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# Assessment of Ergonomics in Indian Dental Practice: A Workplace Analysis

Divya Gadde

Western Kentucky University, [divya.gadde072@topper.wku.edu](mailto:divya.gadde072@topper.wku.edu)

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ASSESSMENT OF ERGONOMICS IN INDIAN DENTAL PRACTICE: A  
WORKPLACE ANALYSIS

A thesis  
Presented to  
The Faculty of the Department of Public Health  
Western Kentucky University  
Bowling Green, Kentucky

In Partial Fulfillment  
Of the Requirements for the Degree  
Master of Science


By  
Divya Gadde, B.D.S

May 2018

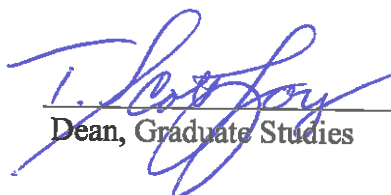
ASSESSMENT OF ERGONOMICS IN INDIAN DENTAL PRACTICE: A  
WORKPLACE ANALYSIS

Date Recommended 4/19/2018

  
\_\_\_\_\_  
Dr. Ritchie Taylor, Director of Thesis

  
\_\_\_\_\_  
Dr. Vijay Golla

  
\_\_\_\_\_  
Dr. Xiuhua Ding

  
\_\_\_\_\_  
Dean, Graduate Studies

4/20/18  
Date

This thesis work is dedicated to all mighty Lord and my parents, David Raju Gadde and Mary Gadde for their constant support and encouragement throughout my graduate life. I am truly thankful for having you in my life. This work is also dedicated to my dear brothers, Sharath, Sham and Vijay who also loved me unconditionally and taught me to work hard to for the things that I aspire to achieve. Without hesitation, I would like to dedicate this work to Richey for your belief in me. Thank you for your understanding and patience. Finally, my sisters-in-law, Soni Gadde and Vimochana Gadde, thank you for your continued support.

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# ASSESSMENT OF ERGONOMICS IN INDIAN DENTAL PRACTICE: A WORKPLACE ANALYSIS

Divya Gadde

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Directed by: Dr. Ritchie Taylor, Dr. Vijay Golla and Dr. Xiuhua Ding

Department of Public Health

Western Kentucky University

Dental practice requires unique working conditions such as prolonged working hours, strained body postures and laborious, high finesse dental techniques. However, it can be more efficiently performed by the application of ergonomics, rather than physically forcing the worker's body to fit the job. Posture is highly influenced by factors such as inadequate working level, incorrect patient positioning, and poor visual comfort. In order to eliminate musculoskeletal disorders it is necessary to control these and other factors, and design the human work environment to be more ergonomic. The aim of this study was to assess ergonomics within Indian dental practice and elucidate factors that prevented application of ergonomics.

An observational study was conducted among 58 Indian dentists, both from a private dental hospital and clinics. A questionnaire that consisted of 37 open-ended and closed-ended questions was used as a research tool for the study. Information on background characteristics, work environment, equipment, work administration, and ergonomic awareness was collected using the questionnaire. Sampling consisted of observing 37 male and 21 female dentists. A total of 58 individuals, 62 % ( 36), worked for a private dental hospital, and 38% (22) for dental clinics. A majority, 84.5% (49), of the dentists reported that they did not receive ergonomic training from their work administration. Most dentists, 96% (56), reported that there was no system of recordkeeping for workplace accidents. Lack of proper ergonomic training and no system

of recordkeeping for workplace accidents were found to be the primary factors for not applying ergonomics by Indian dentists. Ergonomic training programs are needed in India to help educate dentists on workplace safety and health, and thus aid in reducing musculoskeletal pain. Finally, a system is needed in Indian dental practice to promote workplace safety and health by identifying workplace hazards that result in injuries.

## **Chapter 1**

### **Introduction**

Dentistry is a highly respected profession within India, the United States, and abroad, both by the general public and other health professionals. Dental practice has resulted in the reduction of health disparities through prevention and improved public health. However, it is ironic that little attention has been given towards the preventive measures for work-related health problems among dental practitioners. An anticipated problem of dental practitioners, due to difficult work postures, would be musculoskeletal disorders. Yet, prevalence of these disorders is difficult to assess within dental practice due to the lack of information. Specifically, within India, the prevalence of musculoskeletal disorders of dentists are not recorded by the Ministry of Labor and Employment. As a result of this underreporting, the dental profession within India has not received attention from health agencies, researchers, and equipment manufacturers in the evolution of ergonomically designed workplaces. The consequence is that dentists ultimately bear the burden of musculoskeletal disparities.

Dentistry is rapidly expanding and a well-established profession in India. According to Telangana State Dentists' registration Tribunal (TSRDT) there were about 10,000 registered dentists in the State of Telangana in 2016. Each year about 1300 new dentists emerge into practice in the state of Telangana. Studies show that many of the emerging and existing dentists experience work-related musculoskeletal pain during their practice if ergonomics is not a part of their work (Osborn, 1990). Despite technological

advances in dental practice, work-related injuries and illness remain a serious problem among dental health care providers.

Dentistry requires sculpting of materials, precise work with the hands, and a confined work space within patients' mouths, which translates to unique working conditions. Most dentists work prolonged hours with strained body postures and laborious, high finesse, dental preparations which entail continuous interactions of the dentist with dental equipment. This causes the dentists to have tense movements that result in deviations from balanced postures during work. Studies have shown that dental practitioners are at risk of developing cumulative trauma disorders as a result of deviations from the normally balanced postures during work. These deviations can result from repetitive work, awkward or constrained postures, heavy lifting, pinching grasps, forceful movements, and vibrating tools (Gupta, A., Bhat, M., Mohammed, T., Bansal, N., & Gupta, G.,2014).

Causes of deviations in posture at the workplace are poorly designed work environments and lack of equipment maintenance, omission of proper ergonomic practices, and absence of a system to evaluate ergonomics. These factors can hinder the application of ergonomics in the workplace, predisposing dental health care providers to cumulative trauma disorders. Some factors are under the control of the employee, while others can be resolved by administration. Although these different reasons confound the determination of etiology of ergonomically related health disorders among dental health care providers (Wilson & Corlett, 1995). Studies that are engaged in ergonomics and human engineering have recognized this wide range of factors that include:

- System goals

- Equipment design
- Task allocation
- Interactions between the equipment and the employee
- Job design
- Work environment

Analysis of these components of the workplace, followed by designing or redesigning of the system, will help to optimize the health and well-being of the employee and enhance the overall performance of the organization (Buckle, 2005).

Table 1. 1 Ergonomic risk factors in dentistry

<b>Parameter</b>	<b>Dentistry</b>
Workstation layout <ul style="list-style-type: none"> <li>• Affects postures, visibility and reach</li> </ul>	Design and setup with respect to the patient
Tool design <ul style="list-style-type: none"> <li>• Affects posture and force</li> </ul>	Dentist chair, hand instruments and vibration of the power tools.
Work object <ul style="list-style-type: none"> <li>• Affects posture, visibility, and mental workload</li> </ul>	Patient's reactions and fears during the treatment procedures. Use of dental mirror
Work technique <ul style="list-style-type: none"> <li>• Affects posture, force, mental workload and reach.</li> </ul>	Rest breaks and pauses Reassuring and calming patient Scheduling the patients
Work organization <ul style="list-style-type: none"> <li>• Affects repetitiveness, mental workload and force duration</li> <li>• Affects awareness on ergonomics</li> </ul>	Piece rate payment Ergonomic training Record keeping Periodic evaluations of the workplace.

(Murphy & American Public Health Association, 1998, p. 106)

## **Rationale**

In the state of Telangana, India, research on the topic of dental ergonomics has yet to occur. This study will be the first research on dental ergonomics through workplace analysis in this region of India. Results will provide a guide for dentists and administration to achieve the goal of an ergonomic workplace. Furthermore, the data will be useful for the participating dental school and dental clinics to develop an emphasis on ergonomic principles in the dental workplace. The primary outcome will be to identify risks of musculoskeletal disorders caused by a lack of ergonomic practices in the dental practices observed. Finally, this research will identify barriers to ergonomics that can be addressed to promote safety and health, quality of work, and ultimately the productivity of practitioners.

## **Research objectives**

The purpose of this study is to address the wide range of issues related to the application of ergonomic principles among dental health care providers of India in Telangana state.

The objectives of the study are:

1. Assess application of ergonomics practiced by dentists in private dental clinics and a dental hospital of India, Telangana state.
2. Identify risk factors associated with insufficient application of ergonomic principles in dental practices observed in private dental clinics and a dental hospital of India, Telangana state.

## **Chapter 2**

### **Background**

#### **What is Ergonomics?**

According to OSHA, the term ergonomics can be simply defined as the study of work. In detail, it is the science of designing work to fit the employee instead of physically forcing the worker's body to fit the work. It is the interaction of the employee with various elements in the work environment. These elements such as workstations, tasks, tools, and equipment must adapt to fit the job of the employee. Ergonomics at the workplace is envisioned to maximize the productivity by reducing the employee's discomfort and fatigue. This will help to reduce prevalence of work-related health disorders among the workers (U.S Department of Labor, Occupational Safety and Health Administration, 2000).

Back in the 1960's, it was hard to conceptualize the essence of clinical ergonomics in dentistry (Rucker, 2000). The current evolution of far reaching technological advances would seem to predict advancements of ergonomics in the dental workplace. However, there have been many work-related disorders identified and reported in dental practice (Gupta, D., Mathur, A., Patil, G. I., Tippanawar, H. K., Jain, A., Jaggi, N., Garg, P., 2015). In third world countries like India, the big picture of dental ergonomics has not fully emerged or there has been insufficient awareness of ergonomic principles in the dental workplace. The result is continued exposure to ergonomic risks at work and subsequent development of musculoskeletal symptoms. (Kalghatgi, Prasad, Chhabra, Deolia, & Chhabra, 2014).

Burke, Main, & Freeman (1997) conducted a retrospective analysis in U.K. among 393 dentists to investigate the causes of premature retirement of dentists working in a private medical hospital. It was found that 29.5% of dentists experienced premature retirement due to cumulative trauma disorders. Musculoskeletal pain was an important factor that influenced early retirement. This study shows the big picture of the problem of musculoskeletal disorders for dentists. Likewise, extensive research was carried out to find the prevalence of the musculoskeletal disorders among dental health care providers (Bedi, H. S., Moon, N. J., Bhatia, V., Sidhu, G. K., & Khan, N. 2015). However, studies on hazard surveillance to elucidate factors that influence the application of ergonomics in the dental workplace are underreported.

### **Factors influencing ergonomics at the workplace**

Various risk factors can influence the application of ergonomics in the workplace. This range of factors contributes to the causation of cumulative trauma disorders. The workplace must be assessed to ensure that these risk factors are eliminated or controlled to promote the health and well-being of the employee (Workplace Health and Safety, Electrical Safety Office, 2016). The following factors can have an influential effect on the postural alignment of the working dentist:

1. Physical characteristics: Body mass index
2. Job/work characteristics: workload and work pacing
3. Environmental factors: Noise, temperatures, and Lightning
4. Workstation layout: adequate clearance, reach distances, adequate space to work



5. Equipment related factors: ergonomically designed tools and Instruments, maintenance of equipment
6. Work administration characteristics: ergonomic training, periodic evaluations of the workplace and communications, record keeping and resources
7. Psychological factors: Mental stress, financial pressures, and job insecurities

### **Physical characteristics**

Body weight was found as an influential factor to achieve ergonomics in the workplace. A study conducted by Sethi, J., Sandhu, J. S., & Imbanathan, V showed that individuals with higher Body Mass Index (BMI) had decreased postural stability. In this study, elevated BMI was found to be associated with high risk of work-related musculoskeletal disorders. Being overweight causes increased mechanical and physical loads on the tissues of the body resulting in increased pressures on the spinal cord .Obese individuals those who especially requiring upper limb activities reported a higher risk for occupational injuries (Sethi, J., Sandhu, J. S., & Imbanathan, V., 2011).

### **Job characteristics**

Health care providers are under pressure to increase revenues by working more hours and treating as many patients as possible. Increased Work pace (i.e. working faster and treating a greater number of patients) leads to increases in physical and mental stress. Due to time pressures, there is a greater chance of assuming awkward postures at work resulting in amplified tension in the muscles, thus leading to pain and fatigue. Literature shows that taking micro or mini breaks during work hours helps soft tissues to rest and recover from workloads. After performing monotonous dental work taking a short rest

break of at least five minutes is recommended. Short rest breaks create a healthy working environment for dentists. A key ergonomic principle is to equally intersperse rest breaks throughout a work day. Providing pauses to work balances the physical demands of the body throughout the day. Mini breaks provide a timeframe to perform basic stretches and gentle exercises. Work organization should support this habit to attain a safe work culture. (Murphy & American Public Health Association, 1998)

### **Environmental factors**

The physical environment has a considerable effect on the health of dental practitioners. Lighting conditions, temperatures, and noises can contribute to the comfort of the dentists while rendering treatment (Vischer, 2007). Dentistry is a visually demanding job and requires constant concentration throughout a procedure. Visual comfort for a dentist will be affected by the intraoral lighting and general illumination of the workplace. Many errors or inaccuracies can happen if there is difficulty in vision for the practitioner.

Natural light and overhead lighting are the two important sources of illumination in the operating field for a dentist. When lighting is not properly maintained, it makes the dentist's job very difficult, potentially causing improper body alignment. The overhead light should be adjusted depending on the area that is being operated on by the dentist and be parallel to the line of observation. The maximum amount of illumination in the operating site can be achieved when the line of sight and lighting are parallel to each other. However, when there is a greater angulation between these two lines it results in inadequate illumination for vision in the operating site causing the operator to assume improper postures at work (Khalil, 1974).

Extreme temperatures also affect dentists. Temperatures that are too cold because decreased blood flow and circulation leading to the numbness of the extremities. This may require the dentist to apply or exert more force while performing the treatment. (Baheti, Mayuresh, Toshniwal, & Girijalal, 2014). Forceful exertions is another risk factor for ergonomics.

National Institute for Occupational Safety and Health (NIOSH) has recommended exposure limit for occupational exposure to noise as 85dBA for 8hr time-weighted average. The undesirable sounds in the workplace can impede communication between the patient and doctor inducing annoyance, stress and can also result in hearing loss (Dutta, Mala, & Acharya, 2013).

### **Work layout:**

The arrangement of dental equipment in the workspace can affect the efficiency of a dentist. Workstation design requires careful consideration as it plays a major role in dental ergonomics. Arrangement of the workstation should be done in a manner to reduce improper work postures and improve treatment procedures. There are a number of factors that should always be considered while designing the workstation. Dental instruments should be arranged in the way that the operator doesn't have to leave the operating site to reach to retrieve them. According to Kilpatrick (1971), dental instruments, like turbines, syringes, and suction lines should be kept accessible throughout the treatment procedures. Restricted workspace or inadequate clearance in the workspace can cause discomfort to the dentist by limiting the movement (Rundcrantz, Johnsson, Moritz, & Roxendal, 1991). A study conducted by Kalghatgi, Prasad, Chhabra, Deolia, & Chhabra showed that 76% of dental students surveyed considered that have

sufficient work space (Kalghatgi, Prasad, Chhabra, Deolia, & Chhabra, 2014). Suitable work space allows for proper arrangements of tools, instruments and equipment, and improves ergonomics (Murphy & American Public Health Association, 1998).

### **Equipment/Dental Instruments**

The success of a dental treatment depends on the physical and functional characteristics of the dental equipment present in the working area of a dentist.

Equipment should not enforce any demands or undue stresses on the dentist. Stress hastens the onset of fatigue and subsequently results in a decrease of work efficiency by the dentist. Dental delivery systems should promote the adoption of ergonomic postures and achieve pain-free dentistry. Equipment should be well designed and maintained to promote proper human and machine interactions throughout the procedures (Khalil, 1973). An improved work environment can be achieved when defective or inefficient equipment are replaced or updated to provide an ergonomic solution. Maintenance of the equipment is important to practice as it ensures that equipment is well conditioned to deliver work without demanding any extreme forces by the dentist.

Dental instruments should be adept and promote the use of ergonomics in the work environment. It should not only provide ease of use to hands but allow the entire body to be in a well-balanced posture throughout the work process. Hand instruments or tool should require minimal force or pressure to be applied during procedures. Well maintained instruments will reduce the number of forces that need to be applied and also cut down the number of repetitive motions required during the procedure. Therefore, dental instruments having sharp cutting edges minimize the force required to conduct dental procedures. Lighter instruments serve to allow the dentist to apply less force, thus

promoting ergonomics. Another important ergonomic requirement is serrated surfaces of hand instruments. Instruments with serrations allows friction between the fingers and instrument thus improving the grip on instruments. These specifications ease the work of the dentist and foster the ergonomics in the workplace (Murphy & American Public Health Association, 1998).

### **Work organization**

According to OSHA, work organization occurs when the employer has a major role in providing a healthy and safe working environment for their workers. Work organization has to instigate application of ergonomic principles to reduce the number and severity of musculoskeletal disorders resulting from physical and mental overexertion. A strong organization created by well-defined goals is crucial for ergonomic success. Support should be provided through various training programs to the workforce. This is an essential step that helps to educate employee about the benefits of applying ergonomics in the workplace. Training ensures that the workforce becomes informed about musculoskeletal disorders that result from not applying ergonomics. Additionally, understanding the application of ergonomics promotes the importance of early reporting of hazards and injuries in the workplace.

Educational interventional programs reduce unsafe behaviors at the workplace. In a recent study, employees were trained by using various intervention methods that included posters, workshops and providing informational booklets. These interventional methods helped to increase employee knowledge on workplace safety and improve good ergonomic habits at work. Another study showed that employees who were educated by participatory training (discussions, exercises) and traditional training methods reported

less discomfort or pain at work when compared with the individuals who did not receive the training (Burke et al., 2006). However, there are several different ways to educate an employee but a study demonstrated that instructor-directed and self-directed methods of learning had a positive impact on the working habits of the employees. This method of intervention is inexpensive but it will make a great difference in the health and wellness of an employee. Nevertheless, ergonomic training would be effective only when the employees are provided with an ergonomic workplace.

### **Psychological characteristics**

Work-related stress can impact the ergonomics of the workplace leading to the development of musculoskeletal symptoms. Work stress has a mediating role between the postural alignments and development of musculoskeletal disorders (Zakerian & Subramaniam, 2009). Spinal muscular activity increases when the dental professional is subjected to stress. Stressful situations are linked to the patient's behavior. Treating an uncooperative patient can create a fear of failure for the treatment which results in a stressful situation for the dentist, reducing the likelihood that ergonomic principles will be followed. Thus the dentist continues to be exposed to the risks of developing musculoskeletal symptoms (Custódio, Silva, & Brandão. 2012).

### **A situation of Dental ergonomics in India**

In 2014, Baheti, Mayuresh, & Toshniwal reported that one out of ten Indian dentists had poor general health conditions and three out of ten reported poor physical health. This metric shows the health status of the dental health care providers of India. A study conducted by Munaga et al. in 2013 has reported that 70.5% of dental students

performed cervical flexion and torsion of the body to enhance their visibility while working. It was reported that 76.6% of dental students preferred to have direct vision of the oral cavity resulting in the adoption of awkward postures at work. This study concluded that inappropriate ergonomic postures were adopted by students in large percentages. Although, the students reported that they have awareness of ergonomic postures it was not reflected in their practice. The reason for this could be due to lack of training or a gap between theoretical understanding and practical application. A study conducted by Khan & Yee Chew (2013) found that 93% of students did not have any ergonomic training at their dental school.

In India, the curriculum proposed by the Dental Council of India (DCI) does not include dental ergonomics as an essential aspect at both undergraduate and graduate levels. Lack of significant emphasis on these principles can be one of the reasons for not practicing ergonomics in Indian dental practice. (Kalghatgi, Prasad, Chhabra, Deolia, & Chhabra, 2014).

### **The problem**

The most common reason for ignoring ergonomics is because the symptoms are usually misdiagnosed with other conditions. For example, people tend to think the symptom of muscular pain is due to accidental injury. Occasionally this diagnosis may be correct, however poor working conditions may be the actual cause of these symptoms (Irene, 2014). When the human body is subjected to constant stresses it results in the development of a series of symptoms like discomfort, pain, and sometimes profession ending musculoskeletal disorders.

The world health organization defines work-related musculoskeletal disorders as injuries to nerves, muscles, tendons, ligaments, joints and spinal disc caused due to chronic events at work environment. Unnatural deviated or awkward working postures, poor workplace design, forceful exertions, inappropriate work patterns, mental stress, genetic predispositions can lead to muscular imbalance and neuromuscular inhibition (Marklin & Cherney, 2005). A study conducted by Pargali and Jowkar (2010) showed that 73% of the Indian dentists suffered from musculoskeletal pain. Most common musculoskeletal disorders experienced by dentists include carpel tunnel syndrome, lower back pain, and neck and shoulder pain. Awkward finger and wrist positions, vibrations, repetitive tasks and improper tool designs were found to be the reasons for the discomfort/pain in the upper extremities. Both the duration and intensity of exposure to these ergonomic stressors are significant in the development of the symptoms (Murphy & American Public Health Association, 1998)



## **Chapter 3**

### **Materials and Methods**

Upon the approval from Institutional Review Board (IRB) and ethical clearance from the participating dental school and dental clinics, a total of 58 dentists were selected by simple random sampling. Dentists working in the clinical departments of Oral and Maxillofacial Surgery, Orthodontics, Prosthodontics, Endodontics, and Periodontics were selected for the study. The study was conducted between December 2017 and January 2018. Participants were informed about the study that was conducted in their workplaces prior to participation. After obtaining the informed consent from the participating dentists, evaluations and a questionnaire were undertaken at the workstations by the investigator. Workplace investigations were made while the dentists were performing treatment procedures and the findings were documented in the survey. After the completion of the procedures, dentists were requested to answer questions pertaining to ergonomics in their practice of dentistry. Questionnaire that is used for the study is in appendix 1.

#### **Questionnaire**

The questionnaire survey consisted of five different sections to address the issues that are important to understanding the work patterns and for the identification of ergonomic risk factors. The first section consisted of background information like age, gender, number of working hours per week, working days per week and type of facility. Section two included information regarding the tasks performed by the dentists (i.e., how well is the work organized and frequency of taking rest breaks). The third section is concerned about the role of work administration in dental ergonomics. For example,

periodic evaluations of the workplace, recordkeeping of workplace accidents and ergonomic training by work administration. The fourth section investigated the equipment and work space design. This included observation of reach distances for instruments, proper adjustment of the dental chair, maintenance of the equipment, repetitive motions during work, use of automated instruments whenever required, and adequate clearance around the working area of the dentist. Prior knowledge of ergonomics and body postures adopted by the dentists during work were recorded in the fifth section of the questionnaire. Musculoskeletal pain in different anatomical regions from past 12 months was logged in the final section of the questionnaire.

### **Data Analysis**

Data collected during the study were entered into an excel spreadsheet and then imported to SPSS version 7.0 for statistical analysis (IBM SPSS Statistics 24). Descriptive statistics were performed on all the variables. Ordinal type of were recoded into a dichotomous variable for the ease of statistical analysis. A continuous variable, such as number of hours worked in the dental facility, was recoded and transformed into a dichotomous variable having choices < 40hrs/week and > 40hrs/week, for example.

Factors that inhibit the application of ergonomics were broadly divided into individual characteristics, equipment related factors, and work administration factors. Descriptive statistics and frequencies were performed for all exposure variables to find the primary factor or reason for not applying ergonomics. Chi-squared analysis was performed to calculate the measure of association with ergonomic risk factors at work.

## **Hypothesis**

The research hypothesis of the study is:

Hypothesis: Work administration is the primary factor for not administering ergonomics in dental facilities of India.

## Chapter 4

### Results

A total of 58 dentists from private dental clinics and a hospital participated in the study. Out of 58 study participants, a majority (62%) of them worked for the private dental hospital. About 64% (37) were male and 36% (21) female dentists. The average age of the participants was 39.10 years. (Table 4.1)

Table 4. 1 Demographic characteristics of the dental practitioners

Demographics		N	%
Age	25-40	36	62
	41-60	22	38
Gender	Male	37	63.8
	Female	21	36.2
Type of dental facility	Private dental hospital	36	62
	Private dental clinics	22	38

### Working environment and Job characteristics

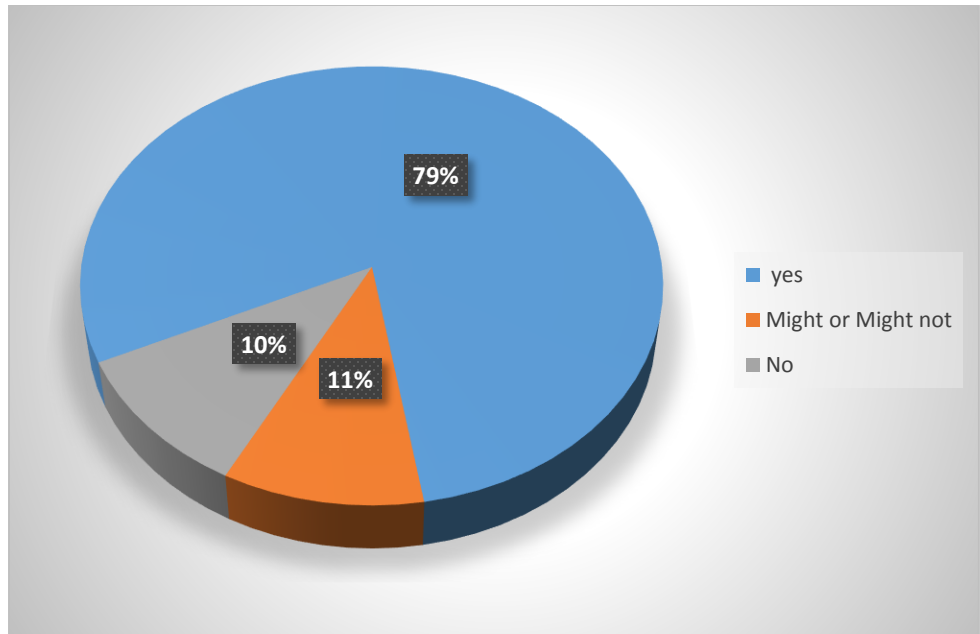
The working environment was represented by three different fields: workplace layout, workload or work pacing, and physical environment. Three items addressed the work layout: the reach distances for seated work, adequate space under work surface for legs, and adequate clearance or accessibility for performing tasks. Job characteristics were addressed by using three different items: frequency of taking rest breaks when stressed at work, number of working hours per week, and repetitive motions performed during dental procedures. The physical environment of the workplace was assessed by

asking the dentists whether the workplace was too noisy or distracting and whether the workplace is too hot or too cold.

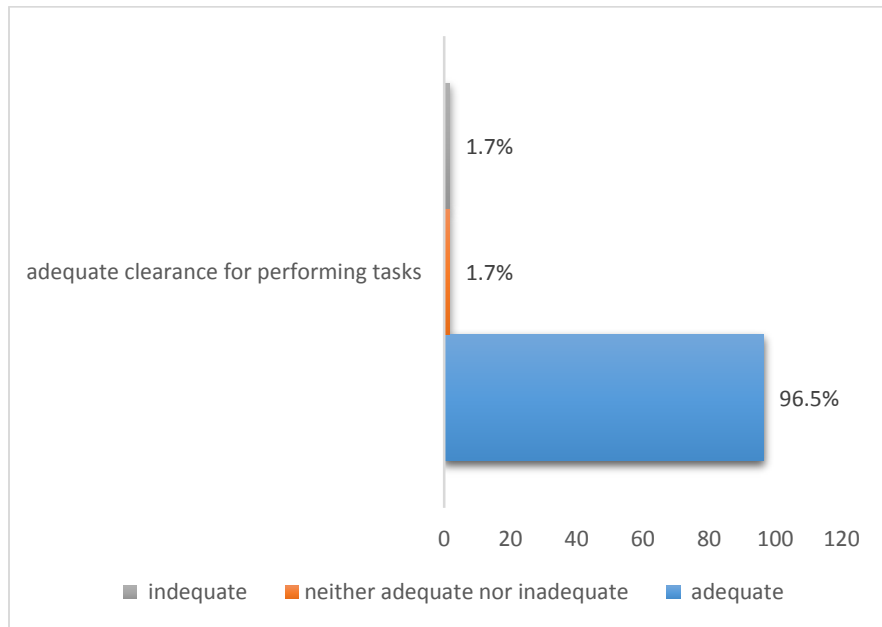
### **Work Layout**

In relation to the workplace layout of the dentists, four variables were assessed: reach distances, adequate space, adequate clearance or accessibility and well-adjusted chair to the workstation. During the observation of dentists while at work, it was found that 77.6% were working with all the dental instruments or tools placed within a comfortable working zone. Observations showed that 22.4 % (13) of the dentists worked with instruments that were not placed within the comfort zone (Fig 4.3).

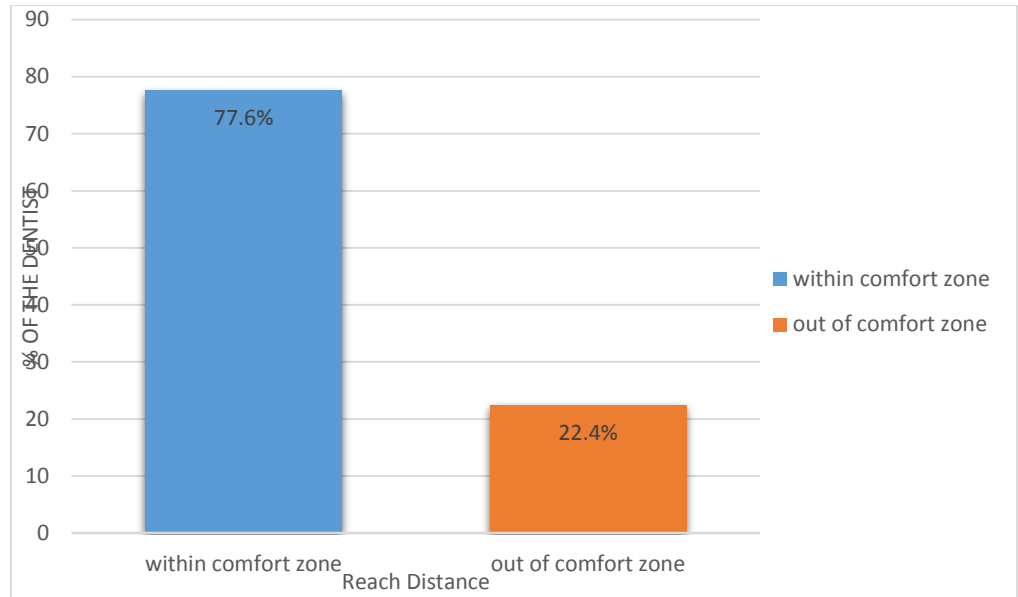
It was observed that 96% (56) of the dentists have adequate clearance and 1.7 % (1) of them have neither adequate nor inadequate clearance nor 1.7 % (1) do not have adequate clearance area in their work station to perform tasks (Fig 4.2). Figure 4.1 shows that 79% (46) of the dentists are working with a properly adjusted chair, 11 % ( 6) might or might not have their chair adjusted and 10% (6) of the dentists are having poorly adjusted dental chair to the workstation.



*Figure 4. 1 Adjustment of the dental chair to the workstation*



*Figure 4. 2 Accessibility for performing tasks*



*Figure 4. 3 Reach distances for tools, instruments, and materials for a dentist*

### **Job Characteristics**

Dentists were asked about how often they took rest breaks when they were stressed at work. Participants who reported as less than 50% of the time were recoded as less often and individuals who take rest breaks greater than 50% of the time were recoded as more often. Table 4.2 shows that 77.6 % (46) of them take rest breaks less often. It was reported that 55.2 % ( 32) of the dentists have  $\leq 40$  Clinical working hours per week and 44.8% (26) of the dentists work for  $\geq 41$  hours per week. It was observed that 51.7% (30) of the dentists need to perform repetitively or series of motions continuously for an extended period of time (table 4.2).

Table 4. 2 Job characteristics of the dental practitioners

		N	%
Rest breaks	Less often	45	77.6
	More often	13	22.4
Clinical working hours per week	≤40 hrs.	32	55.2
	≥ 40hrs.	26	44.8
Repetitive Motions	Yes	30	51.7
	No	28	48.3

\*Less often - < 50 % of the clinical working time, more often - > 50% of the clinical working time

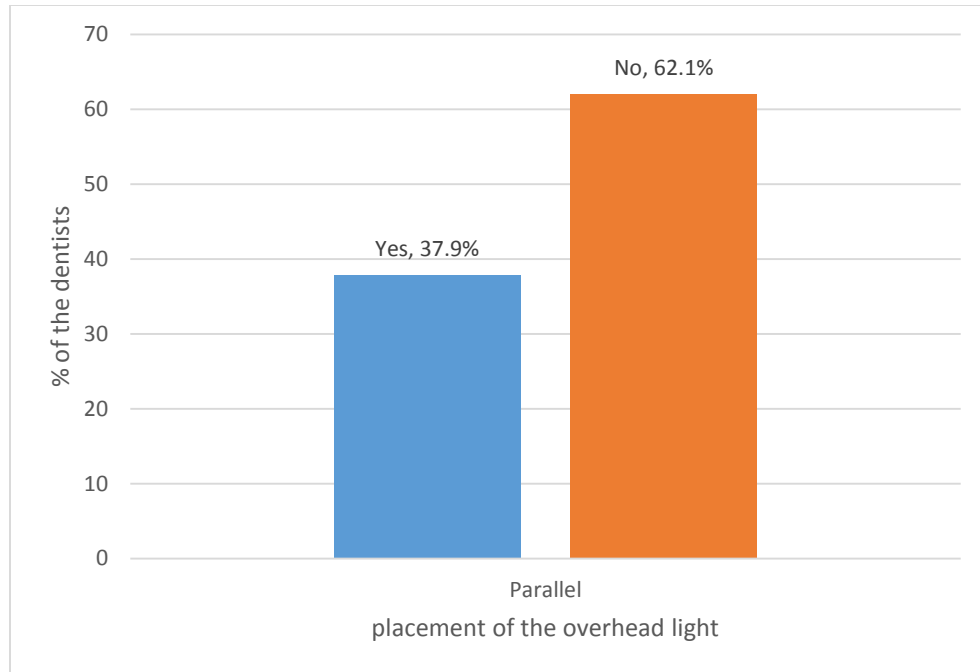
### Physical Environment

When dentists were asked about the physical environment of their workplace, 94% of them reported that it is neither hot nor cold but three (5%) dentists reported that the workplace was too cold for work. Most dentists, 95% (57), indicated that the workplace was neither noisy nor distracting. Only 5% (3) of the dentist's surveyed reported that the work environment was too noisy or disturbing to work (Table 4.3). It was observed that 62.1% (36) of the dentists had improper placement of the overhead operating light (Figure 4.4)

Table 4. 3 Physical environments of the workplace

		N	%
Temperature	Too hot	0	0
	Too cold	3	5
	neither	55	95
Noisy or Distracting	Yes	3	5
	No	55	95





*Figure 4. 4 Light beam parallel to the line of observation*

### **Work Administration**

The influence of work administration on ergonomics was assessed by asking questions to the study participants. Three different questions were asked regarding administration: provision of ergonomic training to employees, performing periodic workplace evaluations, and recordkeeping of workplace accidents. Regarding ergonomic training by work administration, most dentists, 84.5% (49), reported receiving no training from the employer. A majority of dentists, 96.6% (56), recounted that no recordkeeping of workplace accidents was maintained by the hospital or clinics. More than half of the dentists surveyed, 62.1%, conveyed that they did not have any periodic ergonomic evaluations in their workplace by the work administration. (Table 4.4)

Bivariate analysis (SPSS, 2017) showed that there was a relationship between ergonomic risk factors and improper working habits. A significant relationship was found between workplace evaluations and repetitive motions performed during procedures ( $p=0.018$ ) (Table 4.5). Workplace evaluations were found to be associated with the discomfort in the neck region ( $p=0.016$ ) (refer Table 4.5). Ergonomic training was found to be significantly associated with repetitive motions ( $p=0.011$ ) (Table 4.6). Finally, in Table 4.7 we can see that, evaluations were found to be associated with the type of dental facility ( $p=0.018$ ).

Table 4. 4 Work administration characteristics

Work administration		N	%
Ergonomic training	Yes	9	15.5
	No	49	84.5
Periodic evaluations of workplace	Yes	22	37.9
	No	36	62.1
Recordkeeping of workplace accidents	Yes	2	3.4
	No	56	96.6

Table 4. 5 Workplace evaluations and its associations with repetitive motions and neck pain

		Workplace evaluations	
		n (%)	P
Repetitive motions	Yes (30)	7(23.3)	0.018
	No (28)	15(53.6)	
Neck pain	Yes (29)	15( 55.6)	0.016
	No (27)	7(24.1)	

Table 4. 6 Ergonomic training and its association with repetitive motions

		Ergonomic training	
		n (%)	P
Repetitive motions	Yes ( 30)	1 (3.3)	0.011
	No (28)	8(28.6)	

\*Fishers' Exact Test

Table 4. 7 workplace evaluations and its association with a type of dental facility

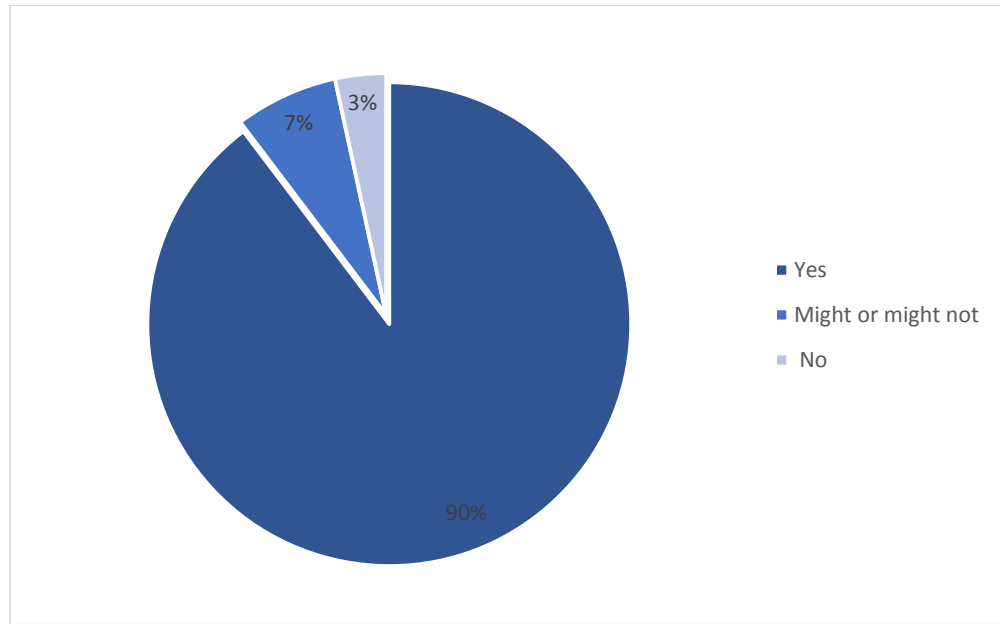
Workplace evaluations		
	n (%)	P
Private dental hospital(n=35)	9(25.7)	0.018
Private dental clinics (n=23)	13(56.5)	

### Equipment and Instruments

Three questions were used to assess the equipment and hand instruments used by the study participants in their workplace: condition of the equipment, physical characteristics of the hand instruments, like weight and type of handle, and sharpness. Results showed that 90% of the dentists were working with well-maintained equipment (Figure 4.5) Dentists used round handled and light weighted hand instruments in most cases (96.6%). It was observed that 86.2% of the dentists were using sharp hand instruments while performing treatment procedures. (Table 4.8)

Table 4. 8 conditions of the hand instruments

		N	%
Round handled and light weighed instruments	Yes	56	96.6
	No	2	3.4
Use of sharp Instruments	Yes	50	86.2
	No	8	13.8



*Figure 4. 5 Maintenance of the equipment in the workplace*

### **Ergonomic Awareness and Attitudes**

To assess their prior knowledge of dental ergonomics the participants were asked several questions. Figure 4.6 shows that a majority, 75.9%, of the dentists stated having awareness of ergonomics, while 18.8% (11) think that they probably know about ergonomics. More than half of the dentists, 53.4 % ( 31), specified assuming ergonomic postures less often at work (less than 50% of the times). (Figure 4.7)

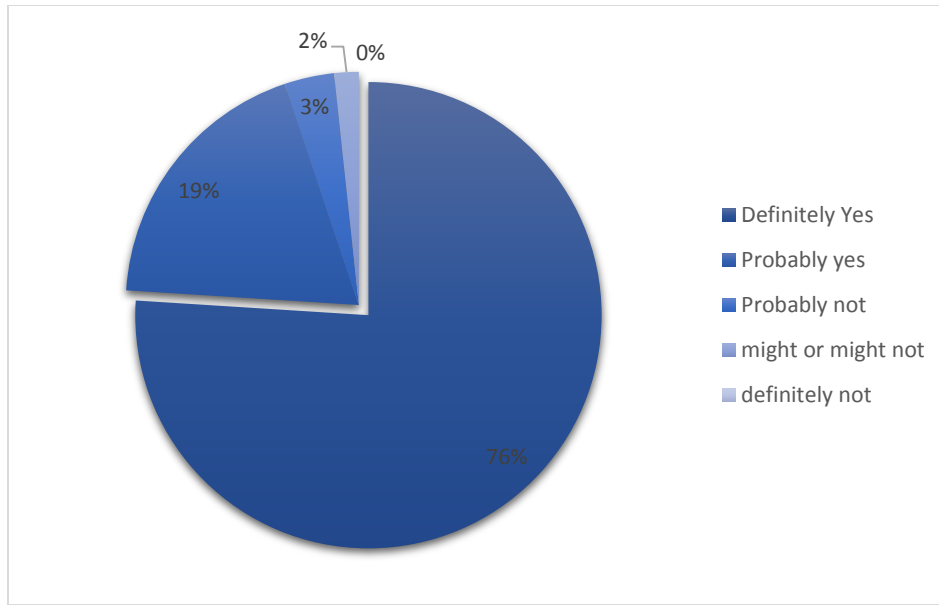


Figure 4. 6. Familiar with dental ergonomics

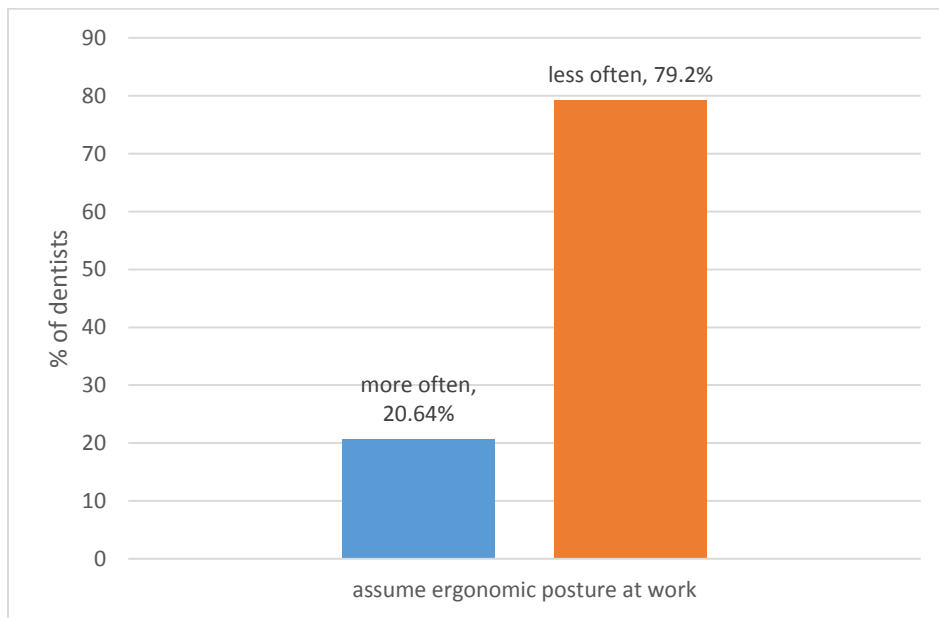


Figure 4. 7. Assume ergonomic posture at work

## Working Postures

Table 4.9 shows the workplace observations of the postural alignments of the dentists while they are performing various treatment procedures. It was observed that 72.4% of the dentists adopted rounding back postures while performing procedures. A majority (91.4%) of dentists did not have proper body support while treating patients. It was observed that 36.2% of the dentists had greater forward inclinations of the head to improve their vision while working. Arms were forward oriented with > 10 angulations in 13.8% (8) and forearms raised horizontally >25 in 31% (18) of the dentists. Further, the study also revealed that 20.7 % (12) of the dentists had to twist their body while working and it was found that 5.2% (3) of the working practitioners did not place the shank perpendicular to the floor.

Table 4. 9 Improper postures assumed by the dentist during treatment procedures

Improper postures	N	%
Rounding back	42	72.4
The greater inclination of the head	21	36.2
The greater inclination of arms	8	13.8
The greater inclination of forearms	18	31
Thighs/shank	3	5.2
Trunk	7	12.1
Tilting	12	20.7
Improper body support	53	91.4

## Prevalence of musculoskeletal symptoms

Discomfort or pain in various anatomical regions was reported in the study (Table 4.10). More than half of the participants have experienced symptoms in the lower back region (67.2%), followed by neck pain (50%). Discomfort in the shoulder region was identified by 27.6% of the dentists. Pain in the arm region was shown by 17.9% of the dentists. Lower prevalence of musculoskeletal symptoms was experienced in the elbow (3.4%), wrist (10.3%), hip (1.7%), and ankle (1.7%) regions.

Table 4.10 Prevalence of musculoskeletal symptoms

Musculoskeletal pain	N	%
Neck pain	29	50
Back pain	39	67.2
Hip pain	1	1.7
Shoulder pain	16	27.6
Elbow pain	2	3.4
Wrist pain	6	10.3
Hand pain	10	17.2
Ankle pain	1	1.7

## **Chapter 5**

### **Discussion**

In order to identify the risk factors associated with ergonomics, a systematic literature review was carried out. Surprisingly, very limited research has been conducted in this field. However, the current research study focused on these factors. The results obtained in the study indicate the improper working habits and poor work administration role associated with the lack of ergonomic application.

Long working hours without sufficient rest breaks can exasperate the negative effects of the static seated postures. In this study, 77.6% of dentists took rest breaks less often. During rest breaks damaged tissue gets repaired. Inadequate rest breaks may lead to increased tissue damage rates resulting in ischemia or necrosis of the muscular tissue. Therefore, control of workload is a very important factor for dentists. A study conducted by Cromie, Robertson, & Best (2000) to investigate the prevalence of work-related musculoskeletal disorders and its contributing factors has concluded that health care providers having inadequate rest breaks during the day, have an increased risk for neck, upper back, shoulder, hand, and wrist symptoms

Visual comfort can be achieved with optimized lighting in the workplace. Illumination and its distribution are important to avoid glare for a working dentist. A study conducted by Aarås, Horgen, & Helland in 2004 found a correlation between visual discomfort, and neck and shoulder pain. Compromised lighting in the workplace can lead to unnatural postures during work. Although the general illumination of the room is well maintained, the overhead light also plays a very important role in maintaining physical ergonomics in the workplace. Light must be kept parallel to the observational line to



ensure maximum lighting and clear field during procedures. In this study, 62.1% of the dentists did not place the operating light parallel to the line of observation. Increased angles of the operating light will result in the deviation from the balanced postures.

According to the International Organization for Standardization (ISO) all the material, equipment and the instruments in use must be present in the comfortable zone (Professional field of vision, distance of 20-25cm) of the dentist. Placement of materials out of this area can cause frequent torsion of the body. In the present study, 22.4% of the dentists were observed that they are working in a layout where the equipment, material, and the instruments appear to be out of the comfortable zone. Placing the instruments out of the comfortable zone will influence the dentists to deviate from balanced postures.

Understanding how ergonomics is affected by dental tools is also another important that need to give attention. Hand instrument should be ergonomically designed to reduce the potential for contact stress. Increased contact stresses can cause carpal tunnel syndrome and muscle load during the repetitive dental procedures. Sharpness, weight, angulations, and texture of the handles influence the working posture of the dentist. Light weighted hand instruments are easy to use and are most preferred. In this study 96.6% of dentists were using round handled and light weighted hand instruments and 86.2% of the dentists were using sharp hand instruments while performing procedures.

Lack of appropriate ergonomic training was reported to be an important risk factor as 84.5% (49) of the dentists did not receive training from the institution or employer. Limited awareness of ergonomic risk factors at the workplace was a contributing influence for not applying ergonomics in the workplace. Educational

interventions and continuing education are key approaches to work-related health problems in dentistry. In 2004, Peper, Gibney, & Wilson conducted a pilot study to investigate whether ergonomic training would reduce discomfort at work between the intervention group and the control group. A two-hour training per week on ergonomic principles for about six weeks was performed among the intervention group. Results showed a significant overall reduction in musculoskeletal symptoms and change in the working habits when compared with the control group who did not receive any training. Working habits and postures can be corrected with proper ergonomic training. The current study suggests the importance of ergonomic training and its impact on the working behaviors of the employees. The present study indicates a significant relationship between poor ergonomic training and repetitive motions performed by the dentists ( $p=0.011^*$ ). And 96.7% of the dentists who performed repetitive motions during their procedures did not receive ergonomic training. 71.45% of the dentists who did not perform repetitive tasks did not receive ergonomic training.

Recordkeeping of workplace accidents or injuries serves as an important source of information regarding the health and safety of the workplace. The United States Occupational Safety and Health Act of 1970 requires that every employer should maintain a record of workplace injuries and accidents and it should be accessible to the employees. Posting of the summaries of the injuries and illnesses allow workers to understand and receive information of the real numbers of injuries and illnesses that have occurred in their workplace. A lack of recordkeeping indicates that a significant portion of workers are not being informed about workplace injury and health risks (Seligman, Sieber, Pedersen, Sundin, & Frazier, 1988). Within this study, 96.6% (56) of the study

participants reported no proper recordkeeping of workplace accidents was maintained by the hospital and clinics. The lack of maintenance logs in the workplace reflects a less safe and healthful workplace.

Workplace evaluations performed by administration helps in identifying the ergonomic risk factors present in the workplace. Identification of ergonomic risk factors may result in abatement, thereby reducing the prevalence of musculoskeletal symptoms among dental health care providers. Employees participate in the evaluation process by reporting hazards and accidents. This process helps to recognize the potential risks. Evaluations encourage employees to follow the recommendations and policies of the workplace, thus creating a healthy working environment (U.S. Food and Drug Administration, 2014). In this study, 62.1% of the dentists reported that there no workplace evaluations were performed by the administration. Dentists, 43.5%, who worked for private dental clinic reported that there are no workplace ergonomic evaluations conducted and 74.3% of dentists from the private dental hospital reported that there are no evaluations conducted in their workplaces. Chi-square analysis showed that there is an association between conducting workplace evaluations and performing repetitive motions during the treatment procedures ( $p=.018$ ). 76.7% of the individuals who performed repetitive tasks did not have workplace evaluations .46.6% of the individuals who did not perform repetitive tasks did not have workplace evaluations.

In dental practice, working postures are determined by various factors in the work environment. All these elements influence and interact with the body of the working dentist. Adoption of unbalanced postures at work can result in the deviation of the workers body. (Pîrvu, C., Pătraşcu, I., Pîrvu, D., & Ionescu, C., 2014). In this study,

postural alignment of dentists was recorded by direct observation. During the current study it was found that dental professionals adapt postures according to the needs of the patient. This is done in detriment to their own comfort to achieve a satisfactory result of treatment. Again, this was noted in the current study as 72.4% of dentists adopted rounding back postures while performing procedures.

Dentists often perform procedures with an unsupported back. Unfortunately, this is a common posture in dentistry. Unsupported sitting postures causes tension in the muscles, ligaments and connective tissue of the spine leading to various musculoskeletal symptoms. (Valachi & Valachi, 2003). A majority (91.4%) of dentists were found to not have proper body support while treating patients. Lack of support for the lumbar spine increases the pressure on the lumbar spinal discs and this may create muscle imbalance between the abdominal and low back muscles

On the other hand, it was found that about 36.2% dentist bent their neck greater than 30° angulations while working on patients. According to Valachi & Valachi (2003), forward positioning of the neck is another common posture observed among dentists to obtain better visibility of the operating field. Dentists tend to position their head forward, which holds the head and neck in an unbalanced position. This can lead to tension neck syndrome.

Generally, dentistry is considered to be a high-risk profession for the development of musculoskeletal symptoms. Musculoskeletal health was also studied as part of the ergonomic assessments. Prevalence and distribution of the musculoskeletal pain are investigated among the study participants. These work-related musculoskeletal disorders affect a significant portion of dentists each year. Numerous factors contribute to the

development of musculoskeletal pain among dentists. Any discrepancy between the physical requirement of the job and physical capacity of the worker can result in musculoskeletal disorders. The symptoms usually begin with fatigue and can finally end with serious complications. (Rucker, Lance & Sunell, Susanne 2002). The present study revealed that 67.2% of the dentist experienced back pain followed by discomfort in the neck (50%) and shoulder (27.6%). Similar findings were observed in a study conducted by Alexopoulos, Stathi, & Charizani, (2004).

### **Study limitations**

The main limitation of this study was the small sample size which could affect the statistical power of the study. Additionally, performing the workplace analysis through a questionnaire survey and observational checklists may not yield highly accurate conclusions for the study. The direct method of measurements through instrumentation yields highly accurate results but they are expensive and time-consuming. Psychological (stress) and physical factors (BMI) also influence the posture alignment of the dentist but they are not recorded in the study. It was difficult to examine all the possible influences of clinical ergonomics in a short period of time. Finally, the study was based on the observations made by the investigator in the workplace. Lower concentrations of the investigator during the analysis can result in the chance of missing details of the workplace.

## **Chapter 6**

### **Conclusions**

Through the effort to satisfy the needs of the patient, a dentist may neglect the protection of their own health and professional practice. Study results on the prevalence of musculoskeletal symptoms among dental practitioners should generate a great concern for practitioners' health. Results of this study and others demonstrate dental health care professionals need to be well-informed about the risk factors in the workplace and protect their employees with ergonomics, especially the dental practices studied in India. A proactive approach should be taken by the Indian government as well as work administration in clinics and hospitals to minimize the potential for occupational health issues.

Consideration should be given to performing workplace analysis and ergonomic assessments to identify the potential hazards in practice. More stringent laws and regulations that mandate that dental clinics and hospitals follow OSHA standards should be developed to protect the health and safety of dentists from work-related injuries which could be a threat for their career. There is a definite need for health protection and promotion in the dental practices observed. It is anticipated that an expansion of this study to the United States may demonstrate similar results.

This study highlights that including equipment related ergonomic risk factors, there are many other important elements that can increase the prevalence of musculoskeletal symptoms. There is a need to increase awareness regarding these risk factors among dental practitioners in India through various programs. Basic educational programs to dental practitioners on ergonomics would help them in the recognition of

ergonomic risks, interpretation of hazards, and reduction of identified high-risk factors of work. This approach may motivate and help clinicians who are high risk yet have not developed musculoskeletal symptoms.

Unfortunately, there was limited application of ergonomic principles by dentists in this study. Dental practitioners should feel responsible for their own health and take necessary corrective ergonomic actions during practice. To increase ergonomics in dentistry both the employee and the employer should be informed on the musculoskeletal risks. Innovative pedagogical methods to better understand the ergonomic principles will be helpful in clinical dentistry.

Despite the small sample size, significant associations were found between the work administrative factors and improper ergonomic habits. Many of the dentists reported that there were no workplace evaluations or recordkeeping of workplace accidents by administration, which were factors that resulted in poor ergonomics of the dentists observed. Even though there are limitations for this study, it serves as a basis for future research. Future research should elucidate controls that can be put in place to improve ergonomics practiced by dentists and other dental practitioners.

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## Appendix 1

Questionnaire survey

### **Factors for not applying ergonomics**

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#### **Personal Information**

Q1 Survey ID

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Q2 Age

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Q3 Gender

Male (1)

Female (2)

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Q4 On average, how many days in a week do you work in the dental facility?

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Q5 On average, how many hours do you per week?

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Q6 What type of dental facility do the dentist work?

- Private Dental hospital (1)
- Private Dental clinic (2)
- Both (3)

---

**Tasks**

Q7 How often do you take rest breaks when you feel that you're stressed at work?

- 0-25% of the time (1)
  - 25-50% of the time (2)
  - 50-75% of the time (3)
  - 75-100% of the time (4)
-

Q8 How often the dentist requires to bend or twist his body to reach tools and instruments?

- 0-25% of the time (1)
  - 25-50% of the time (2)
  - 50-75% of the time (3)
  - 75-100% of the time (4)
- 

Q9 Is the light beam parallel to the observational direction?

- Yes (1)
  - No (2)
- 

**Work administration**

Q10 How would you rate your work organization role in ergonomics?

	Very Satisfied (1)	Somewhat Satisfied (2)	Neutral (3)	Somewhat Dissatisfied (4)	Very Dissatisfied (5)
Respond to employee concerns (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Providing ergonomic workplace (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

---



Q11 Do your work organization provide ergonomics training?

Yes (1)

No (2)

---

Q12 Do your work administration periodically evaluate the workplace to identify the hazards?

yes (1)

no (2)

---

Q13 Is there a system of Recordkeeping for the workplace accidents or health issues at work?

Yes (1)

No (2)

---

**Physical environment**

Q14 Is the workplace too hot or too cold?

too cold (1)

too hot (2)

neither (3)

---

Q15 Is the workplace too noisy or distracting?

Yes (1)

No (2)

### **Equipment and work design**

Q16 For seated work, reach distances for tools and materials are more than forearm distance away from the dentist ( workdesign)

Yes (2)

No (3)

---

Q17 Do the dentist need to perform repetitive or series of motions continuously for an extended period of time ?

Yes (1)

No (2)

---

Q18 Are the instruments round handled and light weighed?

Yes (1)

No (2)

---

Q19 Does the dentist use sharp hand instruments while performing the procedures?

Yes (1)

No (2)

---

Q20 Is there adequate space under work surface for legs ?

- Definitely yes (1)
  - Probably yes (2)
  - Might or might not (3)
  - Probably not (4)
  - Definitely not (5)
- 

Q21 Is the chair properly adjusted to fit the workstation?

- Definitely yes (1)
  - Probably yes (2)
  - Might or might not (3)
  - Probably not (4)
  - Definitely not (5)
-

Q22 Is the equipment well maintained?

- Definitely yes (1)
  - Probably yes (2)
  - Might or might not (3)
  - Probably not (4)
  - Definitely not (5)
- 

Q23 Use of ultrasonic and automatic instruments and tools in the workplace?

- yes (1)
  - no (2)
- 

Q24 Is there adequate clearance or accessibility for performing tasks?

- Extremely adequate (1)
  - Somewhat adequate (2)
  - Neither adequate nor inadequate (3)
  - Somewhat inadequate (4)
  - Extremely inadequate (5)
- 

**Awareness**

Q25 Are you familiar with ergonomic posture?

- Definitely yes (6)
  - Probably yes (7)
  - Might or might not (8)
  - Probably not (9)
  - Definitely not (10)
- 

Q26 How often you think that you assume ergonomic posture at your workplace?

- 0-25% of times (1)
  - 25-50% of times (2)
  - 50-75% of times (3)
  - 75-100% of times (4)
-

Q27 Do you know that ergonomics prevent occupational injuries and illness?

- Definitely yes (1)
  - Probably yes (2)
  - Might or might not (3)
  - Probably not (4)
  - Definitely not (5)
-

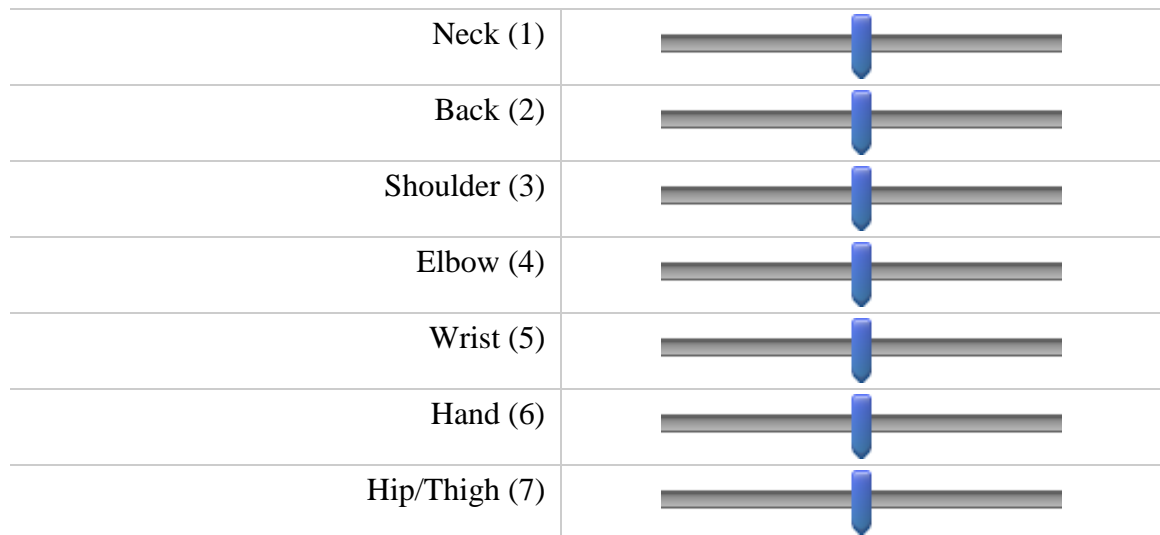
Q28 How often you experience pain while performing work tasks in the past 12 months?

	Always (1)	Most of the time (2)	About half the time (3)	Sometimes (4)	Never (5)
Neck (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Back (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Shoulder (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Elbow (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wrist (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hand (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hip/Thigh (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Knee (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ankle/Foot (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



Q29 How bad was the pain during last 12 months?

0 1 2 3 4 5 6 7 8 9 10



Q30 List any other potential conditions observed in the workplace

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## Postures

Q31 posture of the operating dentist

	Yes (1)	No (3)
rounding back (1)	<input type="radio"/>	<input type="radio"/>
greater forward inclinations of Head (4)	<input type="radio"/>	<input type="radio"/>
greater forward inclinations of Arms (5)	<input type="radio"/>	<input type="radio"/>
greater forward inclinations Forearms (6)	<input type="radio"/>	<input type="radio"/>
greater angulation between thigh and shank (7)	<input type="radio"/>	<input type="radio"/>
trunk rotation (8)	<input type="radio"/>	<input type="radio"/>
Tilting to side to side (9)	<input type="radio"/>	<input type="radio"/>
improper body support (10)	<input type="radio"/>	<input type="radio"/>