Original Article

Effectiveness of Physiotherapy-Based Ergonomics and Postural Correction on Management of Work-related Musculoskeletal Disorders among Dental Practitioners in Tamil Nadu, India: A Randomized Controlled Trial

Christian Chance Ndahiriwe[1*], Emmy Bucyana[1], Jacques Nshimiyimana[1], Moussa Hakizimana[1], Nuhu Assuman[1], Gerard Urimubenshi[1], Donat Uwayezu[2], Jean Marie Vianney Semana[3], Jean De Dieu Rukundo[3], Raja Raja Rajadurai[4], Malachie Tuyizere[1], Jayavel Ayyappan[5]

[1]Physiotherapy, School of Health Sciences, College of Medicine and Health Sciences, University of Rwanda, Remera Campus, Rwanda
[2]Preventive and Community Dentistry,School of Dentistry , College of Medicine and Health Sciences ,University of Rwanda, Kigali, Rwanda
[3]Prosthetics and Orthotics ,School of Health Sciences, College of Medicine and Health Sciences, University of Rwanda, Remera Campus, Rwanda
[4]Physiotherapy, SRM Institute of Science and Technology (Deemed to be University), Kattankulathur, Tamil Nadu, India
[5]Physiotherapy, SRM University College of Medicine and Health Sciences, Kattankulathur, Tamil Nadu, India

***Corresponding author:** Christian Chance Ndahiriwe. Physiotherapy, School of Health Sciences, College of Medicine and Health Sciences, University of Rwanda, Remera Campus, Rwanda. Email: chriseds2020@gmail.com. ORCID: https://orcid.org/0000-0003-2954-846X

Cite as: Ndahiriwe CC, Bucyana E, Nshimiyimana J, Hakizimana M, Assuman N, Urimubenshi G, Uwayezu D, Semana JMV, Rukundo JD, Rajadurai RR, Tuyizere M, Ayyappan J. Effectiveness of Physiotherapy-Based Ergonomics and Postural Correction on Management of Work-related Musculoskeletal Disorders among Dental Practitioners in Tamil Nadu, India: A Randomized Controlled Trial. Rwanda J Med Health Sci. 2025;8(1): 89-99. https://dx.doi.org/10.4314/rjmhs.v8i1.7.

Abstract

Background
Work-related musculoskeletal disorders among dentists have greatly increased since the Industrial Revolution. Self-management interventions, including exercises, have been proven to be effective. The of the study was to determine the effectiveness of physiotherapy-based ergonomic and postural correction on disability and performance among dental practitioners.

Methods
A Randomized Controlled Trial study design was conducted among 30 dental practitioners and students from Sri-Ramaswami Memorial (SRM) Dental College, who reported Work-Related Musculoskeletal Disorders. The Experimental group followed the Posturite protocol and University of California, Los Angeles (UCLA) exercise protocols. The control group was exposed to routine regular exercises of their choice for at least 30 minutes, three times per week. The Neck Disability Index (NDI), Upper Extremity Function Index (UEFI), and Rolland Morris Disability Questionnaire (RMDQ) were administered as outcome measures.

Results
The experimental group improved the symptoms of the neck, upper limb, and lower back than their control counterparts in paired t-tests where there was a high statistical improvement in both experimental and control groups with t=7, p≤0.001 and t=6, p≤0.01 respectively. On other outcomes UEFI and RMDQ the experimental group had a high statistical significance with UEFI -5, p≤0.001; RMDQ 13, p≤0.001. For the same outcomes, the control group was the least favored as it had t=-3, p≤0.05 and t=4, p≤0.05 on UEFI and RMDQ respectively.

Conclusion
Ergonomics and postural correction education interventions can be effective in the management of work-related musculoskeletal disorders.

Rwanda J Med Health Sci 2025;8(1):89-99

Keywords: Work-Related Musculoskeletal disorders, Physiotherapy, Ergonomics, Dental practice

Introduction

Musculoskeletal disorders are among the leading concerns affecting the world nowadays due to their high prevalence, associated costs, socioeconomic impact and reduced quality of life which were reported several times by many authors including health professionals, insurance companies, Non-Government Organizations (NGOs) and the World Health Organization (WHO).[1,2, 3] The prevalence was consistently reported to be higher among the aged working population which can be as high as 90%.
It has been estimated that more than 150 musculoskeletal diagnoses are known by WHO and the burden has risen by 61% between 1990 and 2016, among which the highest proportion is work-related musculoskeletal disorders, with an estimated cost of USD 100 billion each year.[3]

According to Ahlberg and colleagues,[1] around USD 518 billion are considered as the total cost of musculoskeletal disorders, including accidents, resulting from costs of care, absenteeism, labour turnover and disability compensations. Hayes et al,[5] reported that WMSD sufferers experience low economic income due to the inability to do jobs and associated costs for treatment.
Ergonomics is commonly defined as the application of science designed to arrange a safe workplace, reducing occupational health risks and hazards where different professionals, such as engineers, physiotherapists, and fitness experts, work together to manage the WRMSDs.[6,7]
Globally and in India specifically, MSDs are a major occupational hazard for dental practitioners requiring awareness raising on ergonomics as an effective way of preventing WRMSDs as recommended by many researchers.[1,4,8,9,11,12]

Several studies focused on epidemiological features in India, the highest prevalence was reported among dentists and also have been associated with poor posture behaviors in their daily routine practice, number of patients treated daily.[6,9,14,15,23,30,34]
Dentists have been reported to be the most exposed to MSDs risks than any other healthcare practitioners and estimates showed that working 60 000 hours in their lifetime associated with poor working ergonomics designs for dentists in their daily routine practice increased the prevalence of a wide variety of musculoskeletal disorders among them.[4,6,13]

Different epidemiological studies have been conducted and identified several risk factors for MSDs including prolonged sitting, vibrations, repetitive motions, improper body postures and mechanics. Nevertheless, risk estimation and intervention studies are still lagging behind in research, especially among dental practitioners.[4, 16] The American Dental Association;[18, 33] confirms that the major risk factors for WRMSDs for dentists which include repetition, force, and mechanical stress which results from compression to the joints or tension to the soft tissues such as muscles, fascia, ligaments and capsules and awkward Posture and vibration which is common in the dental practice.

The management of work-related injuries includes mainly long-term sustainable programs to prevent injuries. The self-management approach has been reported to be more effective than passive approaches in the prevention of work-related injuries.
From the management perspective, the American Dental Association and other sources, [18, 30, 33, 34, 37] recommends major broad areas for the prevention of WRMSDs based on principles of ergonomics including training on early detection and management, risk factors, correct postures, regular stretching, fitness for work among others. Furthermore, workplace modification and workers' education on risk factors and self-management approaches including maintenance of good postures and body mechanics, regular stretching at work as well as improved fitness for work are stipulated. This can be achieved through varying tasks and movements to avoid static muscle tension caused by postural constraints and avoiding extreme

body postures when work demands the use of maximum physical forces such as heavy object lifting.[18,25, 33,34]

Although dental practitioners are prone to develop WRMSDs than other healthcare professionals, the practices towards the prevention and treatment of such disorders are lacking, and few interventions studies believed to reduce the magnitude of the problem, improve health outcomes, prevent disability and promote work morale and productivity are conducted in their workplace. Therefore, the present study aimed to assess the effectiveness of workplace ergonomics interventions in the management of WRMSDs among dental practitioners

Methods

Study design

Researchers used a Randomized Controlled trial study in dental practitioners with work related musculoskeletal to determine if Physiotherapy Based Ergonomic and Postural correction exercises can have superior benefits in relation to generalized exercise programs in terms of disability specific to the neck and low back and function of the upper limb.

Study setting

The study was conducted at Sri-Ramawami Memorial (SRM) Institute of Sciences and Technology, Dental College among Postgraduate students and teaching staff. The Dental College is located at the Kattankulathur campus, District of Kancheepuram, Tamil Nadu, India.

Selection of participants

Among 83 participants from the post-graduate students and facultys' list or from SRM Dental College enrolled in 2018 and were considered as a sampling frame. In April, the same year, the screening was made to recruit all those who reported work-related musculoskeletal complaints in the previous 3 months, those with no neurological signs and who had not started receiving painkiller treatment were included in the study and the sample of 30 participants was obtained. Participants who practiced dental therapy for less than 6 months were not included in the study as well.

Randomization

The 30 participants who met the inclusion criteria were randomly allocated into two groups: experimental group (n=15) and control group (n =15) with the use of the list by systematic random sampling of skipping pattern (1 skip to 3) using excel document. The ones with even numbers were allocated to the Experimental Group and those with odd numbers were the Control Group with a computer generated shuffling.

Interventions

The experimental group was trained first on risk factors encountered in dental practice and then three positions commonly used in dental practice namely sitting at the side of the patient, standing procedures and sitting behind the patient were selected for safe working posture in their daily procedures. They were trained on how to minimize the risks by adjusting the dental chairs and how to work in neutral postures. The Posturite and UCLA ergonomics exercise Protocols were given to the experimental group by printed protocol for 6 weeks which were performed either before work and or after work; three days per week. The control group performed the general physical activity, 30 minutes of routine exercises thrice weekly of their choice, after ergonomics education regarding dental correct postures. The exercises of their choice included walking, bicycling, swimming, gym aerobic classes/strengthening as preferred by the participants.

Outcome measurement

Primary outcomes were Neck Disability Index (NDI) raw scores on a maximum score of 50, the less the scores the less the disability is Low back pain disability percentage with Rolland Morris Disability Questionnaire (RMDQ) to assess pain-related disabilities.

It has 24-point scale to track clinical improvement over time the scores were transformed into percentages and UEFI scores with 0-80 scores where 0 refers to the lowest function possible while 80 is the maximum function possible. Those are standardized tools used in a clinical setting to assess the level of disability and performance among people who suffer from Work-related Musculoskeletal injuries.
After signing their informed consent forms, they filled the tools chosen based on their qualities in terms of validity and psychometric characteristics. The NDI,[29] UEFI,[30] and RMDQ for Neck, Upper limb, and low back screening were chosen respectively. [28] The Rapid Entire Body Assessment Ergonomics worksheet was used to assess the postural risk in different dental procedures. With the help of pictures of different tasks, the picture was analyzed using the same REBA tool to estimate the level of risk.

The experimental group received a Posturite and UCLA exercise protocols were adapted and given to participants for a period of 6 weeks. The Posturite helps with postural correction while working whereas the UCLA was developed to improve performance in terms of flexibility and endurance. The Posturite protocol is a workstation-based exercise and recommendations developed to help people with whole body (work-related musculoskeletal disorders WRMSDs) reduce aches and pains. There are five exercises for people who spend most time seated, exercises for the wrist and arm, four stretches for the neck and shoulder, 3 exercises for the spine/back, and 2 exercises for the leg and ankle. The participant is advised to hold a stretch for 5 seconds and repeat the same exercise three to five times. The exercises were revised and adapted in the context of dental practitioners as they spend most of their working days sitting. The Posturite protocol was developed as a postural correction tool. In addition to the Posturite protocol, the University of California Los Angeles Ergonomic Postural Strengthening Exercises protocol was given to help the participants achieve strength. It comprises eight exercises namely, Waxing, Wall Angels, Side Lying Exercise, Prone lying scapula exercise, Theraband rows, Isometric abdominal exercise, Wall slide exercise and Sit to Stand exercise. Each exercise was performed and held for three seconds and repeated 10 times.

The experts in exercise and physiotherapy in movement sciences and sports physiotherapy educated the participants and demonstrated the exercises to participants. Then a printed copy of the adapted exercises from both protocols was posted in front of the visual field of the dental chair. All participants were requested to perform Posturite exercises before receiving the first patient in the morning, before lunchtime, and before leaving the workstation in the evening. The UCLA exercises were performed once per day at the end of the day. Neck Disability Index (NDI), Rolland Morris Disability Questionnaire (RMDQ), and Upper Extremity Function Index (UEFI) were the primary outcomes of the study as they track changes in performance and disability among people suffering from injuries affecting the neck, low back and the arm.

The Control Group received the routine Exercise as recommended by the World Health Organization Physical Activity Guideline. [38] Which recommends individuals to amount of moderate Physical activity for at least 30 minutes per day. They were given a chance to choose
any Physical activity of preference either Walking, Jogging, Bicycling, Cricket, Gardening, or swimming.

Statistical analysis

Obtained data were entered in Excel and then transferred to IBM SPSS Statistics for Windows version 21.0 (IBM Corp, Armonk, NY, USA) for analysis. Demographic data including gender, age, working experience in years, working hours per day height, and weight were classified as general participants' characteristics. Percentage, average, and standard deviation (SD)

for demographic data are presented in tables. On the effectiveness of the intervention, we used both paired and independent t-test statistics to compare means within and between groups at 95% confidence limit respectively.

Ethical approval

After obtaining Ethical clearance from SRM Medical College Institutional Review Board, the researchers registered the Indian clinical trial registry No. CTRI/2018/10/016112 (2018). Authorization to conduct a study was obtained from SRM Dental College. Researchers explained to the participants the purpose of the study who were then given an informed consent form to sign freely. Their participation was absolutely voluntary and they had the right to withdraw at any time in the study and their withdrawal would not affect their relationship with investigators or their institution line managers. Their identification was kept confidential and we used code identity in the reports.

Results

In both the experimental and control groups, gender distribution was represented about equally. Age category 20–25 years was the most represented while the least was the 36–40 years of age. There were more PG students than the dental surgeons (Table 1).

Table 1. Demographic data and Participants Characteristics: Sex, age Category and Working Position

PG: *post-graduate*

	Variables		**Frequency**	**Percentage %**
Experimental group	Sex	Male	5	33
		Female	10	66
	Age category (years)	20-25	9	60
		26-30	4	26
		31-35	1	6
		36-40	1	6
	Working position	PG Student	8	53
		Dental Surgeon	7	46
		Total	15	100
Control group	Sex	Male	5	33
		Female	10	66
	Age category (Years)	20-25	9	60
		26-30	4	26
		31-35	2	13
		36-40	0	0
	Working position	PG Student	11	73
		Dental Surgeon	4	26
		Total	15	100

As per Table 1. Sample females represented the majority in both groups with 66% (n=10). The age category was generally in the age range 20 -25 years with 60% (n=9) in both groups as well. Postgraduates represented the majority of the participants where in experimental and control group were represented with 53% (n=8) and 73% (n=8) respectively.

Table 2. Anthropometric characteristics: weight, Height, BMI, Working experience and Working hours/day

	Variables	N	Mean	SD	Minimum	Maximum
Experimental group	Weight (in kg)	15	65.00	10.00	51.00	90.00
	Height in centimetres (cm)	15	164.00	9.00	154.00	186.00
	BMI (kg/m^2)	15	24.00	3.00	18.00	31.00
	Working experience in years	15	2.00	2.00	1.00	10.00
	Working hours per day	15	7.00	1.00	5.00	10.00
Control group	Weight in kg	15	64.00	8.00	50.00	80.00
	Height in meters (m)	15	167.07	8.00	153.00	180.00
	BMI (kg/m^2)	15	22.00	2.00	18.00	29.00
	Work experience (years)	15	2.00	2.00	1.00	10.00
	Working hours per day	15	7.00	1.00	5.00	10.00

SD: standard deviation; **kg:** kilograms; **BMI:** body mass index, **m2:** metre squared; **m:** metres

The average weight, height, and BMI in the experimental group were 64 ± 8 kg, 167 ± 8 cm, and 22 ± 2 kg/m2, respectively. Their working experience was 2 ± 2 years, and average working duration per day 7 ± 1 hours. For the control group the average weight, height, and BMI in the experimental group were 65 ± 10 kg, 164 ± 9 cm, and 24 ± 3 kg/m2 respectively. Their working experience and working hours average per day were 2 ± 2 years and 7 ± 1 hours/day respectively (Table 2).

Table 3 shows that in the post-test there were more remarkable statistically significant improvements in the outcomes of the experimental group namely, NDI from 17 ± 8 to 0 ± 1 (p<0.001); UEFI from 71.00 ± 6.00% to 79.00 ± 0.00% (p<0.001); and RMDQ from 30 ± 11 to 3 ± 6 (p<0.001). In the control group, there was a highly significant difference in NDI 19 ± 12 to 9 ± 11 (p<0.001); UEFI from 67 ± 0% to 73 ± 6% (p<0.005); and RMDQ 29 ± 15 to 20.08 ± 9.00 (p<0.005).

Table 3. Before and after outcomes - neck disability, upper extremity function, and low back pain disability

					Paired differences				
	Outcomes	N	Mean	SD	Upper bound	Lower bound	t	df	p value
Experimental group	NDI Pre-test	15.00	17.00	8.00	12.09	21.00	7.00	14.00	≤0.001**
	NDI Post-test	15.00	0.00	1.00					
	UEFI Pre-test	15.00	71.00	6.00	-11.00	-4.00	-5.00	14.00	≤0.001**
	UEFI Post-test	15.00	79.00	0.00					
	RMDQ Pre-test	15.00	30.00	11.00	23.00	31.00	13.00	14.00	≤0.001**
	RMDQ Post-test	15.00	3.00	6.00					
Control group	NDI Pre-test	15.00	19.00	12.00	6.00	14.00	6.05	14.00	≤0.001**
	NDI Post-test	15.00	9.00	11.00					
	UEFI Pre-test	15.00	67.00	10.00	-9.00	-2.00	-3.00	14.00	≤0.05*
	UEFI Post-test	15.00	73.00	6.00					
	RMDQ Pre test	15.00	29.00	15.00	4.00	15.09	4.08	14.00	≤0.05*
	RMDQ Post-test	15.00	20.08	9.00					

df: degree of freedom; *significant at p<0.05; **significant at p<0.001

Table 4. Experimental and Control group independent t-test comparisons for equality of means before intervention

Independent Samples t-tests between groups						
Outcomes		**t-test for Equality of Means**				
		Mean Difference	**Std. Error Difference**	**t**	**df**	**P-Value**
Neck Disability Index Scores Pre-test	Equal variances assumed	-2.000	3.000	0.000	28.000	≤0.001**
	Equal variances not assumed	-2.000	3.000	0.000	24.000	≤0.001**
Neck Disability Index Scores Post-test	Equal variances assumed	-8.000	2.000	-2.000	28.000	≤0.07
	Equal variances not assumed	-8.000	2.000	-2.000	14.000	≤0.011
Upper Extremity Function Index Pre-test	Equal variances assumed	4.000	3.093	1.000	28.000	≤0.001**
	Equal variances not assumed	4.000	3.093	1.000	23.000	≤0.001**
Upper Extremity Function Index Post-test	Equal variances assumed	6.000	1.000	3.000	28.000	≤0.05*
	Equal variances not assumed	6.000	1.000	3.000	14.000	≤0.05*
Rolland Morris Disability Questionnaire Pre-test	Equal variances assumed	0.000	4.000	0.000	28.000	≤0.001**
	Equal variances not assumed	0.000	4.000	0.000	26.006	≤0.001**
Rolland Morris Disability Questionnaire Post-test	Equal variances assumed	-16.000	3.000	-5.000	28.000	≤0.001**
	Equal variances not assumed	-16.000	3.000	-5.000	24.000	≤0.001**

t: t-test; df: degree of freedom; *statistically significant at p<0.05; **statistically significant at p<0.001

There were statistical differences between groups post-tests in Upper Extremity Functions and Low back Pain Disabilities with p≤0.05 and p≤0.001 respectively. On the other hand the neck disability were not statistically different between experimental and control groups p≤0.07.

Discussion

The present study indicates that ergonomics interventions have effects on both neck and lower back related disability scores. This means that physiotherapy-based ergonomics intervention significantly manages disability-related complaints and improves function. This can be justified by a review by Etuknwa and Humphries,[37] which found that ergonomics education plays an important role of managing repetitive strains in different body regions including neck and lower back. Their findings agree with this study because the interventions considered in the review were patient-oriented, which is believed to result in greater long-term outcomes. The institutionalized WRMSDs management has been proven to be more effective than individual clinical-based management of WRMSDs,[32,35,36,37] and as reported elsewhere,[2,3,7,25,33,36] in consonance with the this study. This indicates that ergonomics interventions conducted at the institutional level to manage WRMSDs should be prioritised in the clinical management of the disorders¬.

There has been have improved function of the upper limb in the intervention group than in the control group, implying that ergonomics training of employees has a great impact on the management of WRMSDs, and it plays preventative and treatment roles at the same time. Various studies also have consistently concluded that employee education has been associated with positive upper limb functional outcomes and pain-related complains not to mention functions of other body parts. [16, 22, 23, 33] This is in line with ergonomic principles which stipulates that the successful management of WRMSDs occurs when managed at the institutional level.[11, 37]

Specific ergonomics interventions have been reportedly to reduce postural risks screening and the need for an intervention, this study is in accord that dental practitioners had an increased risk of RSI due to the nature of the postural demands and workstation design. Contrary some studies demonstrated some gaps and issues in education about ergonomics and management and its impact on disability function and reported pains. [6,9,12,15,26,30,34] In dentistry, most improvements happen due to increased awareness of posture adjustment for either a therapist or patient positioning, manipulating dental chair, regular stretches, and breaks, and supervised exercises have been shown to reduce to the burden of the work-related musculoskeletal disorders.[4, 6] These areconsistent with our findings whereby the ergonomics based on physiotherapy postural exercises improved the participant's pain, neck and back disability scores.

Similarly, a review by Bethany and Keith,[17] highlighted the impact of stretching, micro-breaks during dental procedures, and many forms of exercises in the reduction of the musculoskeletal disorders among dentists. The impact observed in both studies may be due to similarity of methodologies, where the present study and theirs had protocols or program targeting employees and focused on self-management via ergonomic modifications.

Another study conducted by Kajiki et al,[26] also found that participatory-based ergonomics has a great impact on the reduction of work-related musculoskeletal disorders. Although that study focused on the design of the workplace it is assumed that it was also part of posture education and improving the efficiency and safety of the workplace.

Strengths and limitations of the study

Despite the successful completion of the study, the interventions did not include the workstation modifications as an intervention which are considered among the pillars of WRMSDs management. Another limitation of the study is that most of the participants were post-graduate students, as it was conducted in an academic setting, which can affect the generalisability of the results in clinical practice. Therefore, the findings from this study should be interpreted with caution. Nevertheless, the study provides useful insights regarding the role of ergonomics in the safety of dental practice that can be the basis for a larger study.

Conclusions and Recommendations

Dental practitioners reported disability-related scores in the neck, upper extremity, and lower back regions and this was supported by risk assessment with the screening tool widely known in occupational health and safety.

Physiotherapy-based ergonomics by posture correction exercises and education on ergonomics can yield superior benefits to exercise alone in terms of pain reduction and functional improvement. Dentists who participated in this study benefited from physiotherapy-based ergonomics and posture education, with significant improvement in pain and disability.

It is recommend that ergonomics education be given to students enrolled in dental practice colleges and universities with the aim to prevent the early development of the WRMSDs among dental practitioners.

It is recommended that large-scale studies with more advanced methodologies such as RCTs, systematic reviews, and meta-analyses be conducted to study in-depth the WRMSDs among dental practitioners and other healthcare providers. Lastly, dental workstation designs are necessary for an ideal working environment with minimized injury risk. This can be achieved by using high technology standardized and adjustable dental chairs. Other equipment modification strategies including the use of ergonomically handgrips with less vibration are recommended.

Conflict of Interest

The authors declare that there is no conflict of interest in the study.

Authors' Contributions

NCC, JA, and R.R designed the study and were involved in all aspects of the work including intervention design, data collection, and manuscript writing. BE, MT, HM, U.G, NJ, NA, U D, RJD, and SJD contributed to the manuscript's scientific writing and review and provided intellectual inputs.

Acknowledgments

The researchers acknowledge SRM Institute of Science and Technology, SRM College of Physiotherapy for providing the opportunity and approval to conduct this study. We wish also to thank SRM Dental college management and participants who voluntarily participated in the study, their contribution to the scientific development in health sciences cannot be thanked enough.

References

1. Ahlberg I. The economic costs of musculoskeletal disorders: A cost-of-illness study in Sweden for 2012. Masters dissertation. *Lund University.* 2012. https://lup.lub.lu.se/student-papers/record/4698739/file/4698740.pdf.Accessed 2 Feb 2025
2. Rosimeire SP, Ana BO, Rodrigo LC, Tatiana OS Physical therapy in occupational health and ergonomics: practical applications and innovative research approaches. *Braz J Phys Ther.* 2016; 20(5):490-492 http://dx.doi.org/10.1590/bjpt-rbf.2014.0193
3. Luthman A, Jager M, Griefahn B, Graffier B, Liebers F and Steinberg U. Protecting Workers' Health Series No. 5: Preventing musculoskeletal disorders in the workplace. *WHO.* 2017. https://iris.who.int/bitstream/handle/10665/42651/924159053X.pdf. Accessed 5 Jan 2025
4. Gupta A, Ankola AV and Hebbal M. Dental Ergonomics to combat Musculoskeletal disorders: A Review. *JOSE.* 2013. 19(4):561-571. https://doi.org/10.1080/10803548.2013.11077005
5. Hayes SC, Pistorello J and Levin ME. Acceptance and commitment therapy as Unified model of Behavior change. *The Couns. Psych.* 2012; 40(7):976-1002. https://doi.org/10.1177/0011000012460836
6. Gupta A, Bhat M, Mohammed T, Bansal N, Gupta G. Ergonomics in Dentistry. *Int J Clin Pediatr Dent.* 2014;7(1):30-34. https://doi.org/10.5005/jp-journals-10005-1229
7. Middlesworth M. Barriers to implement Musculoskeletal disorders prevention programs. *Ergoplus.* 2018. https://ergo-plus.com/msd-prevention-barriers. Accessed 10 June 2024
8. Alghadir A, Zafar H, Iqbal ZA. Work-related musculoskeletal disorders among dental professionals in Saudi Arabia. *J Phys Ther Sci.*. 2015 Apr;27(4):1107-12. https://doi.org/10.1589/jpts.27.1107.

9. Senthil PK, Kumar V, Baliga M. "Work-related musculoskeletal disorders among dental professionals: An evidence Based Update". *Indian Journal of Dental Education.* 2012; Volume 5(1): 5-12.
10. Ahmed AS and Oraby EE. Work-related musculoskeletal disorders among dentists in Sharkia Governmental Hospitals. *Egyptian Journal of Occupational Medicine*. 2017; 41 (2): 175-186. https://doi.org/10.21608/EJOM.2017.2853.
11. MacLeod D. The Ergonomics Manual-Second Edition. ErgoWeb. The comprehensive Loss Management Inc. 2000. https://ergoweb.com/wp-content/uploads/Ergo-Manual.pdf .Accessed 10 June 2024
12. Hameed M.H., Ghafoor R. and Bada S.B. Prevalence of musculoskeletal disorders among dentists in teaching hospitals in Karachi. *Journal of Pakistan Medical Association.* 2016. 66(10), 36-38. Available at https://core.ac.uk/download/pdf/84854855.pdf Accessed 15th June 2024
13. Bedi H.S., Moon N.J., Bhatia V., Sidhu G.K. and Khan N. Evaluation of Musculoskeletal Disorders in Dentists and Application of DMAIC Technique to Improve the Ergonomics at Dental Clinics and Meta-Analysis of Literature.*J. Clin. & Diagn. Res.* 2015; 9(6):1-3. https://doi.org/10.7860/JCDR/2015/14041.6126.
14. Malarvizhi D, Manivannan M and Narendra Kumar J. Effects of neck exercises and ergonomics modifications among dentists. *Int. J.Adv. Res.* 2017; 5(11)1318-1322. https://dx.doi.org/10.21474/IJAR01/5901.
15. Malarvizhi D, Manivannan M and Narendra Kumar J. "Prevalence of Musculoskeletal disorders among dentists", *IJSER*, 2018; 9(2) 1325-133. ISSN 2229-5518.
16. Diniz de Carvalho M.V., Soriano E.P., Caldas Jr. A., Campello R.I.C., Ferreira de Miranda H. and Cavalcanti F.I.D. Work-Related Musculoskeletal Disorders Among Brazilian Dental Students [Abstract]. *J. Dent. Edu.* 2009; 73(5): 624-630.
17. Bethany V. and Keith V. Mechanisms leading to musculoskeletal disorders dentistry. JADA, 2003; 134: 1344-1351. https://doi.org/10.14219/jada.archive.2003.0048
18. American Dental Association 'An Introduction to Ergonomics-Risk factors, MSDs, Approaches, and Interventions.' A report of the Ergonomics and Disability Support Advisory Committee to CDP. ADA. 2004. Available at https://desergo.com/wp-content/uploads/OTH-White-Paper.pdf Accessed 14th June 2024
19. Hignett S and McAtamney, "Rapid Entire Body Assessment (REBA)" Technical note, Applied Ergonomics. Elsevier. 2000. 31:201-205. https://doi.org/10.1016/s0003-6870(99)00039-3.
20. Agbor A.M and Hilbert K.Work-related musculoskeletal disorders among Oral Health Workers in Cameroun. Universite des Montagnes, Dental School, Bangangte, Western Region, Cameroun. OHDM. 2016. Available at https://www.walshmedicalmedia.com/open-access/workrelated-musculoskeletal-disorders-amongst-oral-health-workers-incameroon-.pdf Accessed 18th May 2024
21. Tunwattanapong P, Kongkasuwan R. and Kuptniratsaikul V. The effectiveness of neck and shoulder stretching exercise program among office workers with neck pain: A Randomized Controlled Trial. Clinical Rehabilitation. 2016.30(1):64-72. https://doi.org/10.1177/0269215515575747
22. Mehrparvar A.H, Heydari M, Mirmohammadi S.J, Mostaghaci M, Davari M.H, Taheri M. Ergonomic intervention, workplace exercises and musculoskeletal complaints: a comparative study. Med J Islam Repub Iran. 2014. Vol. 28:69. Available at https://pmc.ncbi.nlm.nih.gov/articles/PMC4219902/ Accessed 7th August 2024

23. Devanand G, Renu B, Shveta M, Dara J.B, Ankita J., Mohammed S, Ankit Y, Mudita C, Shruti G, Renuka V, Deepak RD and Rajendran K.G. Comparative evaluation of the complementary and Alternative Medicine Therapy and Conventional Therapy Use for Musculoskeletal Disorders management and its association with Job satisfaction among dentists of West India. *J Tradit Complement Med. 2014* Oct;4(4):263-7. doi: 10.4103/2225-4110.126632
24. Rafie F., Zamani J.A., Shahravan A., Raoof M. and Eskandarizadeh A. Prevalence of Upper Extremity Musculoskeletal Disorders in Dentists: Symptoms and Risk Factors. *J Environ Public Health.* 2015. https://doi.org/10.1155/2015/517346.
25. World Health Organization. Prevention of MSDs, Risks factor information, preventive measures for employers, supervisors and occupational health trainers. *WHO*. 2003. Available at https://www.who.int/publications/i/item/preventing-musculoskeletal-disorders-in-the-workplace. Accessed 30th January 2025
26. Kajiki S, Izumi H, Hayashida K, Kusumoto A, Nagata T, and Mori K. A randomized controlled trial of the effect of participatory ergonomic low back pain training on workplace improvement. *J Occup Health.* 2017. 59: 256-266. https://doi.org/10.1539/joh.16-0244-OA.
27. Hignett S. and McAtamney L. "Rapid Entire Body Assessment (REBA)" .*Applied Ergonomics* . 2000; 31: 201-205. https://doi.org/10.1016/s0003-6870(99)00039-3.
28. Brouwer S, Kuijer W, Dijkstra PU, Göeken LN, Groothoff JW, Geertzen JH. Reliability and stability of the Roland Morris Disability Questionnaire: intra class correlation and limits of agreement. *Disabil Rehabil.* 2004. 26(3):162-165. https://doi.org/10.1080/09638280310001639713.
29. Vernon H.T and Mior S. The Neck Disability Index: A Study of Reliability and Validity. *J. Manip & Physiol Ther.* 1991. [Abstract] 14(7): 409-15.
30. Arumugam V. and MacDermid J.C. Appraisal Clinimetrics: Upper Extremity Functional Index. *J Physiother.* 2018. 64:125. https://doi.org/10.1016/j.jphys.2018.01.003.
31. Shaik A.R, Sripathi R.B.H, Husain A and D'sa J. Work Related Musculoskeletal disorders among Dental Surgeons: A Pliot Study. *Cont. Clin. Dent.* 2013. 2(4):308-312. https://doi.org/10.4103/0976-237X.91794.
32. Grooten W.J.A, Johanssons E. "Observational Methods for Assessing Ergonomic Risks for Work-Related musculoskeletal disorders: A Scoping Review. *Rev Cienc Salud.* 2018. 16:8-38. http://dx.doi.org/10.12804/revistas.urosario.edu.co/revsalud/a.6840 Accessed 11th May 2024
33. American Dental Association. An Introduction To Ergonomics: Risk Factors, Msds, Approaches And Interventions. A Report of the Ergonomics and Disability Support Advisory Committee (EDSAC) to Council on Dental Practice (CDP). *ADA.* 2004. 1-26. Available at https://desergo.com/wp-content/uploads/OTH-White-Paper.pdf Accessed 9th March 2025
34. Rambabu T and Suneetha K. "Prevalence of Work Related Musculoskeletal among Physicians, Surgeons and Dentists: A Comparative Study". *Ann Med Health Res.* 2014; 4(4):578-582. https://doi.org/10.4103/2141-9248.139327.
35. International Ergonomics Association "The IEA contribution to Ergonomics and research". *Appl. Ergon.* 2010; 41(6):731-737. https://doi.org/10.1016/j.apergo.2010.03.002.
36. International Ergonomics Association and International Commission on Occupational Health: Ergonomics Guidelines for Occupational Health Practice in Industrially developing Countries. *IEA&ICOH.* ISBN 978-3-935089-16-3.
37. Etuknwa AB, Humpheries S. A Systematic Review on the Effectiveness of Ergonomic Training Intervention in Reducing the Risk of Musculoskeletal Disorder. *J Nurs Health Stud.* 2018; 3(2): 3. https://doi.org/10.21767/2574-2825.1000032.
38. Who. Global Recommendations on Physical Activity for Health. 2010. ISBN 978 92 4 159 997 9. *Geneva, Switzeland.* https://iris.who.int/bitstream/handle/10665/44399/9789241599979_eng.pdf. Accessed 26th June 2024