ORIGINAL ARTICLE

Use of Ergonomics to Control Musculoskeletal Pain among Dental Students at King Abdulaziz University: A Cross-sectional Study

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Abstract

The prevalence of musculoskeletal pain (MS-Pain) increases day by day and is common among dental practitioners. The aim of this study was to assess the relationship between ergonomics use and other related factors in controlling musculoskeletal pain among dental students and interns at King Abdulaziz University, Jeddah, Saudi Arabia. This cross-sectional study was conducted at King Abdulaziz University through a validated self-administered questionnaire. It was distributed among dental students from the fourth academic year up to postgraduate level. The total number of respondents was 402, in which 202 (50.2%) were females and 200 (49.8%) were males. Out of the total respondents, 337 (83.8%) reported musculoskeletal pain and approximately 68% of respondents did not apply proper ergonomics for preventing and reducing MS-Pain. Keeping a straight back and maintaining physical activity are the two main factors that are suggested to help in controlling MS-pain, and thus it needs to be emphasized in the everyday clinical educational years

Keywords

Ergonomics; Work-related musculoskeletal disorders; Dental students; Musculoskeletal pain; Lower back pain; Neck pain

Introduction

The prevalence of musculoskeletal (MS) pain is increasing, and has been reported to be common among dental practitioners[1]. Compared with other populations, dentists and dental hygienists are at a higher risk of developing MS pain[1]. Several studies have reported an association between MS disorders and poor posture[2]. Al-mohrej et al. reported that, of 184 dentists in Saudi Arabia, 90.2% experienced MS pain[3]. In 2010, Brown et al. reported that MS pain was one of the most common causes of early retirement among dentists[4]. MS pain can negatively affect quality of life; therefore, to prevent MS pain or manage work-related MS symptoms among dentists, undergraduate dental students should be encouraged to adopt and maintain an appropriate working posture early at the start of their dentistry careers.

Early intervention for MS pain and effective ergonomics are essential to achieve better outcomes with fewer costs and less inconvenience[5]. Applying ergonomics has been shown to play a key role in preventing MS pain[6]. Effective work-related ergonomics balances MS health and prevents MS pain, which can lead to increased productivity, improved work quality, enhanced workplace safety, and reduced fatigue[1,7].

Ergonomic considerations include analysis of posture and positioning, cognitive overload, and psychological demands. Dentistry can be both mentally and physically challenging. Pope-Ford[8] reported an association between the prevalence of MS-related disorders and various psychological factors in relation to the dental profession. Implementation of dental ergonomics to prevent or control MS pain is invaluable, especially in programs where ergonomics are being enforced throughout preclinical and clinical training among undergraduate and postgraduate students and dental interns. To our knowledge, few studies have investigated the risks and preventive factors related to MS pain among dental students.

This study aimed to investigate the role of dental ergonomics in controlling work-related MS pain in dental students at King Abdulaziz University (KAU). Our null hypothesis was that the use of ergonomics would not control MS pain among dental students at KAU.

Materials and Methods

This cross-sectional study was conducted at KAU in Jeddah, Saudi Arabia between August 2020 and April 2021. The study proposal was reviewed and approved by the Research Ethics Committee (Approval No. 196-12-20) of the Faculty of Dentistry at KAU. Data were obtained from 4th-, 5th-, and 6th-year undergraduate students, dental interns, and postgraduate students at KAU. Sample size calculation was conducted in accordance with a study by Meisha et al. (2019),[9] who reported an odds ratio (OR) of 0.50 for the association between physical exercise and MS pain. The suggested sample size was 85, with a sample power of 80% and an error probability of 0.05. Our study comprised 610 participants. We included dental students who underwent clinical and simulation training sessions requiring physical involvement. Dental interns were considered to be students; given they were being supervised during their clinical training.

Data were collected using a three-section, self-administered, validated questionnaire. Section 1 related to students' demographic data, level of education, dominant hand, duration of a dental procedure, treatment duration, breaks taken during the procedure, and level of physical activity according to a validated scale, namely, the International Physical Activity Questionnaire (IPAQ)[10]. Section 2 involved questions in relation to students' ergonomic application in dental clinics, including neck flexion, shoulder relaxation, elbow tucking, and back straightening. Maintaining a straight back and a respect for body symmetry while avoiding rounding the back into a "C" shape is necessary to avoid MS pain[11]. Ideally, dental students should be seated with their hips flexed, their legs apart, their feet flat on the floor, and their thighs parallel, in consideration of a patient's position, in addition to using an LED light, a saddle style chair, loupes, mirror, and a wedge cushion. Students responded to each question using a 3-point Likert scale (1, always; 2, sometimes; 3, never) and total ergonomic application scores were calculated. The students' ages ranged from 14 to 42 years. A higher score indicated a lower use of ergonomics. Section 3 related to working conditions and MS pain, based on a validated standardized Nordic questionnaire, which was previously tested for reliability using a test-retest method[12].

Validation of the whole questionnaire was performed in two phases. The first phase involved a content assessment by six qualified dentists and physiotherapists who assessed the questionnaire content for ambiguity, clarity, and relevance (content validity index, 0.94). The second phase involved validation of the questionnaire through interviews with a group of ten dental students. Feedback on any of the questions, including difficulties in understanding or answering, was considered to enhance the questionnaire accordingly.

The data collectors explained the study purpose to the students, who were required to provide their written informed consent prior to participation in the study, after which they received the questionnaire online using Google Forms. The data was processed and analyzed using the SPSS version 26 software (IBM Inc., Armonk, NY). The categorical variables were presented as frequencies and percentages and compared using the chi-square test. The fissure-exact test used when the cell is less than five. Logistic regression analysis was conducted to assess the effects of confounders, and adjust the P-value and Odds ratio (AOR) accordingly. MS-pain and its different types were entered as "dependent factors;" whereas, students' education level (grouped into "undergraduate," "interns," and "postgraduate"), ergonomics, work–related variables, gender, hand domain, academic year and physical activity were entered as "independent factors." The significance level was set at $P \leq 0.05$.

Results

In total, 402 students participated in this study (response rate, 65%). Details concerning the participants' characteristics are shown in Table 1. Of the participants, 202 (50.2%) were females, 156 (38.8%) were dental interns, and 101 (25.1%) were postgraduate students. There were 145 undergraduate respondents, of whom 56 (13.9%) were 4th year, 44 (10.9%) were 5th year, and 45 (11.2%) were 6th year students.

Undergraduate dental students reported more MS pain (n = 133, 91.7%) than dental interns (n = 118, 75.6%) and postgraduate students (n = 86, 85.1%). In terms of physical activity levels, 279 (69.4%) participants reported a moderate level of physical activity, 68 (16.9%) reported a high level, and 55 (13.7%) reported a low level of physical activity. Additionally, 164 reported working ≥ 6 h per day in clinics or laboratories, with 121 (73.8%) having experienced MS pain; 167 reported working ≥ 3 h per patient, with 124 (74.3%) having experienced MS pain; and 85 reported taking a break between procedures on a single patient, with 79 (92.9%) having experienced MS pain. Of the total sample, 337 (83.8%) participants reported having experienced MS pain in the previous

Table 1. Distribution of students according to gender, academic year, level of physical activity, working time, taking a break, treatment duration and type of musculoskeletal pain

Variable		Total	Do You Have Pain?		P value
			Yes (%)	No (%)	
Gender	Female	202	181 (89.6%)	21 (10.4%)	**0.002***
	Male	200	156 (78.0%)	44 (22.0%)	
Academic year (GROUPED)	Undergraduate	145	133 (91.7%)	12 (8.3%)	**<0.001***
	Internal	156	118 (75.6%)	38 (24.4%)	
	Postgraduate	101	86 (85.1%)	15 (14.9%)	
Hand domain	Right-handed	374	317 (84.8)	57 (15.2)	0.065
	Left-handed	28	20 (71.4)	8 (28.6)	
What's your general level of activity?	High level	68	52 (76.5%)	16 (23.5%)	**0.004**[b]
	Moderate level	279	231 (82.8%)	48 (17.2%)	
	Low level	55	54 (98.2%)	1 (1.8%)	
Duration of clinical \ lab work in hours per day	3 hours / day	104	92 (88.5%)	12 (11.5%)	**<0.001***
	4-6 hours / day	134	124 (92.5%)	10 (7.5%)	
	6 hours / day	164	121 (73.8%)	43 (26.2%)	
Time spent in treating one patient	30 min	25	23 (92.0%)	2 (8.0%)	**<0.001**[b]
	40-60 min	101	91 (90.1%)	10 (9.9%)	
	60-120 min	109	99 (90.8%)	10 (9.2%)	
	120 min	167	124 (74.3%)	43 (25.7%)	
During procedure on a single patient do you take a break?	Yes	85	79 (92.9%)	6 (7.1%)	**0.010***
	No	317	258 (81.4%)	59 (18.6%)	

**The Chi-square statistic is significant at the 0.05 level*
[b]Fissure exact test used when the cell is less than five

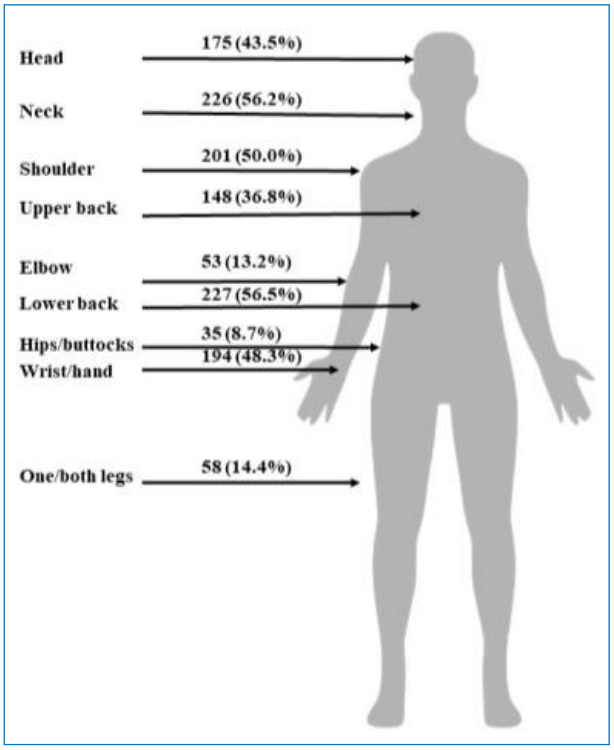

Figure 1. Frequency of different MS-P location among KAU students.

year. Sample distribution according to MS pain location is illustrated in Figure 1.

Table 2 shows the distribution of participants according to ergonomic use and its association with MS pain. No significant differences were observed between the mean total scores of ergonomics applied by the students and their MS pain reports. The most common ergonomic application was mirror usage, with 286 (71.1%) participants reporting always using a mirror during work. Additionally, 184 (45.8%) participants modified a patient's position according to arch treatment, and 177 (44.03%) participants used a dental LED light during work. Participants who responded 'always' or 'sometimes' to the use of suitable ergonomic postures (neck flexion retained at <20° [78.9% and 82.6%, respectively]; elbows tucked to the sides [79.7% and 82.1%, respectively]; maintaining a straight back [66.7% and 87.3%, respectively], and legs slightly apart [88.5% and 78.7%, respectively]) reported significantly less pain ($p = 0.032$, $p = 0.009$, $p < 0.001$, and $p = 0.010$, respectively) compared with those who responded 'never' to the use of suitable ergonomics (97.6%, 98.1%, 96.7%, and 100%, respectively).

Table 3 shows a binary regression analysis of the association between MS pain (dependent variable) and sex, dominant hand, academic year, physical activity, time spent treating one patient, taking a break, and treatment duration. After using a chi-square test (for independent variables) to address the effect of confounders, a statistically significant association was observed between the use of four ergonomic applications and MS pain. Physical activity and maintaining a straight back during work were significantly associated with a lower adjusted OR (aOR) for MS pain (aORs 0.070 and 0.337, respectively). However, being right-handed or keeping the legs spread slightly apart during work was associated with a significantly higher aOR for MS pain (aORs 3.182 and 2.194, respectively).

Discussion

Our study findings indicated that continued use of some of the suggested ergonomic postures and maintaining a moderate-to-high level of physical activity played important roles in controlling MS pain; therefore, the null hypothesis in this study was rejected.

The etiology of MS pain is complex as it is known to be associated with various mechanical, biochemical, and psychosocial factors[13]. Work-related MS pain has frequently been reported in relation to postural strain and poor ergonomics, especially among dentists and dental students[14-18]. The current curriculum at KAU incorporates the teaching and assessment of ergonomics in preclinical training at a simulation laboratory. Ergonomic assessments are undertaken throughout the clinical years as implementing and maintaining effective ergonomic strategies is important for dental students and dental interns in daily practice to prevent or control MS pain when attending KAU.

We found that 337 (83.3%) participants had experienced MS pain during clinical practice. This finding is consistent with those of other studies[14,15,17]. This high prevalence raises concerns about the future occupational health of dental students. MS pain was reportedly present irrespective of suitable ergonomic application frequency. Of note, despite being assessed throughout the clinical training period, fewer students adhered to ergonomic protocols that were taught during their preclinical years, while even fewer responded "always" compared with "sometimes/never"

Table 2. Distribution of Student's according to ergonomics practice and MS-pain (N=402)

How often you keep the following postures & tools?		Do you have pain?		Total	P value
		Yes (%)	No (%)		
Neck flexion no more than 20 degrees	Always	30 (78.9%)	8 (21.1%)	38 (9.5%)	**0.032***
	Sometimes	266(82.6%)	56 (17.4%)	322 (80.1%)	
	Never	41 (97.6%)	1 (2.4%)	42 (10.4%)	
Shoulders relaxed	Always	59 (80.8%)	14 (19.2%)	73 (18.2%)	0.066
	Sometimes	243 (82.9%)	50 (17.1%)	293 (72.9%)	
	Never	35 (97.2%)	1 (2.8%)	36 (8.9%)	
Elbows tucked in at sides	Always	47 (79.7%)	12 (20.3%)	59 (14.7%)	**0.009***
	Sometimes	238 (82.1%)	52 (17.9%)	290 (72.1%)	
	Never	52 (98.1%)	1 (1.9%)	53 (13.2%)	
Straight back	Always	54 (66.7%)	27 (33.3%)	81 (20.1%)	**<0.001***
	Sometimes	254 (87.3%)	37 (12.7%)	291 (72.4%)	
	Never	29 (96.7%)	1 (3.3%)	30 (7.5%)	
Hips higher than knees when seated	Always	104 (84.6%)	19 (15.4%)	123 (30.6%)	0.339
	Sometimes	214 (82.6%)	45 (17.4%)	259 (64.4%)	
	Never	19 (95.0%)	1 (5.0%)	20 (5%)	
Legs spread slightly apart	Always	162 (88.5%)	21 (11.5%)	183 (45.5%)	**0.010***
	Sometimes	163 (78.7%)	44 (21.3%)	207 (51.5%)	
	Never	12 (100.0%)	0 (0.0%)	12 (3%)	
Feet flat on the floor	Always	142 (82.6%)	30 (17.4%)	172 (42.8%)	0.192
	Sometimes	179 (83.6%)	35 (16.4%)	214 (53.2%)	
	Never	16 (100.0%)	0 (0.0%)	16 (4%)	
Dental led light	Always	163 (92.1%)	14 (7.9%)	177 (44.03%)	**<0.001***
	Sometimes	114 (87.7%)	16 (12.3%)	130 (32.34%)	
	Never	60 (63.2%)	35 (36.8%)	95 (23.63%)	
Sit on saddle style chair \ stool	Always	92 (94.8%)	5 (5.2%)	97 (24.1%)	**<0.001***
	Sometimes	148 (88.1%)	20 (11.9%)	168 (41.8%)	
	Never	97 (70.8%)	40 (29.2%)	137 (34.1%)	
Use magnifying loupes	Always	43 (89.6%)	5 (10.4%)	48 (12%)	0.285
	Sometimes	94 (86.2%)	15 (13.8%)	109 (27.1%)	
	Never	200 (81.6%)	45 (18.4%)	245 (60.9%)	
Use mirror	Always	232 (81.1%)	54 (18.9%)	286 (71.1%)	0.060[b]
	Sometimes	100 (90.9%)	10 (9.1%)	110 (27.4%)	
	Never	5 (83.3%)	1 (16.7%)	6 (1.5%)	
Use wedge cushion below patient's upper back	Always	24 (85.7%)	4 (14.3%)	28 (6.9%)	0.271
	Sometimes	87 (88.8%)	11 (11.2%)	98 (24.4%)	
	Never	226 (81.9%)	50 (18.1%)	276 (68.7%)	
Positioning the patient according to arch treated	Always	154 (83.7%)	30 (16.3%)	184 (45.8%)	0.644
	Sometimes	170 (83.3%)	34 (16.7%)	204 (50.7%)	
	Never	13 (92.9%)	1 (7.1%)	14 (3.5%)	
Thigh parallel to the floor	Always	141 (80.1%)	35 (19.9%)	176 (43.8%)	0.157
	Sometimes	182 (86.3%)	29 (13.7%)	211 (52.5%)	
	Never	14 (93.3%)	1 (6.7%)	15 (3.7%)	
Total mean score Mean ± SD**		**26.461 ± 3.482**	**26.137 ± 4.082**	**26.89 ± 3.989**	0.548

** The Chi-square statistic is significant at the 0.05 level*
[b]Fissure exact test used when the cell is less than five
Higher score indicates less use of ergonomics

Table 3. Regression analysis for the relationship between MS-pain (dependent variable) and gender, academic year, physical activity, hand domain, take a break, treatment duration (independent variables)

Variable		P value	AOR	Do you have pain? 95% CI
Gender	Female	0.123	1.655	0.872-3.141
	Male		1	
Academic year	Undergraduate	0.203	1.907	0.705-5.154
	Internal	0.978	1.010	0.486-2.102
	Postgraduate		1	
Physical activity	High level	**0.019***	0.070	0.008-0.644
	Moderate level	**0.028***	0.084	0.009-0.769
	Low level		1	
Hand domain	Right-handed	**0.016***	3.182	1.237-8.187
	Left-handed		1	
Time spent in treating one patient	30 min	0.168	1.808	0.779-4.196
	40-120 min	0.615	1.280	0.488-3.359
	120 min		1	
During procedure on a single patient do you take a break	Yes	0.065	2.618	0.942-7.280
	No		1	
Duration of clinical \ lab work in hours per day	3 hours / day	0.756	0.856	0.320-2.290
	4-6 hours / day	0.241	1.710	0.698-4.191
	6 hours / day		1	
How often you keep the following postures & tools?				
Neck flexion no more than 20 degrees	Always	0.842	0.895	0.302-2.657
	sometimes/never		1	
Elbows tucked in at sides	Always	0.177	0.513	0.195-1.351
	sometimes/never		1	
Straight back	Always	0.002*	0.337	0.166-0.682
	sometimes/never		1	
Legs spread slightly apart	Always	0.041*	2.194	1.032-4.663
	sometimes/never		1	

** P value is significant at 0.05. AOR: adjusted odds ratio. CI: confidence interval*

to the various elements included in the questionnaire. Similarly, poor student adherence to dental ergonomics has been reported elsewhere[11]. The only suitable ergonomic application frequently used in this study was the use of a hand mirror.

A significantly lower percentage of students reported MS pain when practicing back-straightening exercises, which is consistent with a study that found avoiding bending and twisting during dental procedures was a consistent independent protective factor identified in their work[19].

Females reported experiencing more frequent MS pain than males. Zafar also reported a higher prevalence of MS pain among female dental students (females, 68%; males, 43%)[20]. Following a regression analysis, this difference was not found to be significant; however, the OR increased to 1.655, which may be related to hormonal changes that enhance MS pain in females[21].

A significantly higher number of right-handed students reported MS pain than left-handed students, contrary to the findings of a previous study that reported injuries in 20% of left-handed individuals compared with 7% of those who were right-handed. This result was considered to be mainly because most dental instruments and equipment are designed to be operated by right-handed users, and left-handed users may be strained or stressed when using the equipment. The prevalence of right-handed participants was considerably higher; therefore, further research is required to confirm this finding[22].

We found an association between the academic level of the participants and MS pain, with a higher percentage of undergraduate students reporting pain, followed by postgraduates and dental interns, which is consistent with findings reported in a previous study[23]. Undergraduate students are regularly exposed to new procedures that require constant mental focus and progressive physical adjustment to master various

skills, while often not paying attention to their posture. In addition to other psychological stressors related to learning and teaching environments, postgraduate students tend to be more skilled and use different types of operative procedures. However, a lower percentage of dental interns reported MS pain, possibly because the nature of training during internship is less stressful, and part of the field experience is to rotate at various dental health organizations where dental interns tend to observe rather than perform clinical procedures.

In this study, we observed an inverse relationship between physical activity and MS pain. A lower number of students who engaged in high levels of physical activity experienced pain compared with those who engaged in light or moderate activity. A stronger MS system is likely to better tolerate postural alterations when performing various procedures long before the appearance of symptoms. This inverse relationship is consistent with a previous study in which physical activity was found to significantly influence MS pain among dentists[24].

Moreover, regression analysis showed that there was an association between the duration of clinical or laboratory sessions per day and the time spent treating one patient in relation to MS pain. Moreover, taking a break during clinical sessions significantly increased the OR for reporting MS pain. This unexpected finding is supported by a systematic review conducted in 2019 by Luger et al.,[25] who reported low-quality evidence for the effectiveness of work breaks in reducing MS pain among health workers. For dentists, taking breaks might not be efficient when working with a single patient, as the session might exceed an hour. Nonetheless, the Canadian Center for Occupational Health and Safety recommends frequent stand-up breaks for stretching and avoiding sitting for >50 minutes[26].

Our study findings, which are consistent with other previous studies[14-18], showed a high prevalence of MS pain among the participants. It is essential to address the etiology of MS pain and treat the symptoms. Educational interventions are critical for preventing and managing MS pain, and more emphasis on ergonomics is needed in dental program curricula. Reinforcing knowledge and skills to implement targeted dental ergonomics is paramount for preventing MS pain and subsequent risks that can adversely affect students' occupational health. Allowing students to take mini-breaks during their practical sessions and providing facilities or logistics where they can stretch and rest are also important strategies that need to be adopted by dental schools. Furthermore, continuous education courses to increase awareness should be available, using special compliance measuring tools to help provide feedback and facilitate student motivation, as well as appropriate ergonomic equipment, including postural and positioning protocols. Finally, psychological support services should be available for students. The efficacy of adopting these suggested preventive strategies should be explored in future studies.

This study had some limitations. First, we evaluated responses to students' self-administered questionnaires, and recall bias may have influenced our results. We recommend that a prospective cohort study be undertaken in future that assesses students during their educational years and before and after their ergonomic lectures. Additionally, the response rate was low (66%). However, the sample was equally distributed according to sex (almost 50% female and male) and educational year (almost 30% from each of the three student levels).

Conflict of Interest

The authors declared that there is no conflict of interest that is related to this study and this article.

Disclosure

The authors did not receive any form of commercial support, either in the form of compensation or financial assistance, for this case report. The authors have no financial interest in any of the products, devices, or drugs mentioned in this article.

Ethical Approval

The study was approved by the Ethics Committee of the KAUH in Jeddah, Kingdom of Saudi Arabia, also known as the Institutional Review Board of Hospitals.

Conclusion

Maintaining a straight back when performing dental procedures and continuing physical activity were the two main factors identified that helped prevent and control MS pain; therefore, it is recommended that these factors be emphasized throughout educational dental programs, including internships and postgraduate studies.

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