

| |
|---|
| Access this article online |
| Quick Response Code: |
|  |
| Website: www.jehp.net |
| DOI: 10.4103/jehp.jehp_80_16 |

Neck, back, and shoulder pains and ergonomic factors among dental students

Raha Habib Aghahi¹, Rezvan Darabi², Maryam Alsadat Hashemipour^{1,3,2}

Abstract:

BACKGROUND: Dynamic and static activities in dentistry cause musculoskeletal disorders, but dental students do not have sufficient awareness about the effects of ergonomic factors on their health. The aim of this study was to investigate ergonomic factors that cause pain muscle in dental students in Kerman Medical University, Iran.

METHODS: This cross-sectional analysis study was carried out on dental students of the 3rd, 4th, 5th, and 6th year, in clinical practice in the School of Dentistry, Kerman University of Medical Sciences. A convenient sample of 199 students who met the inclusion criteria was selected and those willing to participate signed an informed consent form. Data were collected by means of a structured questionnaire for ergonomic factors and the presence of pain. The variables evaluated were pain, affected zones, gender, postures, and work environment.

RESULTS: The present research work reveals that over 69% of the dental students complained of pain in at least one part of their body. Most individuals suffered from hand and elbow (23%) and head (19%) pain. The clinical areas where more pain was found were endodontics and pedodontics. Furthermore, it was found that a high percentage of students usually worked with their legs slightly separated, with the sole of the feet resting on the stool when working. The presence of muscular pain was higher in males in this study. Furthermore, there was a statistically significant relationship with the final Rapid Entire Body Assessment score in different body parts and the participants' demographic data (sex, age, weight, height, sports, and smoking).

CONCLUSIONS: The results of this study showed that the students' sitting positions and working environments need to be improved and it seems more training is necessary in this field.

Keywords:

Back, dental student, ergonomic factors, neck, pains, shoulders

Introduction

Working has an important role in the health and social and economic development of a society. The environment and working conditions may be the cause of many problems. One of the important factors is the work-related physical disorders that reduce productivity. This is largely due to poor occupational health and education among people. Based on an overall assessment, about 150 million people are affected by these problems

and about four times as much as it was 20 years ago.^[1] Ergonomics is the science that deals with the stresses and damages to human beings in relation to their job and professional activities and its main aim is to prevent work-related disorders and other symptoms.^[1,2]

Dentistry is a profession that often causes muscle pain. These pains are usually harmless and appear lowly, and the symptoms are often ignored until they lead to a chronic disorder and create a permanent injury.^[3] Dentistry, especially general dentistry, is a high-risk profession

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Aghahi RH, Darabi R, Hashemipour MA. Neck, back, and shoulder pains and ergonomic factors among dental students. *J Edu Health Promot* 2018;7:40.

¹Kerman Dental and Oral Diseases Research Center, Kerman University of Medical Sciences, Departments of ²Oral Medicine, School of Dental Kerman, Kerman University of Medical Sciences, ³Kerman Social Determinants on Oral Health Research Center, Kerman University of Medical Sciences, Kerman, Iran

Address for correspondence:

Prof. Maryam Alsadat Hashemipour, Department of Oral Medicine, School of Dentistry, Kerman University of Medical Sciences, Kerman, Iran.
E-mail: m_s_hashemipour@yahoo.com

Received: 24-03-2017

Accepted: 09-12-2017

in terms of muscle and skeletal disorders. Repetitive, long-term, and poor work habits in association with this field's need for good visibility and repeated movements of the upper limb are the causes of these problems in the dental profession.^[2,4] Ergonomic factors include posture, holding tools, stance, and environmental factors such as light and sound. The most common dental positions have undergone changes worldwide during the past 30 years. At the beginning, dentists worked in a standing position. In 1960, sitting position was introduced to dentists as the best position during the working time period. A four-handed dentistry ward was introduced for the first time in a conference in 1960. This plan and use of a dental assistant was another attempt to reduce stress. In this study, the position of the dentists was standardized in terms of patients and their positions. The dental assistant holds the tool tray to help reduce pressures to the dentist.^[4] In recent decades, the work environment of dentists has been examined in several studies, and the prevalence of musculoskeletal pain and dysfunction has been obtained. For the first time in 1946, Biller reported that the prevalence of back pain in dentists was 65%.^[4,5] Seyfarth and Carlson in the 1950s reported that low back pain and dysfunction were more common than neck pain.^[2,4] In fact, the prevalence of low back pain provides the basis for work in a sitting position. In 1977, a study was conducted based on a questionnaire. The results showed that the motor system disorders are often concentrated in the lumbar region, spreading to the neck and shoulders. Other studies in the 1980s showed that despite improvements in the design of dental equipment and ergonomic working environment, neck and shoulder pain and dysfunction are predominant.^[4,5] Some researchers believe that by transition of the position of dentists from standing to sitting, the frequency of the disorder not only did not change but also increased the symptoms of the neck and shoulders. This group reported that transition from the standing position to a sitting during work is not the only factor, but other factors such as environment, work, stress, work periods without interruption, and dentist's vision are very important as the predisposing factors.^[4]

Considering the results published in connection with ergonomic factors causing muscle pain in other countries and due to the lack of accurate statistics on these lesions in the dental society in Iran, this study was designed to investigate ergonomic factors causing muscle pain in dental students in Kerman.

Methods

In this cross-sectional study, the participants were students in Kerman Dental School from semesters 6–12. The lists of dental students were obtained from the Education Department of the university.

A questionnaire was designed and submitted to the students in semesters 6–12 by a final-year student. The aim of this study was explained to each participant, and if they desired, a questionnaire was handed in meanwhile, all the participants were reassured that the information would remain confidential, and just, the statistical aspects would be examined. The questionnaire asked about ergonomic factors and also background information, including gender, semester, and muscle pain. The validity of this study was determined using the content validity index before data collection. To achieve validity, the questionnaire was submitted to eight specialists in Kerman Dental School, who were asked to give their opinion on the questions including perfect, good, no idea, poor, and very poor. After collecting and evaluating the comments, discussions were held about the questions and the comprehensibility of the questions. Based on dentists' views and review of the literature, the validity of the questionnaire was satisfactory. Validity of the questionnaire was 79% and for questions ranged from 77% to 89%.

Reliability coefficients were determined by submitting the questionnaire to 10 dental students within an interval of 10 days, and the students were asked to respond. Reliability coefficient was determined using Cronbach's alpha ($\alpha = 0.80$), which proved satisfactory.

Students with back pain, neck pain, and spinal disorders, those who were in the practice of powerlifting or heavy exercise, students with kyphosis, whom were at risk of lumbar disc disease, those with a history of trunk or lower extremity fractures or a history of lower extremity muscle tear, or those doing calisthenics at least three times a week were excluded from the study.

Furthermore, for more detailed study, forty students were evaluated randomly by researchers during work based on the Rapid Entire Body Assessment (REBA). This method is appropriate to rapid body assessment for occupations with a static long-term status such as dentistry. In this way, people's situation can be assessed in short-term. Different parts of the body to be analyzed were assigned to two groups: A (the trunk, neck, and legs) and B (the arms, forearms, and hands with a tool). The same activities are considered for all genders. After a final review of each individual's situation, data were entered into the EXCEL program. REBA final score was between 1 and 15, respectively, for each side of the body.^[6]

The results were analyzed with *t*-test, Kruskal–Wallis one-way, regression analysis, and Chi-squared test using SPSS 20 (v20, SPSS Inc., Chicago, IL) at a significance level of $P < 0.05$.

Results

In this study, 199 students of Kerman Dental School were evaluated; 61.8% (123 students) were female and 38.2% (76 students) were male. Of the respondents, 45 students were in the 3rd year (22.6%), 52 were in the 4th year (26.1%), 54 were in the 5th year (27.8%), and 48 were in the 6th year (24.1%).

The study showed that 91.9% ($n = 183$) of students were not familiar with the ergonomic dental work time; 69% (137) of the students reported muscle pain during dental work and 62% had experienced pain when working with a handpiece. Table 1 shows the percentages of students answering the above questions based on gender. Fields in which more pain was reported were as follows: endodontics (79%), pedodontics (73%), restorative (54%), prosthetics (34%), periodontics (25%), and surgery (12%). Equal to 62% ($n = 124$) of the participants said that when they were working, they were not able to change their position properly, and 15% ($n = 30$) mentioned that they changed their positions regularly while working. Five percent ($n = 10$) did stretching exercises, and finally, 82% (163) reported that they had severe motions when taking dental appliances in their hands [Table 2].

The results showed that a high percentage of students usually put their legs apart, with the sole of their feet resting on the ground while working. In addition, almost all of them (92.8%) bent their neck toward the patient's oral cavity for better visibility while working. On the other hand, 35% ($n = 70$) of the students put their hands at the sternum level. Forty-two percent ($n = 84$) of students said that they had enough space in their working area. Only 20% ($n = 40$) of the students had comfortable chairs. This study showed that there was a significant relationship between reporting of muscle pain in students and variables such as gender (men more than women, $P = 0.001$), field (endodontics and pedodontics, $P = 0.01$), sitting position (no change in position, $P = 0.01$), and working conditions ($P < 0.001$) [Table 3].

This study shows that only 20% of all students have comfortable dental chair and any difference is observed between male and female ($P = 0.07$).

In this study, 40 students were randomly selected from different departments of the dental school in which they were doing dental work. The results indicated a significant relationship between gender (men more than women), age (older), height (taller), smoking, lack of exercise, and higher REBA scores; in other words, students with a higher REBA score were at greater risk for muscle pain [Table 1].

Table 1: The relationship between the final Rapid Entire Body Assessment score and demographic data

| Characteristics | Mean±SD of REBA score | P** |
|-----------------|-----------------------|--------|
| Gender | | |
| Male | 8.2±0.9 | 0.01* |
| Female | 4.3±0.5 | |
| Age | | |
| <22 | 5.1±0.4 | 0.02* |
| >22 | 9.5±0.8 | |
| Height (cm) | | |
| <160 | 3.3±0.2 | 0.001* |
| >160 | 10.1±0.5 | |
| Weight (kg) | | |
| <50 | 4.4±0.6 | 0.001* |
| >50 | 9.1±0.5 | |
| Sports | | |
| Yes | 3.6±0.4 | 0.001* |
| No | 10.5±0.7 | |
| Smoking | | |
| Yes | 10.1±0.3 | 0.001* |
| No | 3.1±0.2 | |

* $P > 0.05$ is significant, **Chi-squared test. REBA=Rapid Entire Body Assessment, SD=Standard deviation

Table 2: Interpretation of the Rapid Entire Body Assessment

| Final REBA score | Risk level | Corrective measure priority level | Corrective measure necessity and timing |
|------------------|------------|-----------------------------------|---|
| 1 | Negligible | 0 | Unnecessary |
| 2-3 | Low | 1 | Might be necessary |
| 4-7 | Moderate | 2 | Necessary |
| 8-10 | High | 3 | Necessary (as soon as possible) |
| 11-15 | Very high | 4 | Necessary (urgent) |

REBA=Rapid Entire Body Assessment

Regression analysis showed no significant correlation between the scores of REBA for different body parts and pain in the same place [Table 4].

Discussion

According to the World Health Organization, approximately 58% of the world's population will spend a one-third of their lives at work and almost 30%–35% of employees are faced with significant occupational risks. In the dental profession, like other professions, there are a number of harmful factors which will expose health workers in this profession to high risks if they do not conform to occupational health standards. Studies have shown that dentists are exposed to the risk of musculoskeletal problems more than any other professional medical workers. Therefore, recognition of ergonomic factors in the workplace of these people is very important.^[7]

In addition, dentistry is a profession that requires ongoing care. The technical skills of the dentists, where

Table 3: Frequency of answered participants' questions, ergonomics according to gender

| Questions | Yes | | No | |
|---|------|--------|------|--------|
| | Male | Female | Male | Female |
| Do you have muscular pain due to dental practice? | 60 | 77 | 16 | 46 |
| Are you familiar with the ergonomic posture to perform clinical procedures in your dental practice? | 1 | 15 | 75 | 108 |
| Do you experience pain during or after using vibrating instruments (high-speed handpiece, micromotor, contrangle)? | 5 | 73 | 26 | 50 |
| Are you able to change your work posture, seating or standing, during your practice? | 12 | 63 | 64 | 60 |
| Do you frequently change positions during your clinical practice? | 14 | 16 | 62 | 107 |
| After finishing clinical practice, do you perform stretching exercises? | 5 | 5 | 71 | 118 |
| Are the instruments within hand reach without making strenuous movements? | 58 | 41 | 18 | 82 |
| Do you perform torsions or cervical flexions to improve vision when working in the oral cavity? | 70 | 115 | 6 | 8 |
| Do you cross your legs when working? | 75 | 122 | 1 | 1 |
| Do you work with your legs slightly separated? | 74 | 120 | 2 | 3 |
| Do you support yourself on your feet's sole when working? | 35 | 34 | 41 | 89 |
| When you work, do you put your elbows and arms on the rib side (ribs)? | 25 | 30 | 51 | 93 |
| Do you keep your arms at sternum height when working? | 20 | 25 | 56 | 98 |
| Do you have enough space in your workplace? | 40 | 43 | 36 | 80 |
| Is the work stool comfortable? | 20 | 20 | 56 | 103 |
| Do you consider that the dental stool you are using for your clinical practice can be ergonomically regulated for the individual needs (vertical height of the body, horizontal regulation of the back, and vertical regulation of the back)? | 15 | 25 | 61 | 98 |
| When initiating your practice, do you position your chair to maintain an ergonomic posture? | 15 | 30 | 61 | 93 |
| Do you consider that you have sufficient light at your workplace? | 50 | 90 | 26 | 33 |
| Do you think that the work instruments are in optimal conditions so you do not have to do extra work (curettes, files, burs, elevators, etc.)? | 20 | 15 | 56 | 108 |

they work, tools, and technology which they use, all have a significant impacts on the health of practitioners and patients. Dental practice is very different from other professions. For example, changing the dental chair in a manner in which both dentists and patients feel

Table 4: Relationship between the final Rapid Entire Body Assessment score and pain in different parts of the body

| Body part | OR | CI | P* |
|-------------------------|------|-----------|------|
| Neck and back | 0.75 | 0.6-1.11 | 0.12 |
| Shoulder and scapula | 1.02 | 0.82-1.50 | 0.15 |
| Wrist, forearm, and arm | 0.93 | 0.62-1.2 | 0.08 |
| Leg | 1.10 | 0.72-1.54 | 0.21 |

*Regression analysis. OR=Odds ratio, CI=Confidence interval

comfortable can result in the good clinical judgment, improving the dentist's performance. Studies have shown that musculoskeletal disorders with 29.5% and cardiovascular diseases, diseases of the central nervous system, tumors, and neurological symptoms, respectively, each with 1.2%, 6.21%, 5.6%, and 16.7% are responsible for disability and early retirement of dentists.^[8,9]

In this study, ergonomic factors causing muscle pain in 199 students from Kerman Dental School were evaluated. This study showed that 137 students had muscle pains during dental work, and 123 of them had a similar experience of pain when working with a handpiece, consistent with reports by Diaz-Caballero *et al.*, Varmazyar *et al.*, Saremi, Dargahi H *et al.*, Nasle Seraji, Ahmadi Motemayel *et al.*, Mojabi *et al.*,^[3,10-15] Sim *et al.* also showed that musculoskeletal disorders are common in dental profession and can include pain, weakness, impaired sense of touch as itching, and numbness.^[16] Almost all the students reported that they had no knowledge about ergonomic factors that does not conform to the rest of the world. In most dental schools around the world, students are trained in this field according to their education curriculum.^[17] This study showed no significant difference between the students' education year and pain; furthermore, there was no significant correlation between position and posture of students in different years. It indicates that students are not trained to maintain the correct position of the body, even implicitly, along with other training and students will graduate with the wrong posture to work, consistent with Diaz-Caballero *et al.*^[3] However, Rising *et al.* reported greater pain in the final-year students.^[18]

Most pain was reported in endodontic and pedodontics fields that was consistence with studies of Diaz-Caballero *et al.*, Varmazyar *et al.*, and Yaghobee and Esmaeili.^[3,10,19] The high incidence of musculoskeletal pain in root canal treatment is attributed to the need to see more details and accurately so that dentists deviate from the normal position when working. In addition, high-stress levels during root canal therapy might be another reason.

Useful measures, in this case, can teach the principles of ergonomics, with an emphasis on the use of zoom lenses in endodontics. Studies have shown that the

use of magnifying lenses could improve individual job positions.^[20]

Musculoskeletal pain in pedodontics might be due to not placing children in a proper position, the lack of a special unit for children, lack of good vision, lack of patient cooperation and striving for greater control, and therefore, less stress. In this study, the most painful areas were the wrist forearm, arm, neck, back, and lumbar area, consistent with other studies.^[8,21-26]

For the first time in 1946, Biller reported that the prevalence of low back pain in dentists is 65%.^[5] In the 1950s, Seyfarth and Carlson found that lower back disorders and neck pain had a high prevalence.^[2,4] In fact, the prevalence of low back pain provided the basis for work in a sitting position. In 1977, a study was conducted using a questionnaire. The results showed that the motor system disorders are often concentrated in the lumbar region and spread to the neck and shoulders. Other studies in the 1980s showed that despite the ergonomic improvements made in the design of dental equipment and work environment, neck and shoulder pain and dysfunction are very common.^[4,5]

From 1946 to 1997, several studies evaluated the prevalence of musculoskeletal disorders in dentists in countries such as Sweden, the United Kingdom, and Australia. According to researches before the introduction of the sitting position to the dental practice (1960), the most common dental problem was back pain, but statistics showed that since then, pain in the neck, shoulder, and wrist areas has higher prevalence rates.^[27] In 1985, Katevue with radiological examination of 119 dentists and 192 farmers showed that arthritis in the neck and shoulder joint disorders were higher in dentists than farmers. However, based on the findings of Waris in 1980, the relationship between radiographic signs of joint damage and clinical symptoms is weak.^[6] Some researchers believe that the transition from standing to sitting position of dentists did not change the frequency of disorders but increased symptoms of the neck and shoulders disorders. They believe that if changing the standing position to a sitting position during work was not the only factor, factors such as the environment and the workplace, stress, work periods without interruption, and dentist's vision were the predisposing ones.^[4] From 1987 to 1990, musculoskeletal symptoms were evaluated in 395 dentists, indicating symptom percentages of 84% in 1987 and 83% in 1990, but the severity increased during this period (27% in 1990 vs. 24% in 1987). Symptoms were more severe in female dentists. A total of 92% of dentists in this study worked in a sitting position.^[5,28] In a study conducted in Australia in 1997 by Marshall *et al.*, 355 members of the dental community were randomly selected to assess musculoskeletal pain. The results

showed that 82% of the participants (with the help of a dentist or without him) had musculoskeletal pain.^[4] The present study showed that boys had more complaints of pain than girls, which was supported by the results of Yaghobee and Esmaeili and Dehghan *et al.*^[19,27]

However, Lindfors *et al.*,^[29] Diaz-Caballero *et al.*,^[3] Rising *et al.*,^[18] Varmzyar *et al.*,^[10] Alexopoulos I.,^[30] Marshall *et al.*,^[4] and Moan *et al.*^[31] showed that musculoskeletal pain was more prevalent among female dentists than men. One reason for the difference might be longer working hours of male students than female since men work in dental clinics in the city. This study showed a significant relationship between the final REBA score and age, gender, height, weight, smoking, and exercise. Furthermore, there was no significant association between the final score of the instrument and cause of pain in different parts of the body, consistent with other studies.^[10,19] In addition, evaluation of the status of the body of the participants while working showed that most of them by working in this position (based on REBA) had a medium to high probability of developing skeletal and muscular problems. Therefore, these people need to modify their body positions during work. These results supported the findings in many previous studies.^[12,13]

This study shows that only 20% of all students have comfortable dental chair and any difference is observed between male and female. The work environment was not optimal for dental students and this was especially more noticeable with tools (high- and low-speed handpieces) and dental chair. In relation to ergonomics, dental chair should be selected with respect to movement, access, and better visibility of the equipment and compliance with the movement of selected patients. The dental chairs must have five wheels to prevent it from falling back and as well as office chairs should not have large backrests and seats. Dental chairs must have compact wheels that do not interfere with doctor's feet and the unit.^[3]

Conclusions

The results of this study showed that the students' sitting positions and working environments need to be improved and it seems that more training is necessary in this field.

Acknowledgment

The study was designed as a retrospective cross-sectional study with the ethical code of IR. KMU. AC. IR. K.920.499. Furthermore, the study was approved by the Institutional Human Research and Ethics Committee of Kerman University of Medical Sciences, Kerman, Iran. The authors would like to appreciate the continued support of research counselor of Kerman University of Medical Sciences

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Nordin M, Andersson GB, Pope MH. Musculoskeletal Disorder in the Workplace: Principles and Practice. New York Mosby-Year Book, Inc.; 1997. p. 24-5.
2. Rundcrantz BL. Pain and discomfort in the musculoskeletal system among dentists. *Swed Dent J Suppl* 1991;76:1-02.
3. Diaz-Caballero AJ, Gómez-Palencia IP, Díaz-Cárdenas S. Ergonomic factors that cause the presence of pain muscle in students of dentistry. *Med Oral Patol Oral Cir Bucal* 2010;15:e906-11.
4. Marshall ED, Duncombe LM, Robinson RQ, Kilbreath SL. Musculoskeletal symptoms in new south wales dentists. *Aust Dent J* 1997;42:240-6.
5. Biller FE. The occupational hazards in dental practice. *Oral Hyg* 1946;36:1194-201.
6. Health and Wellness. Available from: <http://www.ADA.org>. [Last retrieved on December 2013]
7. A Resource for Ergonomic Design is Oriented toward Those Concerned with Ergonomic Standards in the Field of Dentistry. Available from: <http://www.designbyfeel.com>. [Last retrieved on 2009 Feb 26].
8. Valachi B, Valachi K. Preventing musculoskeletal disorders in clinical dentistry: Strategies to address the mechanisms leading to musculoskeletal disorders. *J Am Dent Assoc* 2003;134:1604-12.
9. Bernard BP. Musculoskeletal Disorders and Workplace Factors. Columbia Parkway. National Institute for Occupational Safety and Health (NIOSH); 1997. p. 34.
10. Varmazyar S, Amini M, Kiafar S. Ergonomic evaluation of work conditions in Qazvin dentists and its association with musculoskeletal disorders using REBA method. *JIDA* 2012;24:182-7.
11. Saremi M. Assessment of Musculoskeletal Disorders among Dentistry of Shahed University, Using REBA Method and Provide Appropriate Corrective Methods. Occupational Health Field Master's. [Thesis]. Tehran: Faculty of Medical Sciences of University Tarbiat Modarres; 2003, No 49130; 2003.
12. Dargahi H, Saraji J, Sadr J, Sadri G. Ergonomics in dentistry. *JDM* 2009;22:199-207.
13. Nasle Seraji J. Ergonomic evaluation of working conditions dental practitioner's careers city of Birjand method (REBA). *J Dent Tehran Univ Med Sci* 2005;18:61-7.
14. Ahmadi Motemayel F, Abdolsamadi HR, Roshanaei G, Jalilian S. Prevalence of musculoskeletal disorders among Hamadan general dental practitioners. *Sci J Hamadan Univ Med Sci* 2012;19:61-6.
15. Mojabi B. Investigation neck, back and shoulders pains and ergonomics factors among general dentists of Qazvin University of Medical Sciences. *Iran Ergonom* 2007;2:25-3.
16. Sim J, Lacey RJ, Lewis M. The impact of workplace risk factors on the occurrence of neck and upper limb pain: A general population study. *BMC Public Health* 2006;6:234.
17. Beach JC, DeBiase CB. Assessment of ergonomic education in dental hygiene curricula. *J Dent Educ* 1998;62:421-5.
18. Rising DW, Bennett BC, Hursh K, Plesh O. Reports of body pain in a dental student population. *J Am Dent Assoc* 2005;136:81-6.
19. Yaghobee S, Esmaeili V. Evaluation of the effect of the ergonomic principles' instructions on the dental students' postures; an ergonomic assessment. *J Tehran Med Univ* 2010;63:121-7.
20. Thornton LJ, Stuart-Buttle C, Wyszynski TC, Wilson ER. Physical and psychosocial stress exposures in US dental schools: The need for expanded ergonomics training. *Appl Ergon* 2004;35:153-7.
21. Rucker LM, Sunell S. Ergonomic risk factors associated with clinical dentistry. *J Calif Dent Assoc* 2002;30:139-48.
22. Bramson JB, Smith S, Romagnoli G. Evaluating dental office ergonomic. Risk factors and hazards. *J Am Dent Assoc* 1998;129:174-83.
23. Caruso CC, Waters TR. A review of work schedule issues and musculoskeletal disorders with an emphasis on the healthcare sector. *Ind Health* 2008;46:523-34.
24. Sartorio F, Franchignoni F, Ferriero G, Vercelli S, Odescalchi L, Augusti D, *et al.* Work-related musculoskeletal disorders in dentistry professionals 2. Prevention, ergonomic strategies and therapeutic programs. *G Ital Med Lav Ergon* 2005;27:442-8.
25. Yamalik N. Musculoskeletal disorders (MSDs) and dental practice Part 2. Risk factors for dentistry, magnitude of the problem, prevention, and dental ergonomics. *Inter Dent J* 2007; 57:45-54.
26. Finkbeiner BL. Selecting equipment for the ergonomic four-handed dental practice. *J Contemp Dent Pract* 2001;2:44-52.
27. Dehghan CA, Amiri Z, Rabiee M. Prevalence of musculoskeletal pain among a group of Iranian dentists, (Tehran-1999). *J Dent Sch* 2003;21:185-92.
28. Wogalter MS, Wendy AR. Human Factors Ergonomics. Available from: <http://www.psichi.org>. [Last retrieved on 2008-12 March].
29. Lindfors P, von Thiele U, Lundberg U. Work characteristics and upper extremity disorders in female dental health workers. *J Occup Health* 2006;48:192-7.
30. Alexopoulos EC, Stathi IC, Charizani F. Prevalence of musculoskeletal disorders in dentists. *BMC Musculoskelet Disord* 2004;5:16.
31. Moen BE, Bjorvatn K. Musculoskeletal symptoms among dentists in a dental school. *Occup Med (Lond)* 1996;46:65-8.