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Prevalence and Ergonomic Intervention Strategies for Preventing Musculoskeletal Disorders among Dental Clinicians: A Cross-Sectional Study

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ABSTRACT

Musculoskeletal disorders (MSDs) are a common occupational health problem among dental clinicians, affecting their physical well-being and work performance. This study aimed to determine the prevalence of MSDs and evaluate the effectiveness of a structured ergonomic intervention. A cross-sectional study was conducted among 487 dental clinicians from 45 practices between January and August 2024. Baseline assessments used the Nordic Musculoskeletal Questionnaire (NMQ) and Rapid Upper Limb Assessment (RULA). Participants then completed a 6-month intervention including workstation modifications, postural training, and exercise programs.The 12-month prevalence of MSDs was 82.3%, with the neck, lower back, and shoulders most frequently affected. Longer years of practice, extended working hours, and poor ergonomic practices were significant risk factors. After the intervention, pain intensity decreased significantly and RULA scores improved ($p < .001$).These findings indicate that MSDs are highly prevalent among dental clinicians; however, structured ergonomic interventions can effectively reduce symptoms and improve occupational health outcomes.

Keywords: *Musculoskeletal disorders, Dental clinicians, Ergonomic intervention, Occupational health, Work-related pain*

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INTRODUCTION

Musculoskeletal disorders (MSDs) represent one of the most prevalent occupational health problems affecting healthcare workers globally, with dental clinicians experiencing particularly high rates of work-related musculoskeletal pain and dysfunction (Hayes et al., 2009). The nature of dental practice requires clinicians to maintain static postures for prolonged periods, perform repetitive fine motor movements, and work in constrained positions while providing patient care. These biomechanical demands, combined with inadequate workplace ergonomics, contribute to the development of chronic pain syndromes affecting the neck, shoulders, back, and upper extremities (Valachi & Valachi, 2003). The consequences of MSDs extend beyond physical discomfort, impacting professional productivity, quality of patient care, career satisfaction, and ultimately leading to early retirement from clinical practice.

Recent epidemiological studies have documented alarmingly high prevalence rates of MSDs among dental professionals. A systematic review by Lietz et al. (2018) reported that between 64% and 93% of dentists experience work-related musculoskeletal symptoms at some point in their careers, with the neck and lower back being the most commonly affected anatomical regions. Similarly, Morse et al. (2010) found that dental hygienists demonstrate even higher prevalence rates, with up to 96% reporting musculoskeletal pain in at least one body region. More recent investigations have revealed that dental assistants, often overlooked in occupational health research, also experience significant musculoskeletal burden, with prevalence rates comparable to those of dentists and hygienists (Custodio et al., 2021). These findings suggest that MSDs represent a universal challenge across all dental occupational categories, regardless of specific job duties or responsibilities.

The etiology of work-related MSDs in dental practice is multifactorial, involving complex interactions between physical, psychosocial, and individual risk factors. Physical risk factors include prolonged static postures, particularly forward head positioning and trunk flexion; repetitive movements associated with instrumentation; forceful exertions during procedures; and vibration exposure from handpieces (Gupta et al., 2014). Psychosocial factors such as high job demands, time pressures, and limited control over work organization have also been implicated in MSD development (Feng et al., 2014). Individual factors including age, gender, body mass index, physical fitness level, and pre-existing musculoskeletal conditions further modulate individual susceptibility to work-related pain. Understanding this complex interplay of risk factors is essential for developing comprehensive prevention strategies.

Despite widespread recognition of MSDs as a significant occupational health concern in dentistry, implementation of evidence-based preventive strategies remains inconsistent across dental practice settings. While various ergonomic interventions have been proposed including workstation redesign, equipment modifications, postural training programs, and regular exercise protocols their adoption in clinical practice has been limited. Barriers to implementation include lack of awareness about proper ergonomic principles, insufficient time for training, financial constraints associated with equipment upgrades, and skepticism regarding intervention effectiveness (Partido

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& Stefanac, 2018). Furthermore, most existing research has focused on prevalence documentation rather than rigorous evaluation of intervention strategies, leaving a critical gap in the evidence base for ergonomic practice guidelines in dentistry.

Therefore, this cross-sectional study was designed to address these gaps by: (1) determining the current prevalence and distribution of MSDs among a diverse sample of dental clinicians including dentists, dental hygienists, and dental assistants; (2) identifying specific risk factors associated with increased MSD prevalence through comprehensive assessment of work practices, postural behaviors, and workplace ergonomics; (3) implementing and evaluating a multicomponent ergonomic intervention program over a 6-month period; and (4) assessing the effectiveness of specific intervention components in reducing musculoskeletal symptoms and improving workplace ergonomics. The novelty of this research lies in its integrated approach combining detailed prevalence assessment with prospective intervention evaluation across multiple dental occupational groups, providing practical evidence for clinical implementation of ergonomic best practices.

METHODS

1. Study Design and Setting

This cross-sectional study with a prospective intervention component was conducted between January and August 2024 across 45 dental practices in three states (Michigan, New York, and Maryland). The study was approved by the Institutional Review Board of the University of Michigan (Protocol #HUM00198765) and was conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent prior to enrollment.

2. Participants and Sampling

Dental practices were recruited through professional dental associations and convenience sampling. Inclusion criteria for participants were: (1) actively practicing dental clinician (dentist, dental hygienist, or dental assistant); (2) minimum of 1 year of clinical experience; (3) working at least 20 hours per week in direct patient care; and (4) willingness to participate in the 6-month intervention program. Exclusion criteria included: (1) current pregnancy; (2) recent musculoskeletal injury or surgery within the past 6 months unrelated to work; (3) diagnosed systemic inflammatory conditions affecting musculoskeletal system; and (4) plans to change employment during the study period. Of 542 eligible clinicians approached, 487 agreed to participate, yielding a response rate of 89.9%. The final sample consisted of 198 dentists (40.7%), 176 dental hygienists (36.1%), and 113 dental assistants (23.2%).

3. Data Collection Instruments

a. Demographic and Work Characteristics

A structured questionnaire collected demographic information (age, gender, body mass index, physical activity level) and work-related variables including years in practice, average daily

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working hours, number of patients seen per day, types of procedures performed, workstation characteristics, and previous ergonomic training.

b. Nordic Musculoskeletal Questionnaire (NMQ)

The validated Nordic Musculoskeletal Questionnaire (Kuorinka et al., 1987) was used to assess the prevalence, location, and severity of musculoskeletal symptoms. The NMQ evaluates nine anatomical regions: neck, shoulders, upper back, elbows, wrists/hands, lower back, hips/thighs, knees, and ankles/feet. For each region, participants reported whether they experienced pain, aching, or discomfort during the past 12 months and past 7 days, whether symptoms prevented normal work activities, and whether they sought medical consultation. Pain intensity was measured using a Visual Analog Scale (VAS) ranging from 0 (no pain) to 10 (worst imaginable pain).

c. Rapid Upper Limb Assessment (RULA)

Work posture was objectively assessed using the Rapid Upper Limb Assessment (RULA) tool (McAtamney & Corlett, 1993), which evaluates biomechanical loading on the neck, trunk, and upper limbs. Trained observers conducted postural assessments during typical clinical procedures, photographing participants at multiple time points. RULA scores range from 1 to 7, with higher scores indicating greater ergonomic risk: 1-2 (acceptable posture), 3-4 (investigate further and change soon), 5-6 (investigate and change soon), and 7 (investigate and change immediately).

d. Ergonomic Practices Checklist

A comprehensive 40-item ergonomic practices checklist was developed based on established dental ergonomic guidelines (Valachi, 2008). The checklist assessed workstation setup (operator stool adjustment, patient chair positioning, equipment placement), lighting conditions, use of magnification loupes, positioning techniques, break frequency and duration, and stretching exercise practices. Each item was scored as present (1) or absent (0), with total scores ranging from 0 to 40, where higher scores indicated better ergonomic practices.

4. Intervention Program

Following baseline assessment, participants received a comprehensive 6-month ergonomic intervention program consisting of three main components: (1) Workstation Modification individual consultations to optimize operator stool height and positioning, patient chair adjustments, instrument tray placement, and lighting; provision of ergonomic equipment including adjustable stools, magnification loupes (for those not already using them), and neutral-position instrument handles where indicated; (2) Postural Training three 2-hour workshops covering dental ergonomic principles, neutral positioning strategies, patient positioning techniques, and body mechanics during common procedures; participants received illustrated reference guides and video demonstrations; and (3) Exercise Protocol structured exercise program including workplace stretching routines (neck, shoulder, back, and wrist stretches performed every 2 hours), strengthening exercises for postural muscles, and general conditioning recommendations. Participants received exercise instruction sheets with photographs and were encouraged to perform exercises daily.

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Intervention compliance was monitored through monthly check-ins via email surveys asking about adherence to recommended practices. At 3-month and 6-month intervals, participants completed follow-up assessments including repeat NMQ, VAS pain scores, RULA observations, and ergonomic practices checklist.

5. Statistical Analysis

Data were analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY). Descriptive statistics including frequencies, percentages, means, and standard deviations were calculated for all variables. The 12-month prevalence of MSDs was calculated as the proportion of participants reporting symptoms in each anatomical region. Chi-square tests were used to compare prevalence rates across occupational groups and demographic categories. Independent samples t-tests and one-way ANOVA compared continuous variables (pain intensity, RULA scores, ergonomic practice scores) across groups. Logistic regression analysis identified independent predictors of MSD presence, with odds ratios (OR) and 95% confidence intervals (CI) reported. Variables significant at $p < .20$ in univariate analyses were entered into multivariate models. Repeated measures ANOVA assessed changes in pain intensity and RULA scores across baseline, 3-month, and 6-month assessments. Statistical significance was set at $p < .05$ (two-tailed).

RESULTS

1. Participant Characteristics

The final sample of 487 participants had a mean age of 38.4 ± 9.7 years (range: 23-64 years). The majority were female (n = 356, 73.1%), reflecting the gender distribution in dental professions. Mean years in practice was 12.8 ± 8.3 years, with dentists having significantly more experience (15.6 ± 9.1 years) compared to dental hygienists (11.2 ± 7.4 years) and dental assistants (9.8 ± 6.9 years) ($F(2, 484) = 18.4$, $p < .001$). Participants worked an average of 36.2 ± 6.8 hours per week, with dentists reporting the highest weekly hours (39.1 ± 5.9 hours). Only 34.5% of participants (n = 168) reported receiving formal ergonomic training during their professional education or continuing education courses. Table 1 presents complete demographic and work-related characteristics stratified by occupational group.

Table 1. Demographic and work-related characteristics of participants by occupational group

Characteristic	Dentists (n=198)	Hygienists (n=176)	Assistants (n=113)	Total (n=487)
Age (years), mean ± SD	40.2 ± 10.1	37.1 ± 9.2	36.8 ± 9.4	38.4 ± 9.7
Female, n (%)	98 (49.5%)	169 (96.0%)	89 (78.8%)	356 (73.1%)
Years in practice, mean ± SD	15.6 ± 9.1	11.2 ± 7.4	9.8 ± 6.9	12.8 ± 8.3
Hours worked/week, mean ± SD	39.1 ± 5.9	34.8 ± 6.5	33.2 ± 7.2	36.2 ± 6.8

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2. Prevalence of Musculoskeletal Disorders

The overall 12-month prevalence of work-related MSDs was 82.3% (n = 401), with participants reporting symptoms in at least one anatomical region. The most commonly affected body regions were the neck (67.8%, n = 330), lower back (64.3%, n = 313), and shoulders (58.1%, n = 283). Upper back pain was reported by 48.7% (n = 237), wrist/hand symptoms by 42.5% (n = 207), and elbow pain by 23.6% (n = 115) of participants. Lower extremity symptoms were less common, with hip/thigh (18.3%), knee (15.8%), and ankle/foot (12.1%) pain reported least frequently.

Significant differences in prevalence were observed across occupational groups. Dental hygienists reported the highest overall MSD prevalence (89.2%), followed by dental assistants (82.3%) and dentists (76.3%) ($\chi^2 = 12.4$, $p = .002$). Hygienists also showed significantly higher prevalence of neck pain (78.4% vs. 62.1% for dentists, $p < .001$) and shoulder pain (68.2% vs. 51.5% for dentists, $p = .001$). The 7-day point prevalence showed similar patterns, with 58.7% of participants reporting current symptoms. Notably, 34.9% of participants (n = 170) reported that musculoskeletal symptoms had prevented them from performing normal work activities during the past 12 months, and 28.5% (n = 139) had sought medical consultation for work-related pain.

Mean pain intensity scores on the VAS were highest for the neck (5.8 ± 2.3), followed by lower back (5.4 ± 2.5) and shoulders (5.1 ± 2.4). Multiple-site pain was common, with 63.2% of symptomatic participants reporting pain in three or more body regions simultaneously. The number of affected body regions correlated significantly with years in practice ($r = .34$, $p < .001$) and weekly working hours ($r = .28$, $p < .001$).

3. Work Posture and Ergonomic Practices Assessment

RULA assessment revealed that 72.1% of participants (n = 351) scored in the high-risk categories (scores 5-7), requiring immediate investigation and corrective action. The mean RULA score was 5.6 ± 1.2, with dental hygienists showing the highest mean scores (6.1 ± 1.1) compared to dentists (5.4 ± 1.2) and assistants (5.3 ± 1.3) ($F(2, 484) = 16.7$, $p < .001$). Common postural problems identified included excessive neck flexion (present in 81.3% of observations), forward head posture (74.5%), shoulder elevation (62.8%), trunk rotation or lateral bending (56.1%), and static holding of instruments with sustained muscle contraction (68.9%).

Ergonomic practices assessment using the 40-point checklist revealed substantial deficiencies in workplace ergonomics. The mean ergonomic practice score was 18.7 ± 6.4 out of 40, indicating that less than half of recommended ergonomic practices were routinely implemented. Specific deficiencies included: inadequate operator stool adjustment (only 23.4% had properly adjusted stools), suboptimal patient positioning (31.2% consistently positioned patients appropriately), insufficient use of magnification loupes (42.9% used loupes regularly), infrequent microbreaks (only 15.8% took recommended 30-second breaks every 20-30 minutes), and lack of structured stretching routines (8.8% performed regular workplace stretches).

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4. Risk Factors for Musculoskeletal Disorders

Multivariate logistic regression analysis identified several independent predictors of MSD presence. Years in practice emerged as a significant risk factor, with clinicians practicing >10 years having 2.34 times higher odds of MSDs compared to those with ≤5 years experience (OR = 2.34, 95% CI: 1.56-3.51, $p < .001$). Working more than 35 hours per week was associated with increased MSD risk (OR = 1.89, 95% CI: 1.23-2.91, $p = .004$). Poor ergonomic practices, defined as scoring in the lowest tertile on the ergonomic practices checklist, showed the strongest association with MSDs (OR = 3.12, 95% CI: 2.14-4.55, $p < .001$).

High RULA scores (≥5) were significantly associated with neck pain (OR = 2.87, 95% CI: 1.89-4.36, $p < .001$), shoulder pain (OR = 2.45, 95% CI: 1.67-3.58, $p < .001$), and upper back pain (OR = 2.12, 95% CI: 1.45-3.10, $p < .001$). Female gender was associated with higher MSD prevalence (OR = 1.67, 95% CI: 1.12-2.49, $p = .012$), consistent with epidemiological patterns in occupational musculoskeletal research. Lack of previous ergonomic training was associated with increased odds of MSDs (OR = 1.78, 95% CI: 1.24-2.56, $p = .002$). Physical inactivity (engaging in <150 minutes of moderate exercise per week) also increased MSD risk (OR = 1.52, 95% CI: 1.08-2.14, $p = .016$).

5. Intervention Outcomes

Of the 487 participants enrolled, 441 (90.6%) completed the full 6-month intervention program. Repeated measures ANOVA revealed significant improvements across all outcome measures. Mean VAS pain intensity for the neck decreased from baseline 5.8 ± 2.3 to 3.9 ± 2.1 at 3 months and 2.6 ± 1.9 at 6 months ($F(2, 880) = 124.5$, $p < .001$), representing a mean reduction of 3.2 points. Similar improvements were observed for lower back pain (baseline 5.4 ± 2.5 to 6-month 2.8 ± 2.0, $p < .001$) and shoulder pain (baseline 5.1 ± 2.4 to 6-month 2.7 ± 1.8, $p < .001$).

RULA scores showed significant improvement, decreasing from a mean baseline score of 5.6 ± 1.2 to 4.1 ± 1.3 at 3 months and 3.2 ± 1.1 at 6 months ($F(2, 880) = 287.3$, $p < .001$). The proportion of participants in the high-risk RULA categories (scores 5-7) decreased from 72.1% at baseline to 31.5% at 6 months ($p < .001$). Ergonomic practices scores improved substantially, from 18.7 ± 6.4 at baseline to 32.4 ± 5.8 at 6 months ($t(440) = 42.3$, $p < .001$), indicating adoption of recommended ergonomic behaviors.

Analysis of specific intervention components revealed that participants who received all three components (workstation modification + postural training + exercise protocol) showed greater improvements compared to those who implemented only one or two components. Complete intervention adherence was associated with a 4.1-point reduction in neck pain VAS scores versus 2.3-point reduction for partial adherence ($t(439) = 6.8$, $p < .001$). Self-reported adherence to the exercise protocol was associated with greater pain reduction ($r = -.42$, $p < .001$) and improved RULA scores ($r = -.38$, $p < .001$). Use of magnification loupes, implemented by 58.3% of participants who were not previously using them, was associated with significant reductions in neck and upper back pain ($p < .001$).

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DISCUSSION

This cross-sectional study with prospective intervention assessment provides comprehensive evidence regarding the prevalence, risk factors, and preventive strategies for work-related musculoskeletal disorders among dental clinicians. The findings confirm that MSDs represent a pervasive occupational health challenge in dental practice, with over four-fifths of clinicians experiencing symptoms affecting their capacity to work effectively. Importantly, the study demonstrates that multicomponent ergonomic interventions can substantially reduce musculoskeletal symptoms and improve workplace ergonomics when systematically implemented and maintained over time.

The observed 12-month MSD prevalence of 82.3% aligns closely with previous epidemiological investigations. The systematic review by Lietz et al. (2018) reported prevalence rates ranging from 64% to 93%, with our findings falling within this established range. The anatomical distribution of symptoms, with neck, lower back, and shoulders most commonly affected, mirrors patterns documented across multiple international studies (Hayes et al., 2009; Morse et al., 2010). These consistent findings across diverse geographical and cultural contexts suggest that the biomechanical demands inherent to dental practice, rather than regional practice variations, primarily drive MSD development.

The higher prevalence among dental hygienists (89.2%) compared to dentists (76.3%) warrants particular attention. This occupational disparity may reflect differences in work organization and task characteristics. Hygienists typically perform repetitive scaling and root planing procedures requiring sustained static postures over extended periods, whereas dentists engage in more varied procedures with greater postural diversity. Additionally, hygienists often have less control over their work schedules and patient flow, potentially limiting opportunities for recovery breaks a factor previously associated with increased MSD risk (Feng et al., 2014). The similarly high prevalence among dental assistants, despite different task profiles, suggests that multiple pathways to MSD development exist within dental practice environments.

The RULA assessment findings reveal concerning levels of biomechanical loading, with nearly three-quarters of participants demonstrating high-risk postures requiring immediate intervention. The specific postural deficiencies identified excessive neck flexion, forward head posture, and shoulder elevation represent well-established MSD risk factors supported by biomechanical research. Forward head posture increases cervical spine loading exponentially; for every inch of anterior head translation, cervical compression forces increase by approximately 10 pounds (Hansraj, 2014). Prolonged maintenance of these postures during clinical work creates cumulative microtrauma to musculoskeletal structures, ultimately manifesting as chronic pain syndromes.

The identification of poor ergonomic practices as the strongest independent predictor of MSDs (OR = 3.12) emphasizes the modifiable nature of MSD risk. The low baseline ergonomic practice scores (mean 18.7 out of 40) indicate substantial room for improvement through targeted interventions. Particularly concerning is the finding that only 23.4% of participants had properly

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adjusted operator stools and merely 8.8% performed regular workplace stretches—two fundamental ergonomic practices with established protective effects (Valachi & Valachi, 2003). These deficiencies likely reflect multiple barriers including lack of ergonomic knowledge, time constraints, workplace culture that does not prioritize preventive behaviors, and absence of systematic implementation frameworks.

The strong association between years in practice and MSD prevalence highlights the cumulative nature of biomechanical exposure. This dose-response relationship supports the hypothesis that MSDs develop through chronic repetitive microtrauma rather than acute injury events. The clinical implication is that prevention must begin early in professional careers, ideally during dental education, rather than waiting until symptoms emerge. Educational institutions should integrate comprehensive ergonomic training into curricula, establishing proper work habits before mal-adaptive patterns become entrenched.

The intervention findings provide robust evidence for the effectiveness of multicomponent ergonomic programs. The mean 3.2-point reduction in neck pain VAS scores exceeds the minimal clinically important difference of 1.5 points established for chronic musculoskeletal pain (Farrar et al., 2001), indicating not merely statistical but clinically meaningful improvements. The improvements in RULA scores, with the proportion in high-risk categories declining from 72.1% to 31.5%, demonstrate successful modification of biomechanical risk factors. Importantly, these improvements were sustained through the 6-month follow-up period, suggesting that participants successfully integrated ergonomic practices into their daily work routines.

The finding that complete intervention adherence (all three components) produced superior outcomes compared to partial adherence supports a comprehensive approach to MSD prevention. Workstation modifications alone, while important, appear insufficient without concurrent behavioral changes. The strong correlation between exercise protocol adherence and pain reduction aligns with extensive evidence supporting therapeutic exercise for chronic musculoskeletal pain management (Gross et al., 2015). Regular stretching and strengthening exercises likely provide both immediate biomechanical benefits (improved tissue flexibility and postural muscle endurance) and neurophysiological effects (pain modulation through descending inhibitory pathways).

The positive impact of magnification loupes adoption deserves emphasis. Loupes enable improved visual access while maintaining more neutral neck and trunk postures, reducing cumulative cervical spine loading. Our finding that loupe use significantly reduced neck and upper back pain supports previous observational studies (Hayes et al., 2016) and provides prospective evidence for this widely recommended but inconsistently adopted ergonomic aid. The initial cost of loupes may deter some clinicians; however, given the high prevalence and impact of MSDs, this investment appears justified from both individual well-being and practice productivity perspectives.

Several study limitations warrant acknowledgment. The convenience sampling approach and voluntary participation may have introduced selection bias, potentially recruiting clinicians with greater MSD awareness or symptom burden. The lack of a true control group limits causal

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inference regarding intervention effects, although the prospective design and magnitude of improvements provide strong suggestive evidence. Intervention adherence was assessed through self-report rather than objective monitoring, potentially overestimating actual compliance. The 6-month follow-up period, while demonstrating sustained improvements, does not address long-term maintenance beyond this timeframe. Future research should employ randomized controlled designs with longer follow-up periods to definitively establish intervention efficacy and optimal implementation strategies.

Despite these limitations, the study provides actionable evidence for dental practice administrators, occupational health professionals, and individual clinicians. The high prevalence rates underscore the urgent need for systematic MSD prevention programs in dental practice settings. The intervention results demonstrate that meaningful symptom reduction and ergonomic improvement are achievable through comprehensive, multicomponent approaches. Implementation recommendations include: (1) establishing ergonomic assessment and intervention as standard components of dental practice management; (2) integrating comprehensive ergonomic education into dental curricula at undergraduate and continuing education levels; (3) promoting workplace cultures that prioritize prevention behaviors including regular breaks and stretching; (4) providing financial support or incentives for ergonomic equipment acquisition; and (5) conducting regular ergonomic audits to identify and address risk factors proactively.

CONCLUSIONS

Musculoskeletal disorders affect the overwhelming majority of dental clinicians, with prevalence exceeding 80% across occupational categories. The neck, lower back, and shoulders represent the most vulnerable anatomical regions, reflecting the biomechanical demands inherent to dental practice. Poor ergonomic practices, prolonged occupational exposure, and excessive working hours emerge as significant modifiable risk factors contributing to MSD development. These findings emphasize the critical importance of prevention rather than reactive symptom management.

Importantly, this study demonstrates that comprehensive ergonomic interventions combining workstation modifications, postural training, and structured exercise protocols can produce clinically meaningful reductions in musculoskeletal symptoms and substantial improvements in workplace ergonomics. The magnitude of improvements observed including 3.2-point reductions in neck pain intensity and transition of over 40% of participants from high-risk to acceptable postural categories provides compelling evidence for systematic implementation of such programs across dental practice settings.

Moving forward, the dental profession must prioritize occupational health as a fundamental component of professional practice. Educational institutions should integrate comprehensive ergonomic training into curricula, practice administrators should establish systematic ergonomic programs, and individual clinicians should commit to implementing evidence-based preventive behaviors. Future research should focus on long-term intervention sustainability, cost-effectiveness

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analyses, and identification of optimal implementation strategies for diverse practice settings. By addressing the MSD epidemic through evidence-based prevention, the dental profession can enhance clinician well-being, improve career longevity, and ultimately better serve patient populations through a healthier, more sustainable workforce.

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