on musculoskeletal pain.[34] Investigators in a randomized controlled trial with a multifaceted ergonomic intervention program found a significant decrease in musculoskeletal pain in the intervention group.[42] In 1 cohort study, the investigators found that most dentists attributed partial to full reduction of musculoskeletal symptoms to the implementation of ergonomic recommendations.[32] Moreover, specific to cervicobrachial disorders, investigators in 1 quasiexperimental study found a significant reduction of symptoms after participants received ergonomic instruction with a psychometric approach.[29] In addition, investigators in 2 case reports and 1 cross-sectional study found that ergonomic education and recommendations had the greatest effect when implemented until the time of follow-up.[30,34,40]

Table 2. Experimental and quasiexperimental studies in which the investigators evaluated a preventive or rehabilitative intervention for a musculoskeletal outcome measure in dental professionals (N = 17).

STUDY	LOCATION	DESIGN	SAMPLE	INTERVENTIONS			OUTCOME MEASURES	FINDINGS	LIMITATIONS
				Physical Activity	Ergonomic Training	Equipment Modification			
Rundcrantz and Colleagues,[29] 1991	Lund, Sweden	Quasiexperimental	45 dentists	No	Yes	No	VAS*	VAS: Psychometric approach results indicated a decrease in pain and discomfort in the neck ($P < .05$). Significant decrease in neck symptoms 5 weeks after intervention ($P < .01$)	Small sample size 5 weeks may not have been adequate time for understanding and implementation of ergonomic techniques
Sanders and Turcotte,[30] 2002	Hamden, Connecticut	Case reports	2 dental hygienists	No	Yes	No	Body map to determine pain levels	Case 1: Follow-up: Decrease in left scapular area pain from 3 of 5 to 1 to 2 of 5 2.5-year follow-up: No pain most of the time, pain level of 2 when stressed Case 2: Follow-up: More relaxed hand because of stretching, no pain in shoulders, minimal pain in wrist 2.5-year follow-up: Symptoms occurred 2 to 3 times per year because of engagement in hobbies	Small sample size
Smith and Colleagues,[31] 2002	North Carolina	Laboratory semiexperimental	5 dental hygienists	No	No	Yes	Neck discomfort	Significant decrease in discomfort with visual modification for both novice and dentist groups	Small sample size Different tasks performed in the 2 parts of the study
Droeze and Jonsson,[32] 2005	The Netherlands	Cohort study	56 dentists	No	Yes	No	Implementation of recommendations MSD† symptoms	53% of participants implemented ergonomic interventions 72% reported pain reduction of their main symptom	Small sample size and low compliance level Questionnaire lacks salience and validation to some extent
von Thiele Schwarz and Colleagues,[33] 2008	Stockholm, Sweden	Quasiexperimental study	162 dentists	Yes	No	No	Physical activity and MSD symptoms	Significant decrease in upper extremity disorders with physical activity ($P = .012$)	Workplace differences affect intervention effects All participants were women
Ferrari and Monticone,[34] 2009	Padova, Italy	Case report	1 dental hygienist	Yes	Yes	No	VAS NPDS‡	VAS: Significant decrease in pain after treatment NPDS: Significant decrease in pain and dysfunction after 2 months of treatment	Small sample size

* VAS: Visual analog scale. † MSD: Musculoskeletal disorder. ‡ NPDS: Neck Pain and Disability Scale. § DASH: Disabilities of the Arm, Shoulder and Hand.

Table 2. Continued

STUDY	LOCATION	DESIGN	SAMPLE	INTERVENTIONS			OUTCOME MEASURES	FINDINGS	LIMITATIONS
				Physical Activity	Ergonomic Training	Equipment Modification			
Branson and Colleagues,[35] 2010	Kansas City, Missouri	Case study	1 dental hygiene student	No	No	Yes	Branson Posture Assessment Instrument and musculoskeletal pain	Branson Posture Assessment Instrument: Positive change in neck and low back posture and mild to unnoticeable pain with magnification loupes	Small sample size Multiple choice journal entries may have limited personal comments in journal
Hayes and Colleagues,[18] 2012	Ourimbah, New South Wales, Australia	Pretest-posttest design	12 dental hygienists	No	No	Yes	DASH[§] and musculoskeletal symptoms	DASH: Significant decrease in pain in treatment group ($P < .04$)	Participants were volunteers. Control not matched to treatment group because of convenience Measurement error and sensitivity
Rempel and Colleagues,[36] 2012	San Francisco, California	Randomized controlled trial	110 dentists and dental hygienists	No	No	Yes	Pain levels in the right wrist or hand, elbow or forearm, and shoulder	Significant decrease in shoulder pain with wider-diameter, light curettes ($P = .02$)	Findings included data of 5 participants who dropped out of study
Gupta and Colleagues,[37] 2013	Delhi, India	Pretest-posttest design	30 dentists	Yes	No	No	Forward head posture Neck Disability Index VAS	Forward head posture: Significant improvement for deep cervical flexion training ($P = .000$) but not for isometrics training Neck Disability Index: Significant improvement for both deep cervical flexion and isometrics training ($P = .000$) VAS: Significant improvement for both deep cervical flexion and isometrics training ($P = .000$)	Small sample size Postures observed and photographically analyzed may not reflect participant's working postures
Nemes and Colleagues,[38] 2013	Timisoara, Romania	Randomized prospective study	390 dentists	Yes	No	No	VAS Health Assessment Questionnaire for Dentists	VAS: Significant decrease in scores at 1 and 2 years Health Assessment Questionnaire for Dentists: Significant decrease in scores in group receiving rehabilitation treatment at 1 and 2 years	Limited information about rehabilitation treatment
Hayes and Colleagues,[39] 2014	Ourimbah, New South Wales, Australia	Pretest-posttest design	12 dental hygienists and 17 final-year dental hygiene students	No	No	Yes	DASH Shoulder range of motion, scapular position, grip and pinch strength	Significant improvement in DASH scores in intervention group ($P < .04$) and worsening of symptoms in control group No statistically significant difference in musculoskeletal measure	Small sample size, convenience sample, predominantly female Nonequivalent control group

Table 2. Continued

STUDY	LOCATION	DESIGN	SAMPLE	INTERVENTIONS			OUTCOME MEASURES	FINDINGS	LIMITATIONS
				Physical Activity	Ergonomic Training	Equipment Modification			
Bedi and Colleagues,[40] 2015	Northern India	Cross-sectional	60 dentists	No	Yes	No	Nordic Musculoskeletal Questionnaire	Standardized Nordic Questionnaire: Significant reduction in pain for dentists who implemented the ergonomic recommendations for 3 months ($P < .048$)	Small sample size because of decreased number of participants at follow-up
Aghilinejad and Colleagues,[41] 2016	Milad Hospital, Tehran Province, Iran	Semiexperimental, census method	75 dentists	No	No	Yes	Musculoskeletal pain	Significant decrease in pain in neck, shoulders and arms, back, elbows, forearms, and the whole body ($P < .05$)	Only the short-term effects were studied during a 7- to 8-hour shift
Dehghan and Colleagues,[42] 2016	Milad Hospital, Tehran Province, Iran	Randomized controlled trial	102 male dentists	Yes	Yes	No	Nordic Musculoskeletal Questionnaire	Nordic Questionnaire: Significant decrease in MSD symptoms with intervention ($P < .05$)	Lack of representation; average age of dentists was fairly young, and there were no female participants
Hayes and Colleagues,[43] 2016	University of Newcastle, Callaghan, Ourimbah, New South Wales, Australia	Pretest-posttest design	12 dental hygienists and 17 final-year dental hygiene students	No	No	Yes	NPDS Cervical range of motion, low-load craniocervical flexion, cervical proprioception, and craniovertebral angle	No significant difference in outcomes according to ANOVA No significant difference in musculoskeletal measures before or after intervention No change in NPDS score between baseline and follow-up for intervention group	Small sample size, convenience sample, predominantly female Nonequivalent control group
Padhye and Colleagues,[44] 2017	Mahatma Gandhi Mission's Dental College and Hospital, Navi Mumbai, India	Randomized controlled study	40 dental professionals	Yes	No	No	3-point pinch with hydraulic pinch gauge (Jamar)	Significant reduction of decrease in pinch strength after scaling and root planing with 5 stretch interventions ($P = .05$)	Small sample size, not stratified for age

Finally, investigators in most of the 7 intervention studies focusing on equipment modifications reported a decrease in musculoskeletal symptoms.[31,35,36,39,41] Investigators in 6 studies assessed changes in pain, discomfort, and function with use of visual modifications such as magnification loupes and prism glasses, and most found a decrease in neck discomfort and improvement in posture.[31,35,39,41,43] Investigators in 1 study did not find a significant difference in neck pain when participants wore magnification loupes.[43] Investigators in a single case study reported that musculoskeletal pain was mild or unnoticeable when the participant was using loupes.[35] Moreover, investigators in 1 randomized controlled trial assessed the effect of periodontal curette handles of varying weight and diameter and found that using lighter curettes with a handle of larger diameter significantly improved pain levels in the shoulder region.[36]

DISCUSSION

Physical activity

Insufficient literature is available to suggest conclusively that physical activity benefits dentists and dental hygienists in alleviating musculoskeletal pain. Because participants in most studies

Table 3. Risk of bias assessment for all prospective intervention studies included in the review.

STUDY	RANDOM SEQUENCE GENERATION	ALLOCATION CONCEALMENT	PERFORMANCE BIAS: BLINDING OF PARTICIPANTS AND PERSONNEL	DETECTION BIAS: BLINDING OF PATIENT-REPORTED OUTCOME ASSESSMENT	ATTRITION: SHORT TERM (2-6 WEEKS)	ATTRITION: LONG TERM (> 6 WEEKS)	REPORTING BIAS
Rundcrantz and Colleagues,[29] 1991	+*	–	–	–	NA†	NA	+
Sanders and Turcotte,[30] 2002	–	–	–	–	NA	NA	–
Smith and Colleagues,[31] 2002	–	–	–	–	NA	NA	–
Droeze and Jonsson,[32] 2005	–	–	–	–	NA	NA	–
von Thiele Schwarz and Colleagues,[33] 2008	+	–	–	–	+	+	+
Ferrari and Monticone,[34] 2009	–	–	–	–	NA	NA	–
Branson and Colleagues,[35] 2010	–	–	–	–	NA	NA	–
Hayes and Colleagues,[18] 2012	–	–	–	–	NA	NA	–
Rempel and Colleagues,[36] 2012	+	+	+	+	+	+	+
Gupta and Colleagues,[37] 2013	+	–	–	–	+	+	+
Nemes and Colleagues,[38] 2013	+	–	–	–	NA	–	+
Hayes and Colleagues,[39] 2014	–	–	–	–	NA	NA	–
Bedi and Colleagues,[40] 2015	–	–	–	–	–	–	–
Aghilinejad and Colleagues,[41] 2016	–	–	–	–	NA	NA	+
Dehghan and Colleagues,[42] 2016	+	–	–	–	NA	NA	+
Hayes and Colleagues,[43] 2016	–	–	–	–	NA	NA	–
Padhye and Colleagues,[44] 2017	+	–	–	U‡	NA	NA	+

* +: The article meets this criterion. —: The article does not meet this criterion. † Not applicable due to study design. ‡ U: Unable to determine.

implemented physical exercise after musculoskeletal symptoms were present, there are few data on the preventive effects of physical activity. Investigators in most studies concerning physical activity, cross-sectional and prospective, focused on exercise that involved the entire body. Investigators in many cross-sectional studies did not differentiate specific types or intensity of exercise, making the findings hard to translate into practice. The studies in which the investigators found significant improvement with physical activity often had limitations such as small sample size or inadequate explanation of the rehabilitation treatment.[37,38,44] Of the different types of physical activity studied, yoga was the most beneficial for decreasing pain once symptoms already were present. Investigators in the cross-sectional study who considered the use of CAM found that it correlated with higher levels of physical functioning but that the therapies used were too varied and inconsistent to draw any definitive conclusions.[24]

Compared with medication alone, a combination of rehabilitation and medication seemed to work better.[38] Investigators in 1 case study implemented both postural reeducation and physical activity and found improvement by measuring change by using a visual analog scale.[34] However,

this study included only a single dental hygienist. According to results from these 2 studies, it seems that once musculoskeletal symptoms are present, a combination of different interventions could provide pain relief.

Investigators in 1 cross-sectional study compared the effect of different durations of physical activity, but there was not enough information about the intensity or type of activity to translate the findings into practice.[21] Investigators in another study implemented finger exercises and stretches before the hygienists performed scaling and root planing.[44] The investigators in this study looked only at the decrease in pinch strength before and after performing scaling and root planing, and the results provided only suggestive evidence about musculoskeletal pain.

Ergonomic training

According to results from the studies reviewed, when ergonomic training is implemented in practice, it seems to decrease musculoskeletal pain effectively, which shows the importance of education, as well as the potential of symptom exacerbation with a lack of education. However, hobbies outside of work also may affect musculoskeletal symptoms. In addition, investigators in 1 study found that 4-handed dentistry significantly increased musculoskeletal pain, but this finding may have resulted from inadequate understanding of the technique.[12] Although results from most intervention studies showed a decrease in musculoskeletal pain after participants received ergonomic training, most of these studies had small sample sizes.[29,30,32,34,40] Despite limitations, when participants of ergonomic training studies followed ergonomic recommendations, researchers found the greatest decrease in pain, which suggests potential positive effects for ergonomic training. Further research to develop and evaluate methods to promote ongoing and sustained implementation of ergonomic recommendations in clinical practice would be a beneficial next step to advance the effectiveness of ergonomic training for reducing MSDs in oral health care professionals.

Equipment modification

Results in the literature also suggested that tools that promote proper ergonomic techniques have the potential to decrease the prevalence of musculoskeletal pain. In most of the studies concerning equipment modification, the investigators implemented loupes to improve posture and decrease neck and back pain. Positive findings relative to the use of loupes to decrease neck discomfort and improve posture limit the interpretation as a general recommendation for the overall use of loupes because investigators evaluated a variety of through-the-lens and flip-up loupe styles across the studies.[31,35,36,39,41,43] Moreover, investigators in none of the studies discussed the evaluation of loupes capable of vertical adjustment to alter and maximize declination angles, which can promote the achievement of neutral neck positioning across users in all working situations. In addition to heterogeneity of loupe type, intervention studies were limited by small sample sizes, nonequivalent control groups, and a lack of data on long-term effects,[31,35,36,39,41,43] and investigators in cross-sectional studies primarily failed to state potential sources of bias.[13,18,23] Future research investigators should assess differential or comparative effectiveness across various styles of equipment, especially between fixed and vertically adjustable loupes, which would be beneficial in advancing knowledge of the most effective modifications for improving posture and reducing musculoskeletal discomfort.

Study quality

Although investigators in some studies established tentative links between physical activity, ergonomic training, and equipment modification and the prevalence of MSDs in oral health care professionals, rigor and conclusive evidence are lacking. As required by the STROBE checklist, investigators in cross-sectional studies should report the source of funding, potential sources of bias, and limitations of the study.[10] However, investigators in many of the studies did not include these areas. Also, most of the studies relied on surveys, which fail to prove causality because of their retrospective nature. In addition, investigators in many studies used convenience sampling by surveying local schools, organizations, and institutions and did not explain sample selection or size.

Intervention studies had similar issues in participant selection, such as small sample size and convenience sampling, thus not being representative of oral health care professionals.[11] Also, many studies were too brief to allow measurement of the long-term effects of the interventions. The nature of the interventions often did not lend themselves to allocation concealment, and

investigators in many studies did not randomize allocation. Although there were several articles about rehabilitative care, none of them had results showing a preventive intervention that reduces the risk of developing MSDs in oral health care professionals.

Limitations

We included only studies published in the English language in the systematic review, which may have led to biases because of available information. Despite the large number of studies reviewed, investigators in few of them focused on preventive and rehabilitative care for MSDs in oral health care professionals. Therefore, we included some articles of low rigor, such as case reports.

CONCLUSIONS

This systematic review's results clearly showed the lack of evidence in the field of preventive and rehabilitative care related to oral health care professionals, and, to our knowledge, there are no other systematic reviews about this subject. Robust research is lacking that otherwise could constitute a body of evidence to support any of the 3 categories of interventions: physical activity, ergonomic training, and equipment modification. Given the high prevalence of MSDs in oral health care professionals and the fact that these problems may begin to develop during the education process, early intervention is crucial for the prevention and treatment of these disorders.[15] Investigators should conduct further interventional research on the topic to provide sufficient support for oral health care professionals. ■

Dr. Roll is an associate professor, Chan Division of Occupational Science and Occupational Therapy, University of Southern California, 1540 Alcazar St., CHP 133, Los Angeles, CA 90089-9003, e-mail sroll@usc.edu. Address correspondence to Dr. Roll.

Dr. Tung is a post-doctoral trainee, Chan Division of Occupational Science and Occupational Therapy, University of Southern California, Los Angeles, CA.

Dr. Chang is a research assistant, Chan Division of Occupational Science and Occupational Therapy, University of Southern California, Los Angeles, CA.

Dr. Sehremelis is a research assistant, Chan Division of Occupational Science and Occupational Therapy, University of Southern California, Los Angeles, CA.

Ms. Fukumura is a research assistant, Chan Division of Occupational Science and Occupational Therapy, University of Southern California, Los Angeles, CA.

Ms. Randolph is a research assistant, Chan Division of Occupational Science and Occupational Therapy, University of Southern California, Los Angeles, CA.

Dr. Forrest is a professor, clinical dentistry, Ostrow School of Dentistry, University of Southern California, Los Angeles, CA.

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