Review

Ergonomic interventions to prevent work-related musculoskeletal disorders and pain among dental professionals

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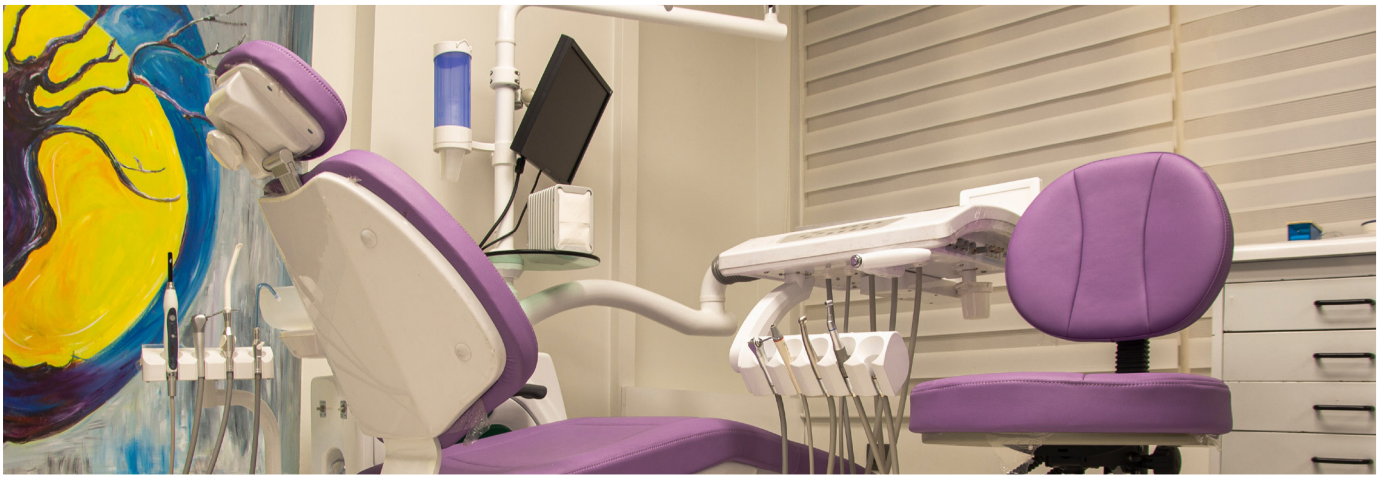

Abbreviations

CC1 - Conventional chair with back rest
CC2 - Conventional chair without back rest
ICC - Intraclass correlation coefficients
DASH - Disabilities of the Arm, Shoulder and Hand
Df - Degrees of freedom
MSDs - Musculoskeletal disorders
MSK - Musculoskeletal
PAC - Posture Assessment Criteria
PICO - Population, Intervention, Comparator, Outcome
RCTs - Randomised controlled trials
RULA - Rapid Upper Limb Assessment
SSC - Salli saddle chair
Vs - Versus

Background Musculoskeletal disorders (MSDs) and pain at work are among the most common occupational disorders worldwide. Such disorders are caused by a variety of factors. However, in dentistry, MSDs are primarily caused by treatment delivery methods such as awkward posturing and working for prolonged hours. The purpose of this literature review is to establish available ergonomic interventions for dental professionals and their role in reducing MSDs.

Search methods Electronic databases (PubMed and Google Scholar) were searched for relevant records to the question of interest. The last search was carried out on 7 June 2022.

Eligibility criteria Randomised controlled trials (RCTs), intervention or evaluation studies and cohort studies published in English and after January 2005 to date were eligible for inclusion.

Conclusion Ergonomic interventions, particularly magnification loupes, Salli Saddle Chair with magnification, ergonomic education and training courses and light dental instruments with wide diameter are effective in improving MSDs symptoms (neck, shoulder and lower back) and working posture. Such interventions should be implemented at early stages of the undergraduate curriculum to prevent MSDs development later in life.

Introduction

Dentistry is a physically demanding profession whereby high levels of clinical training is paramount. Cumulative exposure to such training places undesirable stress on various body regions, affecting one's productivity and therefore increasing the risk of developing work-related musculoskeletal disorders (MSDs) and pain. MSDs are injuries to the musculoskeletal (MSK) system occurring due to singular or repetitive trauma, severely affecting one's daily life. They can manifest in the upper limbs (forearm and wrist), postural muscles (neck, shoulders, upper and lower back) and lower extremities (hips, thighs, knees and ankles). Untreated MSDs can potentially develop into degenerative and inflammatory processes such as tendonitis and carpal tunnel syndrome.[1]

Dentistry carries a concerningly high prevalence for MSDs worldwide. In the US, approximately 46% to 71% of dental students report body pain with the percentage rising by school year. Due to physical differences and gender-specific physiological factors, female dental professionals are more likely to develop MSDs than male counterparts.[2] There are several factors underlying the high rate of MSDs among those practising dentistry. The primary reasoning is that the oral cavity is a constrained working area that is challenging to access and navigate. This would force dental professionals to maintain static body postures, where body positions are maintained

for more than four seconds. It is considered uncomfortable as it involves flexion of the head and neck to the front and side, together with inclination and rotation of the trunk towards the patient. This can be painful when performing dental treatments that may require working for prolonged periods such as root canal treatments and restoring a cavity. Other factors contributing to the development of MSDs include the usage of vibrating tools and the high exposure to repetitive shoulder and hand movements.[3] This would explain why MSDs account for 29.5% of the reasoning for premature retirement.[4]

Emerging evidence illustrates that ergonomic interventions such as ergonomic dental chairs and instruments play a fundamental role throughout a professional's life. Since the physical burden associated with dentistry tends to accumulate from the preclinical years, early and effective implementation of these interventions may lower MSDs rate, potentially reducing early retirement rates.[3-5] This review aims to establish available ergonomic interventions for dental professionals and their role in reducing MSDs.

Methods

Eligibility criteria

The study's eligibility criteria were developed using the Population, Intervention, Comparator, Outcome (PICO) framework (**Table 1**). The review process included randomised controlled trials (RCTs), intervention or evaluation studies, and cohort studies that were available with full texts and published after January 2005. Case reports, descriptive cross-sectional studies, and non-English studies were excluded from the review process.

Table 1. Eligibility Criteria for the study selection per PICO framework.

PICO	Study Inclusion Criteria
Population (P)	Dental professionals such as dentists, dental students, dental assistants, dental laboratory assistants, dental hygienists, dental hygiene students, dental technicians and dental surgeons.
Intervention (I)	Ergonomic design options such as dental chair or lighting, dental loupes, dental instruments, and prismatic spectacles. Only interventions carried out for a minimum of three days were included in the study.
Comparator (C)	All relevant control groups, even those representing both the control and intervention groups (own controls).
Outcome (O)	Associated with symptoms of MSDs (neck, shoulder and lower back pain) or working posture, which is likely to be related to MSDs.

MSDs = Musculoskeletal disorders, PICO = Population, Intervention, Comparator, Outcome.

Literature search strategy

A literature search was conducted to find relevant literature related to ergonomic interventions and MSDs. Electronic databases and hand searches for articles were performed in the following databases: PubMed and Google Scholar. The last search was carried out on 7 June 2022. The search terms for the intervention of interest consisted of: "Dental professionals/personnel", "Ergonomics", "Ergonomic interventions", "(primary) Prevention", "Musculoskeletal pain", "Musculoskeletal disorders". These terms were used in various combinations, together with adjuncts of "or" as well as "and". These terms identified papers relevant to this review's scope. Additional papers were detected by reviewing the bibliographic lists of the original papers.

Selection of studies

Relevant papers found were imported into referencing software Endnote X9. The title and abstract of relevant papers were screened for relevance, and if deemed suitable, the full texts were retrieved and analysed. Those reports which met the eligibility criteria of the present review were selected. The literature search identified eleven papers in total.

Ergonomic dental chair

Dental professionals often adopt awkward postures to deliver dental treatments for prolonged periods of time. Dable et al (2014) compared the working posture of dental students in three different seats including the Salli Saddle Chair (SSC), conventional chair with back rest (CC1) and conventional chair without back rest (CC2) with and without using magnification while performing similar dental procedures. The magnification system used consisted of double lens with detachable light source to create better visibility from a distance. Postures were evaluated using the Rapid Upper Limb Assessment (RULA) (**Appendix 1**). After three months of training, all three groups were taken for assessment. RULA scores were significantly lower for those who used SSC with magnification as opposed to those using conventional chairs without magnification (CC1 and CC2) (1.57 ± 0.50 vs 7.03 ± 0.49 and 7.01 ± 0.45, $P < 0.01$). As a result, students who previously had a mild form of MSK pain reported to experience little to no MSK pain after using SSC compared to CC1 and CC2. In comparing SSC with or without magnification, use of magnification is not beneficial to students who habitually bend at work.[6]

Hallaj et al (2016) evaluated the role of installing arm support (extension) in dental chairs on MSD symptoms. Participants were required to complete a questionnaire which involved answering demographic questions about their age, gender, years of experience, daily hours of exercise and hours of working per day. This feedback questionnaire was split into two parts (i.e. before and after use). Based on the collected data, a customer satisfaction analysis was performed. The body postures of participants were calculated using the RULA scores, which averaged around 3.14, by which the combined bending and twisting of the back decreased by 13.8%. A sharp decline in the wrist's excessive bending up and down and pressure on the neck and shoulder was observed during dental work at 41.4% and 79.3%, respectively.[7] The findings of this study reflect that the arm support installation has improved dentists' body posture significantly, which can be further improved by adjusting the patient positioning and dental chair to support the dentist's neck when carrying out dental procedures.

Magnification loupes

Modern technologies such as magnification loupes have been proposed as a preventive intervention for MSDs in Dentistry. Magnification loupes are optical magnifying devices used in clinical practice and educational settings, mostly to magnify the visual field (teeth and gingiva).[3] Hayes et al (2014) conducted a study to assess the impacts of magnification loupes on health-related outcomes (working posture and symptoms of MSDs) among dental professionals. This was achieved through calculating the Disabilities of the arm, shoulder and hand (DASH) scores (**Appendix 1**). At baseline, DASH scores were lower among participants in the control group (dental hygiene students) compared to the intervention group (dental hygienists) (4.99 ± 6.25 vs 8.56 ± 9.64). However, six months after wearing magnification loupes, the DASH scores for the intervention group declined significantly to be lower than that for the control group (5.17 ± 5.29 vs 7.84 ± 8.73, $P < 0.05$).[8] Despite being statistically significant, improvements in DASH scores were negligible showing that wearing loupes may have little to no impact on improving MSDs and working posture. This may have occurred because DASH scores are designed to detect higher level of pain and disability and thus may not accurately measure lower levels of

pain.[9-10] The findings of this paper limited the ability to conclude whether magnification loupes have a direct effect on reducing symptoms of MSDs or not.

Maillet et al (2008) assessed the efficiency of magnification loupes in improving working posture during the provision of dental treatments (hand scaling) by calculating the Posture Assessment Criteria (PAC). The study found that students who received magnification loupes achieved higher ergonomic scores compared to students who did not (6.4 ± 2.61vs 10.8 ± 4.24, df = 34, $p < 0.000001$). In turn, wearing magnification loupes has enhanced the working postures significantly ($p < 0.001$), simultaneously increasing the quality of their dental work.[11] The findings of this early study were supported by another study which also depicted that magnification loupes positively impacted the working posture of dental professionals.[6]

Two studies investigated the impacts of wearing prismatic spectacles on health-related outcomes. Prismatic spectacles are a specific type of magnification loupes. These include a prism between the lenses, which reflects and magnifies without reducing field of view. Lindegård et al (2012) found that using prismatic spectacles improved working posture and MSDs symptoms, in which 80% of participants reported an improvement in the quality of their work. This could be explained by the reduced neck flexion offered by the prismatic spectacles when comparing both the control group and the intervention group (3.6◦ vs 8.7◦, $p < 0.01$ and 3.3◦ vs 8.2◦, $p < 0.05$). Furthermore, while a reduction of four units in the head and neck exertion inclinometer was noted among the intervention group, only two units' reduction was identified in the control group.[12] Lindegård et al (2016) found similar results. This was the case as those who used prismatic spectacles reported decreased MSD symptoms and also achieved significant improvements in clinical diagnoses ($p < 0.05$), self-reported pain ($p < 0.05$), perceived exertion ($p < 0.01$) and self-work ability ($p < 0.05$) as compared to those who did not use prismatic spectacles.[13] This might mean that prismatic spectacles can facilitate dental work by allowing professionals to maintain a more upright position with less neck bending, which can be paramount when conducting vision-demanding tasks such as root canal treatments. Overall, the findings of these reports may indicate to that an early introduction of the magnification loupes especially during undergraduate dental training, may improve working posture, quality of the dental work, and potentially lower premature retirements associated with MSDs. However, since reports underpinning the role of prismatic spectacles in lowering MSDs symptoms are limited and have a short follow-up period, high quality studies to assess the long-term effects are warranted.

Ergonomic dental instruments

Rempel et al (2012) compared the impacts of two different dental instruments, a lightweight dental Instrument with a wide diameter (Instrument I) vs a heavy dental Instrument with narrow diameters (Instrument II), on MSD prevalence in dental professionals. Pain scores were adjusted for potential confounding factors (age and occupation). It was found that the improvements in adjusted pain scores for instrument I were greater than Instrument II for the shoulder region ($P < 0.05$).[5] This may mean that using light-dental instruments with wide diameters can be a feasible and cost-effective intervention to prevent upper-extremity MSDs, making them more suitable for subgingival professional mechanical plaque removal (PMRP). The authors also noted a reduction in nocturnal disturbance due to finger numbness in those using light-dental instruments with wide diameters compared to heavy-weight dental instruments with narrow diameters.

Ergonomic education and training courses

Farrokhnia et al (2018) evaluated the impacts of incorporating educational interventions in dental professionals who suffer from MSDs. Prior to initiating the intervention, approximately 87% of participants reported MSDs in at least one region of the body. During the follow-up period, there was a decline in reports of MSD symptoms. Fewer participants reported pain in the neck (10.97 ± 20.44 vs. 7.91 ± 17.01, $p < 0.01$), left shoulder (5.80 ± 17.21 vs. 2.95 ± 9.33, $p < 0.01$) and right shoulder (8.85 ± 19.76 vs. 5.24 ± 13.51, $p < 0.01$), amongst other regions of the body, thereby dropping the rate of MSDs to 81%. Although this was associated with improved working posture, which is likely to further reduce MSDs over the long term, the reported confidence intervals are wide. This could be explained by using a relatively small sample size (n=84) which consisted mainly of males. The representativeness of the sample is affected, since it was solely collected from Tehran via convenient sampling. Other factors that may underlie variability in the findings can include: a) males experiencing greater pain in the neck than females; b) pain in the neck worsened with age; c) inconsistencies in the number of breaks between treatments; and d) inconsistencies in the number of regular weekly exercises.[14] Therefore, a high-quality prospective cohort study is warranted to provide a more accurate estimate of the role of ergonomic educational courses in improving MSDs prevalence among dental professionals.

Dehghan et al (2016) conducted a randomised controlled trial (RCT) to evaluate the effectiveness of a multifaceted ergonomic programme. There was a reduction in MSD reports especially in shoulder pain [44% vs 80% ($p < 0.05$)] and neck pain [62% vs 84% ($p < 0.01$)] among those who received the programme at three-and six months post-intervention. The authors also found declined reports of MSD symptoms for all body regions as opposed to participants in the control group who only reported less pain in the back.[15] In another study, there were improvements in MSD symptoms by 49% among those who received training in ergonomics for three months, albeit 17% of students reported opposing effects. During the follow-up, 25% of students reported having improved dynamic working posture. Post-intervention, 87.7% of participants reported adjusting their daily habits.[16] Conclusively, ergonomic education positively led to fewer MSD reports, with improved working posture and quality of dental work. The overall outcomes of both studies would encourage the early implementation of ergonomic education within the dental undergraduate curricula.

Limitations

Several limitations exist in this review and its included studies. First, all studies included involved small sample sizes followed up over a short period, which limited the ability to evaluate the role of ergonomic interventions on MSDs in the long term. Second, six studies had no actual control groups and hence own controls were used and monitored between baseline and follow-up. Hence, these studies were relying mostly on self-reported questionnaires which therefore may have introduced response and recall bias in the outcome results.[5-7,11,14,16] Third, a common surveying method of pain is RULA scores.[6-7] Reports have found that RULA tends to overestimate the ergonomic risk of low-level MSDs.[20-21] Fourth, this review had no geographical restrictions, which limited the ability to compare interventions due to variations in environmental factors and workload associated with dentistry worldwide. However, this did not affect recommendations from being withdrawn based on the findings of the included studies.

Conclusion

In summary, routine dental procedures often require awkward posturing, the use of vibrating instruments for prolonged periods, and repetitive hand and shoulder movements. These are likely to be associated with MSK pain, potentially MSDs. The findings of this paper suggest that ergonomic interventions, especially magnification loupes, SSC with magnification, ergonomic education and training courses, and light dental instruments with wide diameters can effectively reduce neck, shoulder and lower back pain and possibly improve working posture. Effective institutional

implementation of such interventions, particularly at the early stages of the undergraduate curriculum, is likely to reduce MSD development later in life, and thus reduce premature retirement rates. Given that all studies included in this review involved small sample sizes monitored over a relatively short time frame, larger longitudinal studies are required to assess the long-term effects of the ergonomic interventions discussed among dental professionals. Cost-effectiveness analysis studies are also required to justify the routine use of these interventions in dentistry.

Appendix 1

Score interpretation and Reliability of Outcome Measures.

Measure	Description	Score interpretations	ICC*
RULA[17-19]	A survey method developed for investigating ergonomics of workplaces to report work-related upper limb disorders. It incorporates three scoring tables and diagrams depicting various body postures to evaluate not only exposure to risk factors associated with working posture, but also other important factors that are likely to vary between individuals, including operator's pace and apt movements	Potential scores range from 1 to 7, with 1-2 points indicating negligible risk and hence no action required; 3-4 points indicating low risk and hence change may be needed; 5-6 points indicating medium risk and hence further investigation and change should occur soon; ≥6 points indicate very high risk, requiring immediate change. A higher overall score indicates a greater risk of exposure	0.53
DASH[9-10]	A self-report questionnaire that consists of 30 questions that assesses symptoms in the arm, shoulder and hand. Responses are scored one to five on a Likert-type scale based on the participants' ability to perform specific activities.	Potential Scores range from 0 (no disability) to 100 (most severe disability). While a specific score cannot determine the exact level of disability (mild, moderate or severe) or whether an individual is able or not to work objectively, recent reports estimate that a score of 0-29 is the point where upper-limb disorders are no longer an issue. A higher overall score suggests a greater risk of exposure.	0.96

**Reliability expressed as intraclass correlation coefficients (ICC). RULA = Rapid upper limb assessment, DASH = Disabilities of the Arm, Shoulder and Hand*

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References

1. Gupta G, Gupta A, Mohammed T, et al. Ergonomics in dentistry. Int J Clin Paediatric Dent; 2014, 7(1):30-4.
2. Alghadir A, Zafar H, Iqbal ZA. Work-related musculoskeletal disorders among dental professionals in Saudi Arabia. J Phys Ther Sci; 2015, 27(4):1107-12.
3. Ohlendorf D, Naser A, Haas Y, et al. Prevalence of musculoskeletal disorders among dentists and dental students in Germany. Int J Environ Res Public Health; 2020, 17(23):8740.
4. Murphy DC. Ergonomics and dentistry. N Y State Dent J; 1997, 63(7):30–4.
5. Rempel D, Lee DL, Dawson K, et al. he effects of periodontal curette handle weight and diameter on arm pain. The Journal of the American Dental Association; 2012, 143(10):1105-13.
6. Dable RA, Wasnik PB, Yeshwante BJ, et al. Postural assessment of students evaluating the need of ergonomic seat and magnification in dentistry. The Journal of Indian Prosthodontic Society; 2014, 14:51-8.
7. Hallaj, S., Razi, S.S.M. Design and evaluation of an arm support for prevention of MSDs in dentists. In: Rebelo, F., Soares, M. (eds) Advances in Ergonomics in Design. Advances in Intelligent Systems and Computing; 2016, 485:265-75.
8. Hayes M, Osmotherly P, Taylor J, et al. The effect of wearing loupes on upper extremity musculoskeletal disorders among dental hygienists. Int J Dent Hyg; 2014, 12(3):174-9.
9. Beaton DE, Katz JN, Fossel AH, et al. Measuring the whole or the parts? Validity, reliability, and responsiveness of the disabilities of the arm, shoulder and hand outcome measure in different regions of the upper extremity. J Hand Ther; 2001, 14(2):128-46.
10. Beaton DE, Davis AM, Hudak P, et al. The DASH (Disabilities of the Arm, Shoulder and Hand) outcome measure: what do we know about it now? The British Journal of Hand Therapy; 2001, 6(4):109-118.
11. Maillet JP, Millar AM, Burke JM, et al. Effect of magnification loupes on dental hygiene student posture. J Dent Educ; 2008, 72(1): 33-44.
12. Lindegård A, Gustafsson M, Hansson GÅ. Effects of prismatic glasses including optometric correction on head and neck kinematics, perceived exertion and comfort during dental work in the oral cavity--a randomised controlled intervention. Appl Ergon; 2012, 43(1):246-53.
13. Lindegård A, Nordander C, Jacobsson H, et al. Opting to wear prismatic spectacles was associated with reduced neck pain in dental personnel: a longitudinal cohort study. BMC Musculoskeletal Disord; 2016, 17:347.
14. Farrokhnia T, Rezai M, Vaziri MH. Investigating the effect of educational intervention on musculoskeletal disorders in dentists; 2018.
15. Dehghan N, Aghilinejad M, Nassiri-Kashani MH, et al. The effect of a multifaceted ergonomic intervention program on reducing musculoskeletal disorders in dentists. Med J Islam Repub Iran; 2016, 30:472.
16. Koni A, Kufersin M, Ronchese F, et al. Approach to prevention of musculoskeletal symptoms in dental students: an interventional study. Med Lav; 2018, 109(4):276–84.
17. McAtamney L, Corlett EN. RULA: a survey method for the investigation of work-related upper limb disorders. Appl Ergon. 1993, 24:91–99.
18. McPhee BJ. Work-related musculoskeletal disorders of the neck and upper extremities in workers engaged in light, highly repetitive work. In: Osterholz U, Karmaus W, Hullman B, Ritz B (eds). In proceedings of the International Symposium on Work related Musculoskeletal Disorders, Bonn, Germany; 1997:224-258.
19. Valentim DP, Sato T de O, Comper MLC, et al. Reliability, construct validity and interpretability of the Brazilian version of the Rapid Upper Limb Assessment (RULA) and Strain Index (SI). Braz J Phys Ther; 2018, 22(3):198–204.
20. Kee D, Karwowski,W. A Comparison of Three Observational Techniques for Assessing Postural Loads in Industry. International Journal of Occupational Safety and Ergonomics; 2007;13(1):3-14
21. Chiasson M, Imbeau D, Aubry K et al. Comparing the results of eight methods used to evaluate risk factors associated with musculoskeletal disorders. International Journal of Industrial Ergonomics;2012, 42(5):478-488

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Hi! I am Mohammad. I was born and raised in Kuwait. Currently, I'm a second-year dental student at the University of Glasgow. I have a keen interest in medical research. Outside of academia, my other interests include volunteering and photography.