



Original Article

## Awareness of ergonomics & work-related musculoskeletal disorders among dental professionals and students in Riyadh, Saudi Arabia

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**Abstract.** [Purpose] The present research was undertaken to investigate the awareness of ergonomics and prevalence of musculoskeletal disorders among dental professionals and students in Riyadh, Saudi Arabia and to find a mean to decrease the prevalence of musculoskeletal disorders in the future. [Subjects and Methods] A self-administered survey was prepared and disseminated to dental professionals and students in Riyadh, Saudi Arabia. The questionnaire was focused on the awareness of ergonomics and musculoskeletal disorders. Five hundred and sixty-one participants were included in this survey. [Results] Within the present study, significant differences were noticed among specialists, general practitioners and undergraduate students. Work load (risk factors) had great influence on musculoskeletal disorders in all dental practitioners, and lower back pain was the most common reported disorder among all practitioners. [Conclusion] Most of the respondent dentists seem to work in conditions that aggravate disorders of the musculoskeletal system, the increased prophylactic remedies were directly associated with the increase of the musculoskeletal disorders symptoms. All dentists regardless of their dental specialties, are recommended to apply principles of ergonomics in their daily practice. Moreover, dental ergonomics should be taught to undergraduate students and strictly implemented in the clinics to provide comfortable working environment for all dental professionals.

**Key words:** Ergonomics, Musculoskeletal disorders, Dentists in Saudi Arabia

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### INTRODUCTION

Musculoskeletal disorders (MSDs) are significantly accompanied with a varied range of occupations<sup>1, 2)</sup>, even though the majority of these disorders can be eluded or at least reduced with more consideration to ergonomics<sup>3, 4)</sup>.

Ergonomics is the scientific discipline concerned with designing equipment's and techniques for maximum efficiency and safety<sup>5, 6)</sup> to optimize human well-being and overall system performance in the work area<sup>7)</sup>. Dental professionals, in particular, often adopt uncomfortable and asymmetric positions; such as advancing and rotating the head sideways with the arms stretched out from the body<sup>8, 9)</sup>. This approach, if detained for extended periods of time each day, tends to overstrain muscles and joints, particularly those of the neck, back and shoulder, triggering symptoms such as headache, backache, neck and shoulder pain<sup>10, 11)</sup>.

Musculoskeletal disorders have been gradually spreading worldwide over the last years<sup>12)</sup>. It is a common source of

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work-related disability among personnel with considerable economic concerns due to workers' compensation and medical expenses<sup>13</sup>). The constant use of high frequency vibration tools have been affirmed to be responsible for minor hand neuropathy<sup>14</sup>).

The application of ergonomics in dentistry would enhance optimum access, discernibility, relief and control in clinical practice<sup>15</sup>). In order to ameliorate the dental profession's working conditions; the sit-down and four-handed dentistry perceptions have been implemented<sup>16</sup>). Appropriate ergonomic design is essential to avoid repetitive strain injuries, which can progress to long-term disability over time<sup>17</sup>).

Dentists are capable to access required equipment and materials through monitoring the patient's mouth position, that aid them to work more accurately, more competently, and with less physical and mental wear and tear on both the patient and the dentist<sup>18, 19</sup>).

The objective of the present study is primarily to investigate the awareness of ergonomics and prevalence of musculoskeletal disorders among dental professionals and students in Riyadh, Saudi Arabia and secondly to find a mean to decrease the prevalence of musculoskeletal disorders in the future.

## SUBJECTS AND METHODS

A self-administered survey was prepared and distributed to dental professionals and students in Riyadh, Saudi Arabia. The questionnaire mainly focused on the awareness of ergonomics and MSDs. The study was approved and supported by the College of Dentistry Research Center (CDRC) and Deanship of Scientific Research, King Saud University (Research project No. IR 0050).

The questionnaire was divided into 4 sections; the first section included the demographic characteristics regarding gender, age, work duration and type of clinic. The second section involved the implementation of ergonomics. The third dealt with the work conditions (such as working posture, working with or without an assistant) and the organization of dentist's work (number of breaks and their purpose) and the last section was concerned with the MSDs and the prophylactic physical activities (type and effectiveness). Some questions had multiple response options.

The SPSS statistical package software version 20 (IBM Corp., Armonk, NY, USA) was used to perform the analysis of the data collected from the questionnaires. The frequency and percentage of all the nominal variables were calculated, additionally,  $\chi^2$  test was utilized to compare between the nominal variables. The level of statistical significant difference was set at  $p \leq 0.05$ .

## RESULTS

Out of the 700 questionnaires distributed to the different dental schools and clinics in Riyadh, 561 questionnaires were only included in the present study after excluding the questionnaires with incomplete data as well as the ones that were not returned.

The questionnaire comprised four parts; the demographic information of the participants, the implementation of ergonomics, the working conditions, the musculoskeletal disorders and the prophylactic physical activities as shown in Tables 1–6.

The patients' age ranged from 21 to 52 years with a mean and standard deviation of  $27.5 \pm 6.8$ , the majority of the respondents were below 30 years (79.1%). Fifty seven percent of the respondents were males 43% were females as shown in Table 1. The study group presented various specialties in different fields of dentistry, including endodontists (16.8%), restorative dentists (16.8%), prosthodontists (12.6%), oral maxillofacial surgeons (21%), pediatric dentists (9.2%), periodontists (11%), and orthodontists (12.6%). 58.1% of them were working in governmental institutions and 86.5% of them were right handed.

Table 2 represents the awareness of the participants according to gender and profession where 75.8% of female dentists responded they had an idea what the term ergonomics meant, in comparison to 52.6% of the males with statically significant difference ( $p < 0.05$ ). Additionally, female dentists seemed to be aware of the related risk factors whether implementing ergonomics or not. Statistical significant differences were also noticed among specialists, general practitioners and undergraduate students.

The majority of dentists in the present study indicated that they prefer working while sitting rather than standing, 71% of them stated that they always work with an assistant, while only half of the undergraduate students responded that they work without an assistant (Table 3).

The majority of dentists work from 5–10 hours daily, while 51.3% of the undergraduate students work less than 5 hours daily. The number of treated patients appeared to increase among the specialists (>9 patients) followed by the general practitioners and interns (4–6 patients) which was statistically significant.

Most of the participants reported they take breaks between patients. Whereas 50% responded, they do physical activities and stretching during and after work (Table 3).

The self-reported risk factors (workloads) for musculoskeletal complaints are shown in Table 4. Strenuous shoulder/ hand movements were 88% reported by pediatric dentists, periodontists and restorative dentists, while the least exposed were the oral maxillofacial surgeons (62%). Likewise, the question regarding frequent use of vibrating tools, the oral maxillofacial surgeons were the least users (44%) among the specialists, contrary to the periodontists and endodontists respectively (91.7% and 86.4%).

**Table 1.** Demographic data of the patients

Data variables		Frequency N (%)
Gender	Male	320 (57)
	Female	241 (43)
Age (years)	20–25	325 (57.9)
	26–30	119 (21.1)
	31–35	57 (10.2)
	36–40	27 (4.8)
	>40	33 (5.9)
Clinical profession	Student	236 (42.1)
	Intern	123 (21.9)
	GP	77 (13.7)
	Specialists	119 (21.4)
Working institution	Government	326 (58.1)
	Private	183 (32.6)
Years of practice	≤5	373 (66.5)
	6–10	80 (14.3)
	11–15	42 (7.5)
	16–20	20 (3.6)
	>20	18 (3.2)
Handedness	Right-handed	485 (86.5)
	Left-handed	52 (9.3)
	Both hands	19 (3.4)

**Table 2.** Awareness regarding the importance of ergonomics according to gender and profession

Data Variables		Gender		Clinical profession			
		Male	Female	Students	Interns	GP	Specialists
Did you have any idea about ergonomics?	N	180	182	125	88	59	84
	%	56.2	75.8*	53.0	71.5	77.6*	70.6
Are you applying ergonomics in your dental practice?	N	135	131	93	60	47	61
	%	43.1	55*	40.4	49.2	61.8*	23.4
Do you think ergonomics is useful?	N	253	205	172	108	68	105
	%	81.1	86.9	75.4	88.5	88.3	91.3*
Are you aware of work related risk factors if you do not apply ergonomics	N	203	186	148	88	61	87
	%	64.2	78.8*	63.8	71.5	80.3*	75.7
Do you feel exhausted after clinical work	N	259	200	188	99	68	99
	%	81.7	83.3	80.3	81.1	88.3	83.9
Do you think dental work is physically demanding?	N	280	216	195	111	70	115
	%	87.8	90.4	83.7	90.2	90.9	96.6*
Do you think ergonomics might improve your daily performance in the clinic?	N	263	202	181	107	67	105
	%	83.2	86.2	78.0	87.7	87.0	90.5*

\*Statistically significant at  $p < 0.05$ .

Awkward (inconvenient) working postures were pronounced in prosthodontists and periodontists respectively (100% and 91.7%) in comparison with the other specialties. No significant variations were reported for prolonged sitting and/or standing habits although prosthodontists and endodontists reported a higher percentage, subsequently, undergraduate students were likely less exposed to all of these workload demands.

Regarding the occurrence of musculoskeletal disorders, no significant differences were observed with the years of practices, except for knee joint pains. Workload (risk factors) had great influence on MSDs in all dental practitioners as shown in Table 5, lower back pain being the most common disorder in all practitioners (80%). Increased hand/wrist pain in professionals was readily an obvious finding when compared to students, while the students and professionals had equal chances of having lower back pain when exposed to inconvenient working postures.

**Table 3.** Working conditions according to gender and profession

Data variables	Gender		Clinical profession			
	Male	Female	Students	Interns	GP	Specialists
Do you prefer working						
Standing	9.1	12.1	14.1	8.1	6.5	7.6
Sitting	57.4	58.8	53.0	63.4	59.7	62.2
Both	33.5	29.2	32.9	28.5	33.8	30.3
Do you work with an assistant?	70.5	71.0	50.4	74.8	87.0	95.0*
Working Hours						
<5	38.6	23.4	51.3*	28.5	13.0	1.0
5–10	55.5	68.6*	43.2	69.1	76.6	78.8*
>10	6.0	7.9	5.6	2.4	10.4	10.2
Number of treated patients / day						
1–3	52.4*	38.2	89.0*	25.2	5.2	11.0
4–6	24.1	29.0	10.6	52.0*	35.1	24.6
7–9	13.2	19.9	0.0	21.1	32.5	30.5
>9	10.3	12.9	0.4	1.6	27.3	33.9
Do you take breaks in between patients?	77.1*	62.4	82.1*	70.7	50.7	62.7
Physical activities or stretching during or after work	50.5	45.7	43.2	47.2	53.3	56.4

\*Statistically significant at  $p < 0.05$ . Values in the table are percentages.

**Table 4.** Workload demand according profession

Work load demand	Clinical profession			
	Student	Intern	GP	Specialists
Strenuous shoulder/Arm movement	75	78.7	83.1	82.6
Frequent use of vibrating tools	55.6	70.5*	64.9	61.4
Inconvenient working postures	70.6	75.2	79.2	78.8
Prolonged sitting or standing	78.9	82.6	85.7	87.9

\*Statistically significant at  $p < 0.05$ . Values in the table are percentages.

**Table 5.** MSDs associated with workload demand among professionals and students

Work load demand	Musculoskeletal disorders							
	Students vs. professionals							
	Hand/Wrist		Lower back pain		Upper back pain		Neck pain	
St	Pf	St	Pf	St	Pf	St	Pf	
Strenuous shoulder/arm movement	65.7*	57.6	80.1	80	72.9*	68.8	79.1*	75.9
Frequent use of vibrating tools	64.2*	51.6	82.6	80	72.9	72.4	75.4	80.9*
Inconvenient working postures	62.3*	53.8	81.9	81.9	71.7	69.8	77.5	77.1
Prolonged sitting or standing	62.4*	54.7	80.3	79.5	72	69.8	76.4	85.3

\*Statistically significant at  $p < 0.05$ . Values in the table are percentages. St: students; Pf: professionals.

The least chance among the common MSDs was hand /wrists and shoulders. In general, when the workload demand was increased as seen in the present findings, there seemed to be an increased chance to have musculoskeletal disorders. There was a significant variation in neck pain increase in professionals than students during frequent use of vibrating tools.

Commonly used prophylactic remedies that could treat or decrease the symptoms of musculoskeletal disorders such as analgesics, steroids, physiotherapy were commonly used with aging dentists, which was highly significant with the increased years of practice. The increased prophylactic remedies were directly associated with the increase of the MSDs symptoms. On the other hand, the physical activities were inversely associated with increase years of practice, the more workload the less physical activities was performed by the professionals in comparison to the younger dentists as shown in Table 6.

Analgesics were commonly used after 10 years of practice. Where 40% reported sometimes and 12.9% always, but steroids were minimally used and were diminished due to awareness of the side effects of the drug. The professionals with less than

**Table 6.** Commonly used prophylactic remedies

Variables	Years of practice	Always	Sometimes	Never
Analgesics	≤5	5.3	22.7	72*
	6–10	8.3	36.1	55.6*
	>10	12.9	40	47.1
Physiotherapy	≤5	2.2	13.9	83*
	6–10	5.7	20	74.3*
	>10	2.9	29.4	67.6*
Steroids	≤5	1	7.3	91.7*
	6–10	0	14.5	85.5*
	>10	0	19.1	82.1*
Physical activities	≤5	10.3	20.6	69.1*
	6–10	9.9	33.8	56.3*
	>10	1.4	44.9	53.6

\*Statistically significant at  $p < 0.05$ . Values in the table are percentages.

5 years' experience were performing physical activities more regularly than the older professionals who reported to undergo less frequent physical activities. Most professionals (55.2%) agreed on sharing a mutual physical activity that was walking, followed by stretching exercises (45.3%) in addition to other activities such as relaxation techniques, swimming and fitness.

## DISCUSSION

The present self-administered survey was designed to investigate the awareness of ergonomics and prevalence of musculoskeletal disorders among dental professionals and students in Riyadh, Saudi Arabia and to find a mean to decrease the prevalence of musculoskeletal disorders in the future. The provided self-reported information by the respondents was of clinical relevance for the assessment of occupational health hazards among dental professionals at various educational levels.

There was an appreciable difference in awareness between the demographic variables of the participants' where female dentists seemed to have a better awareness regarding the importance of ergonomics. Similarly, the more specialized professional dentists showed an increased awareness in ergonomics than the general practitioners and undergraduate students. Interestingly, both genders seemed to agree on feeling exhausted after a long clinical working day and emphasized the usefulness of applying ergonomics in the dental environment whether working in governmental or private institutions in accordance with previous researches<sup>20, 21</sup>.

Al Wazzan et al.<sup>22</sup> presumed that the number of years of practice have an essential part in the occurrence of MSDs, even though younger and older dentists equally reported the same symptoms, as confirmed in the present study. The present findings show that pain in the upper and lower back, hand/wrists, hips, ankles, knees increased with the increased years of practice supporting previous findings<sup>20, 22</sup>. However, the young general dental practitioners often work over 8 hours a day in the earliest years of their practice, which trigger premature occurrence of MSDs within 3 years.

The prevalence and distribution of symptoms of MSDs was also observed within the frame of the present work occurring even among dental students similar to previous reports<sup>23, 24</sup>. The present findings suggest that awareness of these problems should be taught to the students from the early preclinical stage of their undergraduate studies, as a preventive measure regarding proper work practices and positions to reduce the risk of early MSDs<sup>25</sup>. Numerous investigators showed major interest in the field of ergonomics for the correct working posture of the dentists since it is considered an essential risk factor for developing musculoskeletal disorders<sup>26, 27</sup>.

The majority of the male and female dentists from different specialties preferred to work in a sitting position when working conservatively rather than standing, few reported to be alternating between sitting and standing similar to Rundcrantz et al.<sup>1</sup> and Chaikumarn<sup>21</sup>. On the other hand, Ratzon et al.<sup>28</sup> observed that dentists who unceasingly worked in a sitting posture had more severe low back pain than those who alternated between sitting and standing. The main objective for any clinician is to find a position that permits him to attain optimal access, visibility, comfort, and control at all times.

Interruptions or micro pauses are assumed essential in reducing or varying musculoskeletal load. The majority of the male (77.1%) and female (62.4%) dental professionals reported that they needed to take small breaks between patients contrary to that reported by Szymańska<sup>29</sup> who discovered that more than 30% of the dentists worked without breaks. Similarly Chaikumarn<sup>21</sup> reported that only 41.7% of the dentists had breaks of around 5 minutes between patients. Ilmarinen and his colleagues<sup>30</sup> have previously pointed out that among 88 professions, the highest stress factor level was observed in dentists, kitchen supervisors and physicians. A thorough study regarding the rest breaks in the dental practice have been well-documented<sup>31</sup>. Constant sitting and no breaks are possibly associated to sitting in the same posture, and it is thus related to musculoskeletal discomfort, affecting the dentists' awareness of dental work as a challenging job causing exhaustion after

work. One-third of the male and female dentists (22.9% and 37.6% respectively) were not attentive of the preventive role of rest breaks, and in turn jeopardize the occurrence of fatigue and disorders. Short rest breaks taken in dental practice at regular intermissions can lessen the discomfort in the musculoskeletal and nervous system. Nonetheless, Szymańska<sup>29)</sup> found no apparent correlation between the lack of rest breaks and presence of physical activity and the number of musculoskeletal disorders.

It is indispensable to change the tiresome working habits in the dental profession. According to Newell and Kumar<sup>32)</sup>, dentists can diminish the risk of developing MSDs by using suitable body posture and positioning during clinical procedures, integrating regular rest breaks, sustaining good general health, and carrying out exercises for the affected regions of the body. Furthermore, they emphasized that regular physical examinations of the dentists would provide more detailed information and early diagnosis of MSDs.

To the question relating to whether they used prophylaxis to treat some of the musculoskeletal system disorders (steroids, analgesics and physiotherapy), a highly statistical significant relationship was found in the present findings between the years of practice and prophylactic remedies undertaken confiding with the previous study of Szymańska<sup>29)</sup>.

The prime objective of Ergonomics is the prevention of work-related musculoskeletal disorders and the associated symptoms that aggravate these disorders<sup>3)</sup>. In dentistry, bad working practices, and repetitive tasks such as root planning, scaling and uncomfortable physical postures significantly contribute to musculoskeletal disorders, stress, and loss of productivity. The working capacity and productivity of dental professionals would be improved by practicing correct postures, in turn, they will be able to practice in a pain-free environment for quality dental care to their patients<sup>25, 33)</sup>.

The result of long hours every day was unreasonable from the viewpoint of ergonomics. The experience of numerous disorders of the musculoskeletal system increased with the number of years in dental practice. For these ailments, dentists must make use of various forms of treatment. Only some of the respondents utilized effective prophylaxis concerning the musculoskeletal system. Physical exercise was frequently used without prophylactics. Those who were persuaded by physical exercise were mainly those who had enough awareness to overcome their problems by self-treatment. Moreover, 90.3% of respondents believe physical activities may decrease MSDs. The most common physical activities performed by the respondents were walking followed by stretching techniques more than other activities. Accurate Ergonomics alongside regular exercises, relaxation techniques (meditation, biofeedback and yoga), and appropriate nutrition could help fight stress, preserving the productive energy for increasing comfort and quality of life enhancement and eventually leading to prolonged careers.

The present findings are in accordance to previous studies carried out around the world, such as India<sup>27, 34)</sup>, Greece<sup>35)</sup>, Sweden<sup>14)</sup>, Canada<sup>36)</sup>. Few studies were also carried out in different regions of Saudi Arabia including Eastern province<sup>37)</sup>, Ha'il region<sup>38)</sup> and Jeddah<sup>39)</sup>. They all reported that the prevalence of work related musculoskeletal disorders among dentists<sup>22, 37, 38)</sup>, dental auxiliaries<sup>22)</sup> and nurses<sup>39)</sup> in Saudi Arabia is high, affecting their daily activities confirming the present research findings.

Most of the respondent dentists seem to work in conditions that exacerbate disorders of the musculoskeletal system, the increased prophylactic remedies were directly associated with the increase of the musculoskeletal disorders symptoms. All dentists irrespective of their dental specialties, are recommended to apply principles of ergonomics in their daily practice including regular rest breaks and physical exercise to prevent the risk of having musculoskeletal disorders. Moreover, dental ergonomics should be taught to undergraduate students and strictly implemented in the clinics to provide comfortable working environment for all dental professionals.

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### *Poster presentation in a conference*

The present research entitled "Awareness of Ergonomics & Work-related Musculoskeletal Disorders among Saudi Dental Professionals and Students" was presented by all authors as a poster only during the 14th Makkah International Dental Conference from March 28–30th, 2017, in Makkah, Saudi Arabia. It was only published as title, no abstract was included in the official booklet of the conference on page 63 number 98.

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### *Conflict of interest*

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## REFERENCES

- 1) Rundcrantz BL, Johnsson B, Moritz U: Cervical pain and discomfort among dentists. Epidemiological, clinical and therapeutic aspects. Part 1. A survey of pain and discomfort. *Swed Dent J*, 1990, 14: 71–80. [Medline]
- 2) Rundcrantz BL, Johnsson B, Moritz U: Occupational cervico-brachial disorders among dentists. Analysis of ergonomics and locomotor functions. *Swed Dent J*, 1991, 15: 105–115. [Medline]
- 3) Laderas S, Felsenfeld AL: Ergonomics and the dental office: an overview and consideration of regulatory influences. *J Calif Dent Assoc*, 2002, 30: 135–138, 137–138. [Medline]
- 4) Rucker LM, Sunell S: Ergonomic risk factors associated with clinical dentistry. *J Calif Dent Assoc*, 2002, 30: 139–148. [Medline]
- 5) Chang BJ: Ergonomic benefits of surgical telescope systems: selection guidelines. *J Calif Dent Assoc*, 2002, 30: 161–169. [Medline]
- 6) Yoser AJ, Mito RS: Injury prevention for the practice of dentistry. *J Calif Dent Assoc*, 2002, 30: 170–176. [Medline]
- 7) Gupta A, Bhat M, Mohammed T, et al.: Ergonomics in dentistry. *Int J Clin Pediatr Dent*, 2014, 7: 30–34. [Medline]
- 8) Marshall ED, Duncombe LM, Robinson RQ, et al.: Musculoskeletal symptoms in New South Wales dentists. *Aust Dent J*, 1997, 42: 240–246. [Medline] [Cross-Ref]
- 9) Milerad E, Ekenvall L: Symptoms of the neck and upper extremities in dentists. *Scand J Work Environ Health*, 1990, 16: 129–134. [Medline] [CrossRef]
- 10) Shugars D, Miller D, Williams D, et al.: Musculoskeletal pain among general dentists. *Gen Dent*, 1987, 35: 272–276. [Medline]
- 11) Fox JG, Jones JM: Occupational stress in dental practice. *Br Dent J*, 1967, 123: 465–473. [Medline]
- 12) Kerosuo E, Kerosuo H, Kanerva L: Self-reported health complaints among general dental practitioners, orthodontists, and office employees. *Acta Odontol Scand*, 2000, 58: 207–212. [Medline] [CrossRef]
- 13) Andersson GB: Epidemiological features of chronic low-back pain. *Lancet*, 1999, 354: 581–585. [Medline] [CrossRef]
- 14) Akesson I, Lundborg G, Horstmann V, et al.: Neuropathy in female dental personnel exposed to high frequency vibrations. *Occup Environ Med*, 1995, 52: 116–123. [Medline] [CrossRef]
- 15) Pollack R: Dental office ergonomics: how to reduce stress factors and increase efficiency. *J Can Dent Assoc*, 1996, 62: 508–510. [Medline]
- 16) Finkbeiner BL: Four-handed dentistry: instrument transfer. *J Contemp Dent Pract*, 2001, 2: 57–76. [Medline]
- 17) Sarkar PA, Shigli AL: Ergonomics in general dental practice. *People's J Sci Res*, 2012, 5: 56–60.
- 18) Gupta A, Ankola AV, Hebbal M: Dental ergonomics to combat musculoskeletal disorders: a review. *Int J Occup Saf Ergon*, 2013, 19: 561–571. [Medline] [CrossRef]
- 19) Tezel A, Kavrut F, Tezel A, et al.: Musculoskeletal disorders in left- and right-handed Turkish dental students. *Int J Neurosci*, 2005, 115: 255–266. [Medline] [CrossRef]
- 20) Alexopoulos EC, Stathi IC, Charizani F: Prevalence of musculoskeletal disorders in dentists. *BMC Musculoskelet Disord*, 2004, 5: 16. [Medline] [CrossRef]
- 21) Chaikumarn M: Working conditions and dentists' attitude towards proprioceptive derivation. *Int J Occup Saf Ergon*, 2004, 10: 137–146. [Medline] [CrossRef]
- 22) Al Wazzan KA, Almas K, Al Shethri SE, et al.: Back & neck problems among dentists and dental auxiliaries. *J Contemp Dent Pract*, 2001, 2: 17–30. [Medline]
- 23) Melis M, Abou-Atme YS, Cottogno L, et al.: Upper body musculoskeletal symptoms in Sardinian dental students. *J Can Dent Assoc*, 2004, 70: 306–310. [Medline]
- 24) Rising DW, Bennett BC, Hursh K, et al.: Reports of body pain in a dental student population. *J Am Dent Assoc*, 2005, 136: 81–86. [Medline] [CrossRef]
- 25) Rabiei M, Shakiba M, Shahreza HD, et al.: Musculoskeletal disorders in dentists. *Int J Occup Hyg*, 2012, 4: 36–40.
- 26) Muralidharan D, Fareed N, Shanthy M: Musculoskeletal disorders among dental practitioners: does it affect practice? *Epidemiology Research International*, 2013, 2013:1–6.
- 27) Bedi HS, Moon NJ, Bhatia V, et al.: 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: ZC01–ZC03. [Medline]
- 28) Ratzon NZ, Yaros T, Mizlik A, et al.: Musculoskeletal symptoms among dentists in relation to work posture. *Work*, 2000, 15: 153–158. [Medline]
- 29) Szymańska J: Disorders of the musculoskeletal system among dentists from the aspect of ergonomics and prophylaxis. *Ann Agric Environ Med*, 2002, 9: 169–173. [Medline]
- 30) Ilmarinen J, Suurnäkki T, Nygård CH, et al.: Classification of municipal occupations. *Scand J Work Environ Health*, 1991, 17: 12–29. [Medline]
- 31) Kierklo A, Kobus A, Jaworska M, et al.: Work-related musculoskeletal disorders among dentists—a questionnaire survey. *Ann Agric Environ Med*, 2011, 18: 79–84. [Medline]
- 32) Newell TM, Kumar S: Prevalence of musculoskeletal disorders among orthodontics in Alberta. *Int J Ind Ergon*, 2004, 33: 99–107. [CrossRef]
- 33) Pandis N, Pandis BD, Pandis V, et al.: Occupational hazards in orthodontics: a review of risks and associated pathology. *Am J Orthod Dentofacial Orthop*, 2007, 132: 280–292. [Medline] [CrossRef]
- 34) Dabholkar T, Gandhi P, Yardi S, et al.: Prevalence of musculoskeletal disorders in dental surgeons of Mumbai. *J Health Res Rev*, 2015, 2: 50–53. [CrossRef]
- 35) Tsekoura M, Koufogianni A, Billis E, et al.: Work-related musculoskeletal disorders among female and male nursing personnel in Greece. *World J Res and Review*, 2017, 3: 8–15.
- 36) Liss GM, Jesin E, Kusiak RA, et al.: Musculoskeletal problems among Ontario dental hygienists. *Am J Ind Med*, 1995, 28: 521–540. [Medline] [CrossRef]
- 37) Abduljabbar TA: Musculoskeletal disorders among dentists in Saudi Arabia. *Pak Oral Dent J*, 2008, 28: 135–144.
- 38) Aljanakh M, Shaikh S, Siddiqui AA, et al.: Prevalence of musculoskeletal disorders among dentists in the Hail Region of Saudi Arabia. *Ann Saudi Med*, 2015, 35: 456–461. [Medline] [CrossRef]
- 39) Attar SM: Frequency and risk factors of musculoskeletal pain in nurses at a tertiary centre in Jeddah, Saudi Arabia: a cross sectional study. *BMC Res Notes*, 2014, 7: 61. [Medline] [CrossRef]