



Work-related musculoskeletal disorders among dental students: a cross-sectional study integrating the pain adaptation model

Manuel Barbosa de Almeida^{1,2,3,4,5} · Paula Moleirinho-Alves^{2,3,5} · Raúl Oliveira¹

Received: 3 January 2024 / Accepted: 9 March 2024
© The Author(s) 2024

Abstract

Aim This study aimed to assess the prevalence, anatomical distribution, and contributing biological and psychosocial factors of work-related musculoskeletal disorders (WMSDs) among dental students.

Subject and methods We used the Nordic Musculoskeletal Questionnaire (NMQ) to determine the prevalence and anatomical distribution of WMSDs, integrating biological and psychosocial variables, including stress, anxiety, and quality of life levels measured by the Perceived Stress Scale (PSS), Generalized Anxiety Disorder Assessment (GAD-7), and World Health Organization Quality of Life-Brief Form (WHOQOL-Bref), respectively. We used chi-square tests to analyze differences between the prevalences of independent groups, and binary logistic regression models to identify potential predictors among sociodemographic and psychosocial characteristics.

Results A total of 239 students were contacted to participate and 123 answered the questionnaire, setting the response rate at 51.5%. We excluded 18 for being over 30 years old and 25 for having diagnosed and ongoing musculoskeletal injuries, leaving 80 participants. They were 77.5% women and 22.5% men with 22.69 ± 1.63 years, 1.67 ± 0.08 m, 60.44 ± 10.94 kg and a body mass index (BMI) of 21.46 ± 2.61 kg/m². A total of 91.3% of the participants reported symptoms in at least one body region in the past year. The neck and lower back (63.8%) were the most frequently affected areas, followed by 40% in the shoulders and 31% in the wrists/hands. Over the period of a week, 23.8% experienced symptoms in the lower back, 21.3% in the cervical region, and 15% in both shoulders and wrists/hands. Additionally, male students are 90% more likely to develop WMSDs in the shoulders, and students with anxiety are 49% more prone to refer WMSDs in lower back region.

Conclusion High WMSDs rates were observed in dental students in neck, low back, and shoulders. Male students and those with increased levels of anxiety were more likely to develop WMSDs. Further investigation focused on the motor-behavior adaptations and psychosocial determinants underpinning these findings is fundamental to fully understand them, allowing the development and implementation of strategies to prevent and manage WMSDs in dental students.

Keywords Musculoskeletal disorders · Dentistry · Students · Occupational health · Pain

✉ Manuel Barbosa de Almeida
mbalmeida@egasmoniz.edu.pt

¹ Neuromuscular Research Lab, Interdisciplinary Centre for the Study of Human Performance (CIPER), Faculty of Human Kinetics, University of Lisbon, 1499-002 Oeiras, Portugal

² Egas Moniz Center for Interdisciplinary Research (CiiEM), Egas Moniz School of Health & Science, 2829-511 Caparica, Almada, Portugal

³ Integrative Movement and Networking Systems Laboratory (INMOV-NET LAB) - Egas Moniz Center for Interdisciplinary Research (CiiEM), Egas Moniz School of Health & Science, 2829-511 Caparica, Almada, Portugal

⁴ Physical and Functional Assessment Laboratory in Physiotherapy (LAFFFi) - Egas Moniz Center for Interdisciplinary Research (CiiEM), Egas Moniz School of Health & Science, 2829-511 Caparica, Almada, Portugal

⁵ Department of Physiotherapy, Egas Moniz School of Health & Science, Campus Universitario, Quinta da Granja, 2829-511 Caparica, Almada, Portugal

Introduction

Work-related musculoskeletal disorders (WMSDs) have surfaced as a prominent health concern amongst healthcare professionals, notably dentists, with an alarming 95.8% reportedly encountering these issues in their lifetime (Hayes et al. 2009). Early manifestations are observed in dental students, with reported prevalence ranging from 44 to 93% (Aboalshamat 2020; Kapitán et al. 2019; Ohlendorf et al. 2020). These disorders, characterized by discomfort or persistent pain in muscles, ligaments, tendons, and other components of the locomotor system, are often exacerbated by the professional environment and working conditions (Hayes et al. 2009; Suganthirababu et al. 2022).

Dental professionals are particularly susceptible due to the nature of their work, which often involves static, asymmetrical postures and repetitive movements (Aboalshamat 2020; Almeida et al. 2023; Kapitán et al. 2019; Ohlendorf et al. 2020). The prevalence and impact of WMSDs are not only rooted in physical strains but are also intricately linked to psychosocial factors, a dimension often overlooked in traditional epidemiological studies (Almeida et al. 2023; Hayes et al. 2009; Santucci et al. 2021). A comprehensive analysis through a recent systematic review with a meta-analysis underscored this concern, highlighting a pervasive occurrence of WMSDs, especially in the cervicothoracic, lumbar, and shoulder regions (Almeida et al. 2023). However, the lack of data linking these disorders to specific biological, behavioral, and psychosocial factors impeded the establishment of clear correlations, signaling a need for in-depth, multifaceted research. The pain adaptation model (PAM) suggests that the intersection of multidimensional aspects of pain and individual sensory-motor systems underpins the complexity of WMSDs (Murray and Peck 2007; Peck et al. 2008). Each unique pain experience, marked by distinct characteristics, induces specific motor responses, underscoring the necessity for individualized approaches to intervention (Murray and Peck 2007; Peck et al. 2008). This research is anchored in a holistic perspective, aspiring to yield insights that could inform personalized, effective interventions to mitigate the impacts of WMSDs and enhance the occupational well-being of future dental professionals.

Therefore, our study aimed to assess the prevalence, anatomical distribution, and associated biological and psychosocial elements of WMSDs in dental students enrolled in clinical practice.

Methods

Study design

We implemented a cross-sectional, questionnaire-based study approved by the Egas Moniz School of Health &

Science Ethics Committee, under the number CEEM-1121, in September 2022. Anonymity and confidentiality of the data were strictly maintained, aligning with ethical guidelines, and ensuring participants' privacy and data protection. All methodologies applied within the study rigorously adhered to the ethical principles rooted in the 1975 Declaration of Helsinki, as revised in 2008.

Participants

Dental students in their fourth or fifth year enrolled in the master's degree in dentistry at Egas Moniz School of Health & Science – Portugal volunteered to participate in the study. The inclusion criteria focused on students actively engaged in clinical practice, while students over the age of 30 years or with ongoing musculoskeletal disorders were excluded.

Data collection

We employed an online questionnaire ensuring an efficient, participant-friendly experience, while collecting comprehensive data on WMSDs, stress, anxiety, and quality of life. The online form included the Nordic Musculoskeletal Questionnaire (NMQ) (Mesquita et al. 2010), the Perceived Stress Scale (PSS) (Amaral et al. 1991; Trigo et al. 2010), the Generalized Anxiety Disorder Assessment (GAD-7) (Sousa et al. 2015), and the World Health Organization Quality of Life-Brief Form (WHOQOL-Bref) (Vaz Serra et al. 2006). The questionnaires were administered at the beginning of the second semester, from January to March. Participants were required to read and provide their consent digitally, before answering the questionnaire.

Statistical analysis

We used the Statistical Package for Social Sciences (SPSS®) 27 software (IBM Corp., Armonk, New York, USA) for the statistical analysis of this study. We employed chi-square tests to analyze differences between independent groups for categorical variables. Categorical variables were reported as frequencies and percentages, while continuous variables were presented as mean and standard deviation (SD). To assess the influence of demographic factors and health-related attributes on WMSDs, binary logistic regression models were utilized to identify potential predictors, including sociodemographic and psychosocial characteristics. This regression model was applied to the body regions with a prevalence over 25%.

Results

The study garnered responses from 123 out of 239 contacted students, representing a 51.5% response rate. After applying the exclusion criteria, which removed 18 participants aged over 30 years and 25 with ongoing musculoskeletal injuries, 80 participants were included in the final analysis. The participants comprised 77.5% women ($n = 62$) and 22.5% men ($n = 18$) with an average age of 22.69 ± 1.63 years and an average body mass index (BMI) of 21.46 ± 2.61 kg/m²: 35 were from the 4th year and 45 from the 5th year. Comprehensive sociodemographic information on the participants can be found in Table 1.

Analysis of the NMQ data indicated the distribution of work-related musculoskeletal symptoms among the participants. In the last 12 months, 91.3% of students enrolled in clinical practice reported symptoms in at least one body region. The cervical region and low back both shared the highest prevalence of reported WMSDs at 63.8%, followed by the shoulders at 40.0%. Pain affecting work or activity was mostly reported in the low back (13.8%), followed by the cervical region (10.0%) and ankles/feet (7.5%). The symptoms experienced in the previous 7 days, depicted the low back as the most affected area at 23.8%, with the cervical region close behind at 21.3%. Both shoulders and wrists/hands had a prevalence rate of 15%. Prevalence rates for each of the nine body regions as per the NMQ are provided in Fig. 1 and detailed in Appendix 1 (Almeida 2023).

When differentiating prevalence by curricular year, the analysis revealed that 5th-year students exhibited higher occurrence rates in the neck (73.3%) and shoulders (46.7%), while 4th-year students reported a 71.4% rate in the lower back over a 12-month period. In contrast, over a 7-day span,

prevalence rates remained consistent across both years, with the notable exception of a 37.1% rate in the lower back for 4th-year students. Figure 2 illustrates the distribution of WMSDs among participants by curricular year.

When prevalence was analyzed by student's sex, female students exhibited higher rates in the neck (67.7%) and hands/wrists (33.9%), whereas male students reported greater prevalence in the shoulders (50%) and upper back (33.3%) over a 12-month period. With regard to WMSDs that hindered work or regular activities, females predominantly experienced symptoms in the hands/wrists (4.8%), while males had elevated rates in the neck (22.2%), shoulders (11.1%), and upper back (16.7%). In a 7-day review, female students showed higher prevalence rates in the neck (24.2%) and lower back (25.8%). Figure 3 represents the distribution of WMSDs among participants, categorized by sex.

A binary logistic regression used to determine the relation of sociodemographic and psychosocial factors with the development of WMSDs showed that male students are 90% more likely to develop shoulders WMSDs and students with anxiety are 49% more prone to refer WMSDs in lower back region as detailed in Table 2.

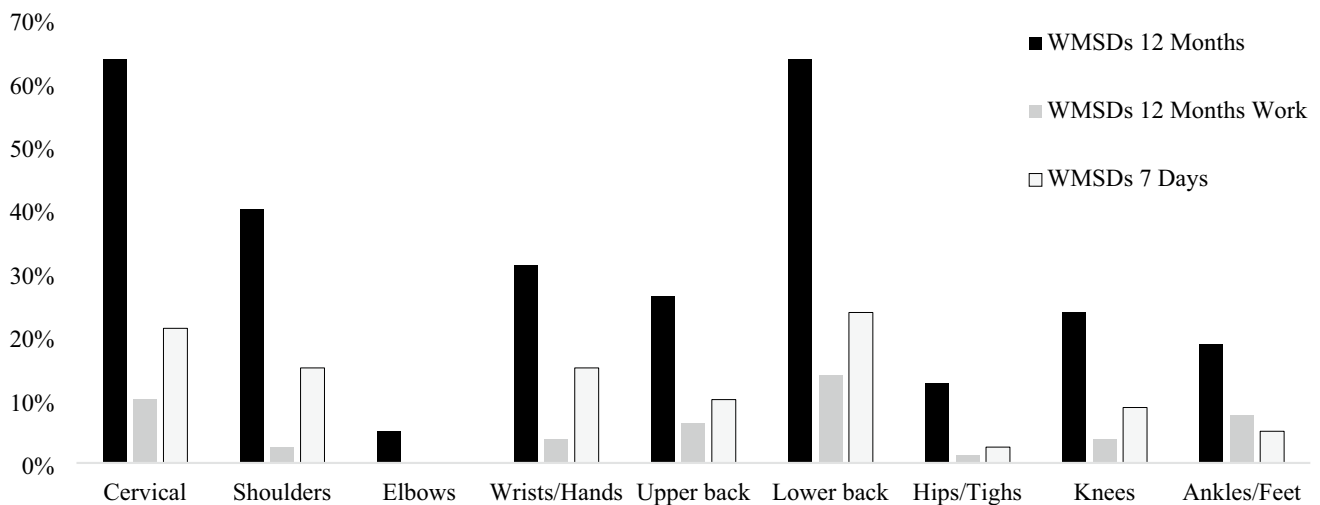
Discussion

Work-related musculoskeletal disorders associated to work physical burden and environmental factors have been an area of significant concern, especially in professional dentists. With WMSDs reported rates as high as 95.8% during their working careers, concerns arise about their affected areas, causes, risk factors, economic burden, and prevention, since high rates have been

Table 1 Sociodemographic and health-related characteristics of the participants

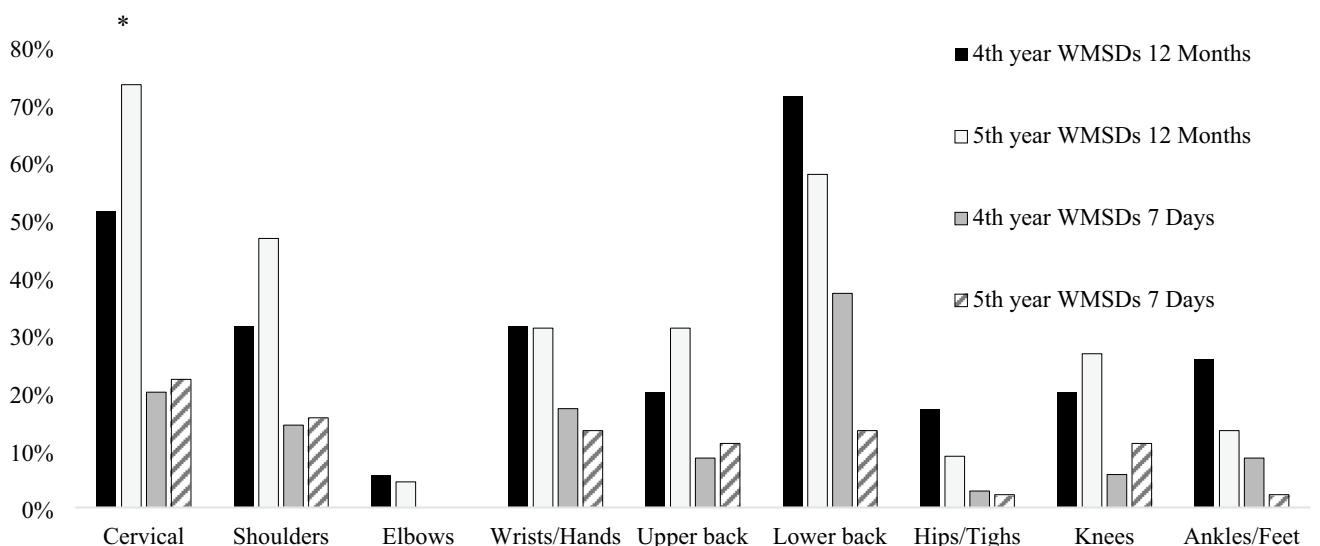
	Mean (\pm SD)	Range	Frequency (n)	
Age (years)	22.69 (\pm 1.63)	20–30		
Sex (male female)			22.5% (18)	77.5% (62)
Height (m)	1.67 (\pm 0.08)	1.53–1.96		
Weight (kg)	60.44 (\pm 10.94)	41–96		
BMI (kg/m^2)	21.46 (\pm 2.61)	16.22–29.30		
Curricular year (4th 5th)			43.7% (35)	56.3% (45)
Dominance (left right)			3.7% (3)	96.3% (77)
Smoker (yes no)			13.7% (11)	86.3% (69)
Alcohol consumption (yes no)			76.3% (61)	23.7% (19)
Chronic medication (yes no)			3.7% (3)	96.3% (77)
Physical activity (yes no)			53.7% (43)	46.3% (37)
Stress (0–40)	20.69 (\pm 3.59)	11–30		
Anxiety (0–21)	7.12 (\pm 5.58)	0–21		
Quality of life (0–100)	78.95 (\pm 8.49)	58.72–92.62		

BMI body mass index, SD standard deviation



WMSDs 12 Months Work: Work-related musculoskeletal disorders impeding work or normal activity

Fig. 1 Musculoskeletal symptoms prevalence by body region

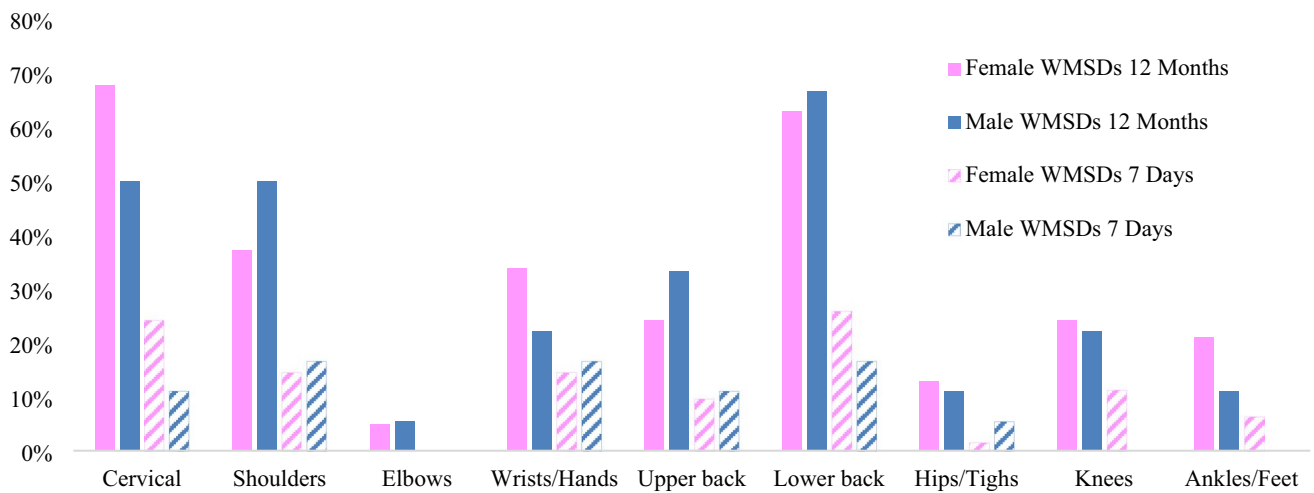


4th year ($n = 35$); *5th year* ($n = 45$); *WMSDs*: work-related musculoskeletal disorders; * = p -value < 0.05

Fig. 2 Musculoskeletal symptoms prevalence by curricular year

reported since their student years (Aboalshamat 2020; Hayes et al. 2009; Kapitán et al. 2019; Koni et al. 2018; Ohlendorf et al. 2020; Suganthirababu et al. 2022). The higher prevalence of WMSDs in dental students can be attributed to the rigorousness of their educational journey, encompassing intensive theoretical and practical training, examinations, and their relative inexperience compared to established dental professionals (Aboalshamat 2020; Almeida et al. 2023; Faust et al. 2021; Kapitán et al. 2019; Ohlendorf et al. 2020). The insufficiency of

data associating these disorders to distinct biological, behavioral, and psychosocial elements hinders the formation of definitive relations, highlighting the necessity for comprehensive and multidimensional research to fill this knowledge gap (Almeida et al. 2023). With this study, we aimed to assess the prevalence, anatomical distribution, and associated biological and psychosocial elements of WMSDs in dental students enrolled in clinical practice, comparing with the occurrence rates reported for their peers and professional dentists.



Males (n = 18); Females (n = 62); WMSDs: Work-related musculoskeletal disorders; * =p-value < 0.05

Fig. 3 Musculoskeletal symptoms prevalence by sex

Table 2 Binary logistic regression of physical and psychosocial determinants for WMSDs development

	Neck		Shoulders		Hands/Wrists		Upper back		Lower back	
	p	OR	p	OR	p	OR	p	OR	p	OR
Sex	0.221	0.140	0.042*	0.099	0.745	1.439	0.126	0.134	0.246	0.232
Age	0.116	1.880	0.112	0.503	0.091	1.600	0.070	0.305	0.255	0.716
Body Mass Index	0.125	0.709	0.214	0.820	0.363	0.850	0.299	0.814	0.924	1.016
Dominance	0.998	0.000	0.999	0.000	0.694	2.050	0.999	0.000	0.999	–
Smoker	0.654	2.014	0.723	1.643	0.999	0.000	0.999	0.000	0.054	0.001
Alcohol consumer	0.074	11.429	0.836	1.212	0.673	1.542	0.260	4.755	0.293	0.233
Family history of MSK disorders	0.998	–	0.320	2.671	0.836	0.803	0.318	3.700	0.370	3.329
Regular exercise	0.229	4.006	0.075	0.179	0.866	1.163	0.258	4.237	0.993	1.010
Stress	0.107	1.473	0.547	1.092	0.606	0.918	0.125	1.431	0.635	0.908
Anxiety	0.891	0.978	0.267	0.864	0.386	0.903	0.141	0.707	0.040*	1.489
Quality of life	0.999	1.000	0.137	0.908	0.108	0.911	0.558	0.958	0.590	0.963

MSK musculoskeletal, OR odds ratio, p = p-value; * = p-value < 0.05

Our study found that 91.3% of students enrolled in clinical practice reported WMSD symptoms in at least one body region over the past 12 months, which came notably close to the reported rates for professional dentists (92%) (Hayes et al. 2009; Lietz et al. 2018; Zakerjafari and YektaKooshali 2018) and consistent with the higher range of previously reported for this population, between 44% and 93% (Aboalshamat 2020; Felemban et al. 2021; Kapitán et al. 2019; Lestari and Palupi 2020; Ohlendorf et al. 2020; Sulimany 2021; Zafar and Almosa 2019). The cervical region and low back both exhibited the highest prevalence of WMSDs at 63.8%. These findings mark an increase from rates found in dental students

reported in a recent systematic review with meta-analysis, which showed occurrence rates of 51% for the neck, 45.3% for the shoulders, and 42% for the lower back (Almeida et al. 2023). Notably, the annual prevalence for shoulder disorders with 40% was slightly lower than these reference figures. Our findings highlight a concerning trend of elevated WMSDs rates in our study's population compared to those previously documented in similar demographic groups (Almeida et al. 2023). Our study confirmed that a high 12-month prevalence rate could be seen since the first years of dentistry clinical practice, with special incidence in the body regions expected to sustain a higher demand during their training.

Nonetheless, while our research elucidates high rates of WMSDs in dental students, it is noteworthy that the rates of incapacity to work due to WMSDs were slightly lower than those recently reported (Almeida et al. 2023). Similarly, 13.8% of students reported that lower back symptoms affected their work, compared to the reported 15.2% (Almeida et al. 2023) and only 10% were incapacitated to work due to neck symptoms, compared to the 13.9% previously reported (Almeida et al. 2023). Similar discrepancies were observed for other regions like the shoulders, upper back, and hands/wrists. The data regarding prevalence affecting work or activity in this population should be interpreted carefully, since the clinical practice is part of their evaluation process, which could prompt students to keep their clinical practice despite their symptoms.

The 7-day prevalence report in our study mirrors the recent findings in this area, suggesting a consistent trend in short-term symptom prevalence in the dental student population, with main affected body regions being low back, neck, and shoulders, with rates slightly lower in our study when comparing to previous studies (Almeida et al. 2023). The lower rates of WMSDs reported over a 7-day period as compared to the annual figures may be influenced by the timing of the survey, which was conducted post-holiday, suggesting that temporary breaks in clinical practice could alleviate symptoms in the short term. However, the overall higher annual rates point to the persistent nature of these disorders, and highlight the cumulative impact of the physical and psychosocial demands and ergonomic challenges faced in dental practice, especially if we consider the unique requirements throughout the academic year. This emphasizes the critical need for further investigation on this issue to guide ergonomic improvements and proactive preventive strategies in dental education aiming to reduce the long-term risk of WMSDs among future dental professionals.

When analyzing the reporting differences between curricular years we observed that 5th-year students have a higher incidence of WMSDs in the neck ($p=0.043$) and shoulders ($p=0.168$), which could be attributable to the increased physical burden of clinical practice they undergo, especially given that their clinical hours are double those of the 4th-year students. Conversely, higher rates of lower back ($p=0.208$) WMSDs observed in 4th-year students compared to their 5th-year peers could stem from their relative inexperience, which might translate to poor techniques, as already reported in other studies (Botta et al. 2018; Lestari and Palupi 2020; Rendzova et al. 2021; Sulimany 2021). This inexperience subsequently places a greater strain on their lower backs, further evidenced by a higher 7-day prevalence rate for the same group, which could indicate a short-term issue that evolves to a long-term problem since it is a body region with one of the highest annual reported rates. Although we found these tendencies between curricular years, only the difference in neck WMSDs was significant,

which could suggest specific factors at play in the 4th and 5th years, such as the mentioned total of clinical training hours. To understand these results better, it would be beneficial to explore the specific conditions and behaviors of students in these years, as well as the motor behavior adaptations underlying these prevalence rates. Additionally, a longitudinal study design could be useful to track the evolution of these prevalence rates and motor control changes associated with the increasing clinical practice hours.

In examining the sex-specific data, we observed that female students reported a higher incidence of WMSDs in the cervical region ($p=0.168$) and hands/wrists ($p=0.348$), a trend that is in line with previous findings among female dental professionals and students (Felemban et al. 2021; Kurşun et al. 2014; Lestari and Palupi 2020; Sulimany 2021; Zafar and Almosa 2019). While the prevalence of cervical discomfort aligns with well-documented patterns, where females are generally more susceptible to neck pain (Fejer et al. 2006), a phenomenon usually attributed to distinct physiological pain perception mechanisms across sexes, our findings are opposed to existing literature that suggests higher hand/wrist symptomatology in male students (Aboalshamat 2020). Our study reveals a pronounced sex-related disparity, with female students experiencing a higher annual rate of cervical WMSDs (67.7%) compared to their male counterparts (50%), which is in accordance with the majority of previous studies in this area (Felemban et al. 2021; Kurşun et al. 2014; Lestari and Palupi 2020; Sulimany 2021; Zafar and Almosa 2019). Given that dental tasks often require sustained head flexion, leading to cervical muscle strain and joint stress, the interaction between occupational demands and inherent sex-related differences in pain sensitivity could explain the elevated incidence of neck issues among female students. Conversely, our results indicated that male students were more affected by shoulder ($p=0.325$) and upper back ($p=0.438$) WMSDs. Such a pattern suggests that male and female students may adopt distinct ergonomic strategies during dental procedures. Although the unbalanced sex ratio in our participant group and the sex differences found being non-significant could affect the robustness of these findings, the tendency of differences observed between male and female students could highlight the necessity for further investigation on this topic and for sex-specific ergonomic and preventive measures in dental education to address the unique vulnerabilities of each group.

In our exploration of risk factors associated with this WMSDs reporting, the binary logistic regression analysis highlighted two possible associations. Male students were found to be 90% more prone to develop WMSDs in shoulders despite the prevalence between sexes were non-significant as referred. Additionally, we found that students with higher anxiety levels are 49% more prone to refer WMSDs in lower back region, which is consistent with the existing literature (Hu et al. 2022; Oliveira et al. 2019).

The observed patterns of WMSDs total prevalence and group-specific occurrence in this population and their associations with physical and psychological factors underscore the importance of further research into the underlying motor behavior changes. Understanding the biomechanical and motor control adaptations that dental students develop in response to the demands of clinical practice could be crucial for creating more effective ergonomic interventions and develop adjusted preventive measures. Investigating these adaptations can provide valuable insights into the development of targeted preventive measures that can be integrated into dental studies curriculum. Moreover, the role of psychological factors in mediating the experience and reporting of WMSDs cannot be overstated. The interconnection between mental health, quality of life, and the physical manifestation of musculoskeletal symptoms necessitates a multidisciplinary approach to research, combining ergonomic, psychological, and physical dimensions. By delving into the different aspects that may predispose or protect against WMSDs and their real impact on their occurrence, stakeholders can develop more holistic and effective strategies to enhance the welfare of dental students, ultimately fostering a healthier and more productive future workforce in the dental profession.

Our study sought to address previously noted shortcomings such as incomplete participant data, a limited scope of associated factors, and the omission of the psychosocial dimension. However, we encountered certain limitations. The reliance on self-reported questionnaires, while cost-effective and widely accessible, carries an inherent risk of recall bias, particularly for the 12-month reporting period. While our response rate was commendable, capturing over half of the student body, a larger sample would lend more robustness to our findings. Additionally, the focus on senior dental students from a single academic institution may not reflect the wider student experience, given that educational and environmental conditions vary across different universities, both public and private, and across regions. The asymmetry between male and female students is representative of this student population, but may influence the interpretation and generalization of the results. These factors should be considered when extrapolating our results to a broader context.

Conclusion

Our study underscores the persistent high rates of WMSDs among dental students, especially in neck, low back, and shoulders, following the tendencies reported in previous studies with this population. Physical factors such as a student's sex, along with anxiety, were associated to WMSDs reported rates, and could play an important role in future understanding and managing

of WMSDs. Hence, a comprehensive and multifaceted study of motor behavior alterations and psychological determinants underlying these findings is essential. This approach will not only deepen our understanding of their causes but also aid in developing theoretical support for future coping strategies and interventions. Addressing these issues holistically can lead to better health outcomes for dental students, ensuring a more sustainable future in dental practice.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10389-024-02237-8>.

Authors' contributions All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by Manuel Barbosa de Almeida, Paula Moleirinho Alves, and Raúl Oliveira. The first draft of the manuscript was written by Manuel Barbosa de Almeida, and all authors commented and reviewed previous versions of the manuscript. All authors read and approved the final manuscript.

Funding Open access funding provided by FCTIFCCN (b-on). Our study was developed within the scope of the Egas Moniz Multidisciplinary Research Center (CiiEM) and funded by Portugal's national funds through the FCT — Foundation for Science and Technology, I.P. under the project <https://doi.org/10.54499/UIDB/04585/2020>.

Data availability The dataset used during the current study is published in open access on Mendeley Data and available from <https://data.mendeley.com/datasets/pym334vmrf/1>.

Declarations

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Egas Moniz School of Health & Science (Date September 2022/No. CEEM-1121).

Consent to participate Participants were required to read and provide their consent digitally, before starting data collection.

Competing interests The authors have no competing interests to declare that are relevant to the content of this article.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

Aboalshamat KT (2020) Nordic assessment of occupational disorders among dental students and dentists in Saudi Arabia. *J Int*

- Soc Prev Community Dent 10(5):561. https://doi.org/10.4103/jispcd.jispcd_142_20
- Almeida MB, Póvoa R, Tavares D, Alves P M, Oliveira R (2023) Prevalence of musculoskeletal disorders among dental students: a systematic review and meta-analysis. *Heliyon* 9(10):e19956. <https://doi.org/10.1016/j.heliyon.2023.e19956>
- Almeida MB (2023) DATASET — Work-related musculoskeletal disorders among dental students. Mendeley Data, V1. <https://doi.org/10.17632/pym334vmrf.1>
- Amaral AP, Soares MJ, Bos SC, Pereira AT, Marques M, Valente J, Nogueira V, Madeira N, Roque C, Macedo A (1991) The perceived stress scale (PSS-10)—a Portuguese version. *Clínica* 12:187–193
- Botta A, Presoto C, Wajngarten D, Campos J, Garcia P (2018) Perception of dental students on risk factors of musculoskeletal disorders. *Eur J Dent Educ* 22(4):209–214. <https://doi.org/10.1111/eje.12328>
- Faust AM, Ahmed SN, Johnston LB, Harmon JB (2021) Teaching methodologies for improving dental students' implementation of ergonomic operator and patient positioning. *J Dent Educ* 85(3):370–378. <https://doi.org/10.1002/jdd.12438>
- Fejer R, Kyvik KO, Hartvigsen J (2006) The prevalence of neck pain in the world population: a systematic critical review of the literature. *Eur Spine J* 15:834–848. <https://doi.org/10.1007/s00586-004-0864-4>
- Felemban RA, Sofi RA, Alhebshi SA, Alharbi SG, Farsi NJ, Abduljabbar FH, Farsi JM (2021) Prevalence and predictors of musculoskeletal pain among undergraduate students at a dental school in Saudi Arabia. *Clin Cosmet Investig Dent* 13:39–46. <https://doi.org/10.2147/ccide.s292970>
- Hayes M, Cockrell D, Smith D (2009) A systematic review of musculoskeletal disorders among dental professionals. *Int J Dent Hyg* 7(3):159–165. <https://doi.org/10.1111/j.1601-5037.2009.00395.x>
- Hu Y, Yang Z, Li Y, Xu Y, Zhou X, Guo N (2022) Anxiety symptoms and associated factors among chronic low back pain patients in China: a cross-sectional study. *Front Public Health* 10:878865. <https://doi.org/10.3389/fpubh.2022.878865>
- Kapitán M, Pilbauerová N, Vavříčková L, Šustová Z, Machač S (2019) Prevalence of musculoskeletal disorders symptoms among Czech dental students. Part I: a questionnaire survey. *Acta Med* 61(4):131–136. <https://doi.org/10.14712/18059694.2018.131>
- Koni A, Kufersin M, Ronchese F, Travani M, Cadenaro M, Filon FL (2018) Approach to prevention of musculoskeletal symptoms in dental students: an interventional study. *La Medicina del Lavoro* 109(4):276. <https://doi.org/10.23749/mdl.v109i4.6841>
- Kurşun Ş, Evirgen S, Akbulut N, Oztas B, Vaizoglu SA (2014) Work characteristics and musculoskeletal disorders among postgraduate dental students: a pilot study. *J Musculoskelet Pain* 22(1):62–67. <https://doi.org/10.3109/10582452.2014.883010>
- Lestari AI, Palupi R (2020) Better early prevention: dental students awareness of musculoskeletal disorders. *Syst Rev Pharm* 11(3):941–945. <https://doi.org/10.31838/srp.2020.3.143>
- Lietz J, Kozak A, Nienhaus A (2018) Prevalence and occupational risk factors of musculoskeletal diseases and pain among dental professionals in Western countries: a systematic literature review and meta-analysis. *PLoS ONE* 13(12):e0208628. <https://doi.org/10.1371/journal.pone.0208628>
- Mesquita CC, Ribeiro JC, Moreira P (2010) Portuguese version of the standardized Nordic musculoskeletal questionnaire: cross cultural and reliability. *J Public Health* 18:461–466. <https://doi.org/10.1007/s10389-010-0331-0>
- Murray GM, Peck CC (2007) Orofacial pain and jaw muscle activity: a new model. *J Orofac Pain* 21(4):263–278. (Discussion 279–288)
- Ohlendorf D, Naser A, Haas Y, Haenel J, Fraeulin L, Holzgreve F, Erbe C, Betz W, Wanke EM, Brueggmann D (2020) Prevalence of musculoskeletal disorders among dentists and dental students in Germany. *Int J Environ Res Public Health* 17(23):8740. <https://doi.org/10.3390/ijerph17238740>
- Oliveira DS, Mendonça L, Sampaio R, Castro-Lopes J, Azevedo LF (2019) The impact of anxiety and depression on the outcomes of chronic low back pain multidisciplinary pain management—a multicenter prospective cohort study in pain clinics with one-year follow-up. *Pain Med* 20(4):736–746. <https://doi.org/10.1093/pm/pty128>
- Peck C, Murray G, Gerzina T (2008) How does pain affect jaw muscle activity? the integrated pain adaptation model. *Aust Dent J* 53(3):201–207. <https://doi.org/10.1111/j.1834-7819.2008.00050.x>
- Rendzova V, Nikolovska J, Apostolska S, Petričević N (2021) Prevalence of work-related musculoskeletal symptoms among dental students at Ss. Cyril and Methodius University dental school in Skopje. *Open Access Maced J Med Sci* 9(D):19–23. <https://doi.org/10.3889/oamjms.2021.5582>
- Santucci NM, Jellin J, Davenport TE (2021) Dental and physical therapy faculty collaborate in assessing and educating dental students on musculoskeletal disorders. *J Dent Educ* 85(1):53–59. <https://doi.org/10.1002/jdd.12387>
- Sousa TV, Viveiros V, Chai MV, Vicente FL, Jesus G, Carnot MJ, Gordo AC, Ferreira PL (2015) Reliability and validity of the Portuguese version of the Generalized Anxiety Disorder (GAD-7) scale. *Health Qual Life Outcomes* 13(1):1–8. <https://doi.org/10.1186/s12955-015-0244-2>
- Suganthirababu P, Parveen A, Mohan Krishna P, Sivaram B, Kumaresan A, Srinivasan V, Vishnuram S, Alagesan J, Prathap L (2022) Prevalence of work-related musculoskeletal disorders among health care professionals: a systematic review. *Work* 74(2):455–467. <https://doi.org/10.3233/wor-211041>
- Sulimany AM (2021) Cervical and lumbar pain among dental interns in Saudi Arabia: a national cross-sectional study. *J Contemp Dent Pract* 22(8):860–866. <https://doi.org/10.5005/jp-journals-10024-3160>
- Trigo M, Canudo N, Branco F, Silva D (2010) Estudo das propriedades psicométricas da Perceived Stress Scale (PSS) na população portuguesa. *Psicologica* 53:353–378. https://doi.org/10.14195/1647-8606_53_17
- Vaz Serra A, Canavarro MC, Simões M, Pereira M, Gameiro S, Quartilho MJ, Rijo D, Carona C, Paredes T (2006) Estudos psicométricos do instrumento de avaliação da qualidade de vida da Organização Mundial de Saúde (WHOQOL-Bref) para Português de Portugal. *Psiquiatria Clínica* 27(1):41–49
- Zafar H, Almosa N (2019) Prevalence of work-related musculoskeletal disorders among dental students of King Saud University, Riyadh, Kingdom of Saudi Arabia. *J Contemp Dent Pract* 20(4):449–453. <https://doi.org/10.13075/mp.5893.01281>
- Zakerjafari HR, YektaKooshali MH (2018) Work-related musculoskeletal disorders in Iranian dentists: a systematic review and meta-analysis. *Saf Health Work* 9(1):1–9. <https://doi.org/10.1016/j.shaw.2017.06.006>

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.