Ergonomic Analysis of Repetitive Physical Workload in Dental work

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ABSTRACT

The aim of this study is to determine musculoskeletal discomfort among dentists based on discomfort occurence in last 12 months and 7 days. The other goal is to identify musculoskeletal discomfort locally which has been occuring in dentists and examine the degree of influence to dentists.

In this scope of study, a questionnaire survey is created and fulfilled by 67 dentists. The questionnaire survey is published on a website as a link form in order to reach dentists in various universities of the dentist group. Except for a small number of questionnaires filled out manually, it has been imported into the system. Survey results revealed that, Dentists' most commonly used position of the dentist while performing their profession was static, and prolonged sitting / standing position.

Occurence of musculoskeletal discomfort in the last 12 months has seen mostly in neck, hand / wrist, upper back, and shoulder regions. Musculoskeletal discomfort seen mostly during the last 7 days as in elbows, feet, hip, and wrist / hand regions.

Electromyographic studies were applied on three dentists. These tests consist; endodontic treatment, dental filling therapy, fix prosthodontic, removable prosthodontic, dental examination, tooth cleaning treatment, and tooth extraction. In addition, the muscles activities are analyzed from six different region of the body which is determined based on questionnaire result.

Hypothesis testing was established for the analysis of electromyographic data which were collected from participant dentists while applying 7 different tasks (endodontic,

dental filling therapy, tooth extraction, dental examination, and removable prosthodontics treatments). In most tests, hypothesis was rejected. As a result, discomfort occurrence in the body of the participants is observed which caused by the seven tasks. Finally, ANOVA was constructed and results were examined based on interaction between body and seven dental tasks which caused the discomforts in the dentists.

Keywords: Musculoskeletal discomfort, Dentists, electromyogram

ÖZ

Bu çalısmanın amacı, Dişhekimlerinin son 12 ayda ve son 7 günde yaşadıkları kas iskelet sistemi rahatsızlıklarını tanımlamaktır. Bir diğer amacı ise, Dişhekimlerinin yaşamakta olduğu kas iskelet sistemi rahatsızlıklarını bölgesel olarak tespit edip, etki derecelerini incelemektir.

Bu çalışma kapsamında bir anket hazırlanmış olup 67 dişhekimi tarafından doldurulmuştur. Anket, web sitesinde yayınlanarak çeşitli üniversitelerin dişhekimleri grubunda link olarak dişhekimlerine ulaşmıştır. Bunun haricinde çok az sayıda anket manual doldurulup, sistem içine aktarılmıştır. Anket sonuçlarına göre, Dişhekimlerinin mesleğini icra ederken en çok kullandıkları duruş sabit ve uzun süreli oturma/ayakta durma pozisyonu olarak çıkmıştır.

Son 12 ayda yaşanan kas iskelet sistemi rahatsızlıklarının en çok görülmekte olduğu bölgeler boyun, el/bilek, üst sırt, ve omuzlar olarak saptanmıştır. Son 7 günde yaşanan kas iskelet sistemi rahatsızlıkları en çok dirsek, ayaklar, kalça, ve bilek/el bölgelerinde görülmektedir.

Üç Dişhekimine elektromiyografi testi yapılmıştır. Bu testler; endodonti, dolgu, sabit protez, hareketli protez, muayene, diş temizleme, ve diş çekimi olarak, anket sonuçlarına göre belirlenip, vücudun altı değişik bölgesinden kas hareketleri incelenerek gerçekleştirilmiştir.

Elektromiyografik dataların analizi için Hipotez testi oluşturulmuştur. Teste katılan dişhekimleri yedi ayrı görevi uygularken alınmış olan veriler ANOVA tablosuna

koyulup, hipotez testi yapılmıştır. Tüm hipotezler reddedilmiştir. Sonuç olarak, katılımcıların vücut bölgelerinde yaşadıkları rahatsızlıklara yedi görevin yol açtığını gözlemlenmektedir.

Son olarak yedi ayrı görevin dişhekimlerinin vücut bölgesiyle etkileşimi ANOVA tablosu yapılarak incelenmiştir. Diş hekimlerinin uygulamakta olduğu Endodonti, dolgu, diş çekimi, muayene, ve çıkarılabilir protez tedavilerinin, vücut bölgeleriyle etkileşerek kas-iskelet sistemi rahatsızlıklarına yol açtığı ortaya çıkmıştır.

Anahtar Kelimeler: Kas-iskelet sistemi rahatsızlıkları, Dişhekimleri, elektromiyografi

To My Family

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INTRODUCTION

Musculoskeletal discomfort can be affected by wrong, awkward positions and forceful, repetitive movements for human body. These discomforts can be seen in several body parts such as neck, back, shoulders, elbows, knees, hand, wrists, hips, and fingers which associate with daily life and profession (Khan and Chew, 2013). Mostly, discomforts can be shown by occupation. First step of protecting human health is awareness and consciousness.

Dentists' work conditions, positions and rules affect and determine their personal health as well as the other professions. Nowadays, occupational health problems have been increasing which are highly shown in dentistry. When we consider the reasons; repetitive and forceful movements, vibrated tools, and prolonged and awkward postures can conclude as reasons. Costly health problems and early retirements can also occur as a result of these working conditions. During dental education, dentists lack the training lessons to teach them the proper body position while treating the patients.

Precautions and awareness about how important their life and importance of correct acting when treating can decrease musculoskeletal discomfort substantially.

I have chosen the subject for research of this study in order to be the first degree of witness of dentists' working environments and conditions.

The aim of this study is to investigate the occurrence of musculoskeletal discomfort among dentists in a statistical way. When they were treating patient, their bodies are studied in order to obtain statistical data according to muscle groups which are used based on determined tasks.

In this study, a questionnaire is used to collect personal information and socio demographic data of dentists and ergonomic risk factors which affect performance are determined. Then, six muscles activities are taken by surface electromyography (EMG) according to determined job tasks which are attached to dentists while operating.

With the help of this study, awareness and complement of necessary parts ergonomically are aimed. Also, in order to prevent health problems, training is suggested.

Chapter 2

LITERATURE REVIEW

2.1 Musculoskeletal disorders (MSDs)

Musculoskeletal disorders are extremely common and risk increases with age. Some injuries and pain in the body's ligaments, muscles, nerves, tendons and joints calls musculoskeletal disorders. These disorders can occur pain in body segments such as upper and lower back, neck, shoulders, and extremities (arms, legs, feet, and hands). In addition of those repetitive movements, static or awkward posture, forceful movements, and vibration can increase existence of musculoskeletal disorders.

Carpal Tunnel Syndrome (CTS) and Tendinitis are common examples for musculoskeletal disorders. MSDs affect psychological and social factors. Regarding psychological factors, there is a relationship between MSDs and pain sensitivity reduction, pupil dilation, increased blood and fluid pressure. Commonly affected parts are shown as back, neck, shoulders and upper limbs.

2.2 Work- Related MSDs

Workplace conditions, organizational, psychosocial and socio cultural variables incline the work related musculoskeletal disorders (Khan and Chew, 2013). Dentists work in a sitting or standing position. Some of them are working with own assistance which is an effective way to decrease musculoskeletal disorders for dentists. Regarding to their working position, dental personnel can have disorders because of their wrong posture. Work environment and their working system should be considered to

investigate ergonomically in their work area. Dentists have inflexible and narrow working area (the mouth of the patient). This situation can be caused by some discomforts. These discomforts should be measured in all body parts whether the result cannot be realistic or valid.

Dentists have been found one of the most stressful health professions. This profession is included some risk factors which may be related to work or not. Musculoskeletal disorders are shown lower back, neck, and shoulders commonly. The most common pains reported in shoulder region followed by neck and low back regions by dentists. Neck and shoulder discomforts are highly seen among dentists who had 23 year job experiments. Neck and upper limbs were common disorders associated to work related musculoskeletal disorders (WMSDs). These disorders were mostly related with some risk factors such as prolonged postures, repetitive movements, and lack of pauses. Work related musculoskeletal disorders are associated to the work system factors. Prolonged static muscle loads, highly repetitive and monotonous work, high force exertion or mechanical compression of tissues, are using vibrated tools are highly shown in dentistry. High job stress and non-work related stress reactions are associated to upper extremity musculoskeletal disorders. During the last two decades, work-related disorders are recorded among dentists (Palliser et al., 2005). Generally, factors are affecting human health but outcome depends on individual character.

Some musculoskeletal disorders are demonstrated (Gijbels et al., 2006). These disorders are included in neurovascular disorders, sight and hearing complaints, inflection, allergies, psychological stress, kidney disease, and disturbances in short-term memory. Female dentists have musculoskeletal disorders more than male

dentists. Also, young dentists are at high risk rather than older dentists. Latex gloves can cause allergy to dentists based on statistical results. Mechanical injuries can affect dentist's tissues while scaling and drilling operation. And also blue light, prolonged and concentrated working days are harmful for the eye. Another risk factors are bacteria, viruses, prions and fungi which can cause occupational infection for dentists. Hearing loss may occur with high speed drills and ultrasonic scalars among dentists. For hand, vibrating tools are harmful and may cause carpal tunnel syndrome. Carpal tunnel syndrome (CTS) affected by forceful pinching or gripping, using vibration tools, unsupported wrists positions, and repetitive movements. Regarding to hygienists, CTS is found as the most common disorder (Dong et al., 2006). According to examination, %57 disorders are diagnosed which are including the trapezius muscles which are; tension neck syndrome (%33), trapezius myalgia (%22), and cervical syndrome (%2). Also diagnosed is seen in shoulder region such as: acromioclavicular syndrome (%14), shoulder tendonitis (%8). In wrist and lower arm region %16 disorders are diagnosed. Carpal syndrome (%10 and %6 bilaterally) and also overuse (%5) are diagnosed (Åkesson et al., 2012).

Majority of studies have been conducted in USA, Canada, UK, and Scandinavia. First research observed postures and movements with report by photos and sketches in USA. In this study, neck bent forward and arm abduction are observed in %69 of dentists. (Zoidaki et al., 2013).

Upper extremities and neck region are most widely used in dentistry (Åkesson et al., 1997).

One of the most common and occupational health problems is musculoskeletal disorders which affects quality of life. Narrow visual field of oral cavity and working with a limited scope of movement can cause disorder in low back, neck, and wrist region among dentists. Disorders are still found after evaluation of seat and 4 handed dentistry (Rabiei et al., 2012).

Dentistry includes repetitive movements, visual acuity, extreme static postures and force exertion. The most common disorders are shown in the back (36.3-60.1%) and neck (19.8-85%) among dentists. For considering hygienists, most prevalent region for pain has been shown in hand/wrists region. Musculoskeletal disorders affects human life such as reduce productivity and early retirement. Risk factors are revealed such as static and awkward posture and work practices contribute to long term health problems among dental hygienists and dentists. Painful areas among dental works are revealed as lower back, upper back, hand/wrists, neck and/or shoulder and lower extremities (Kar and Mullick, 2012).

Dentists and dental hygienists have some musculoskeletal disorders mostly in their neck, shoulder and wrists/hand regions. These disorders are associated to their work tasks. Dental hygienists' tasks were mostly including repetitive and forceful movements (Åkesson et al., 2012).

Dentists suffered musculoskeletal disorders with high rates (%64) in Australia, Queensland is reported musculoskeletal disorders with high frequency in the past 12 months (%87) also Thailand (%78) (Hayes et al., 2013). The most common disorder was back pain (%64) and wrist pain (%69) in Sweden (Åkesson et al., 1999) and USA

According to these results, training programs are existed in Australia for dental hygienists (Hayes et al., 2013).

Work related musculoskeletal disorders (WMSD) are common problems among dentistry in order to investigate such risk factors in dentistry. Many studies investigated to obtain some results which are related to find relationship between complaints and work related tasks. Injuries and traumas may cause by WMSD. To prevent this; good ergonomic practices, training, and correct posture can reduce disorders (Khan and Chew, 2013). In addition to that, genetic susceptibility, obesity, mechanical stress, and traumatic injuries also cause osteoarthritis (OA) problem, especially female dentists. OA is shown highly after age of 55 years. OA may increase with repetitive work tasks, fatigue of the muscles and more using joints. Also when they investigate OA problem, interestingly female teachers have higher prevalence of OA than female dentists. Dentists are commonly use three fingers (thumb, index, and middle) constantly to grip equipment (Solovieva et al., 2006). Age, gender, and perceived moderate/bad general health are important factors for defining musculoskeletal complaints.

2.3 Occupational Musculoskeletal Discomfort

Dentists' health and their career may be related with occupational risk factors and permanent pain. Their work area is limited and it can cause neck, and back problems for them. On the other hand, dentists' posture and their work habits are also affect their health conditions. While dentists are treating patients, back pain, arm abduction, cervical spine flexion, and back/neck/shoulder rotation are found. Musculoskeletal disorders are observed highly on dentists. Neck/shoulder/back pains are registered when dentists work in dental school (Finsen et al., 1997).

Musculoskeletal disorders are increased during last decades because work-related activities are increased. There are lots of reasons which may cause disorders such as vibration, static posture, bending, twisting. These risk factors may effect on neck and back region. Few risk factors are considered which are not enough to reveal specific risk factors (Pargali and Jowkar, 2010).

Disorders can affect body's muscles, tendons, joints, ligaments, and nerve system. Dentists may be forced to leave the job because disorders reduce work quality. The most common disorders' ranges are determined such as shoulder pain (21-81%), neck pain (19.8-68%). Interestingly, Saudi Arabian dentists had lowest neck pain (19.8%) according to 2003 report (Lin et al., 2012). The 2008 report shows us the increase of neck pain (67.9%). Dentists are at risk when treating patients because their work area is inflexible and limited.

178 Thai dentists are investigated to reveal disorders, eye problem, hearing loss and skin diseases are found. In Polish dentists, neck pain, lower extremities disorders, wrists/ hands pain, and pain in the thoracic lumbar are demonstrated. The most common disorder is found low back pain for Danish and Australian dentists. Major risk factors such as repetitive movements, awkward and non-ergonomic positions, and forceful tasks can cause the disorders (Alexandre et al., 2011).

Musculoskeletal disorders can be seen in type of milder and severe among dentists which depends on their experience year. The most common disorder is found as back pain followed by neck pain (Yousef and Al-Zain, 2009).

2.4 Musculoskeletal Discomfort among dentist

2.4.1 Regional Studies

In their study, Lotte et al., (1998) risk factors were searched for dentistry such as musculoskeletal disorders. First of all, questionnaire involves 115 member of Danish society for Craniomandibular Disorder. Community is comprised of %41 female and %51 male and the mean age is 45 years. Questionnaire is consisted of personnel information such as age, gender and seniority working conditions and Nordic standardized questionnaire. Working conditions determine common tasks, frequencies and durations of tasks, delay, working positions and assistant existence. Lastly, Nordic standardized questionnaire is used for identifying ache, pain, discomforts in musculoskeletal system, and defining common work tasks and finding common troubles (65% neck/shoulder, 59% low back).

Working postures and electromyography were used on three most common work tasks. According to research of their study some dentists use right side of the patient and some dentists prefer left side of patient while operating. High frequencies of musculoskeletal disorders were observed in dentists such as neck and shoulders. Dentists' performance may be related to pain in neck and shoulders. In order to find the dentists exposure, electromyography were used. There has not been a study done on the field of frequency of musculoskeletal disorders before Lotte et al's study (1998). Their study was performed on Danish dentists and obtained high frequency of musculoskeletal troubles was observed in neck and shoulder regions. The study assumed that if verity of work posture is increased, lowered muscle activity may decrease the risk of musculoskeletal disorders for dentists.

Since musculoskeletal disorders are a common problem for dental work, in their study, Artenio et al., (2011) aims to investigate this fact with the help of epidemiological study by evaluation of the size of the risk. The risk reports were obtained by two electronic databases. Out of 25 studies, 8 were reported for risk measurements which represented weak association. 32% of the studies were analyzed with at least one competing explanation merely half of them were not adequate for adjustments.

The physical problems for the dental workers has been referred as a work related condition without enough scientific evidences and also due to the high stress dental worker may result in having burnout syndrome. 92% of dentists have upper extremities musculoskeletal disorders which 20% of them require surgery and more 40% need to reduce their work hours. The possibility of making changes in the work stations is limited and it can be overcome by factors such as increased frequency of breaks, time away from practice, reduced number of patients and etc. Although some studies found alternative explanations, still studies on the association between dental work load and disorders are required.

Bhornsawan et al., (2012) constructed a system which intends to predict and prevent work related musculoskeletal disorders (WMSDs) among dentist. Strong evidence found such as gender, age, repetitive movements and etc. which is associated with WMSDs. Bayesian network (BN) is used with multiple variables which are provided by direct measurement of dentist's movements and questionnaire survey. The aim of BN prediction model is offered as guidance to dentists for reducing WMSDs which is associated with multiple factors. The advantage of BNs model is that they can be used to predict a target variable and can be represented by an arc between two nodes and resulting in valid output when a subset of the model is present. 16 dentists are selected

randomly to assign into 2x2 cross over trial. These sequences are: receiving feedback or no feedback related to WMSDs and risk factors. According to the post test, extensions of neck and upper back are revealed. Quantitative case-specific and dynamic predictions done by BN prediction model which reduced the risk of dentist's inappropriate posture and some incorrect movements while dental operations.

Shrestha et al., (2008) study's intends to investigate the common pain and musculoskeletal disorders on the male and female dentists in Nepal. Pretested questionnaires are used to obtain the results from the dentists in Dharan and Britnagar. 68 dentists were investigated and according to their questionnaires, most common affect was back pain which covered 80% followed by 58.8% neck pain and 47% shoulder pain of this population. Shoulder pain is affected female almost double comparing to males however neck pain was significantly higher in males to consider females. The data were processed using excel and analyze with the help of SPSS. Their study obtained that there is no measure differences between male and female musculoskeletal symptoms. The dentists assumed that they practice the correct posture without knowing that it was actually wrong. Most pain and disorders can be recovered by performing regular specific exercises.

Abdul Rahim et al., (2011) examined musculoskeletal disorders such as pain and stiffness which is related with vibration of dental work among dental surgeons. Socio-demographic variables are selected for finding relationship between pain and stiffness. Their study includes 30 graduated dental surgeons whom have 1 year or more experience and some staff of Yenepoya dental college in this field for using close-ended questionnaire and finding relation between pain and stiffness.

According to the results common disorder is experienced in shoulder pain (6.6%), additionally back pain (83.3) and neck pain (70%) are experienced in dental surgeons. Regarding to back pain (73.3%) which is related to stiffness and neck pain (23.3%) are observed in dental surgeons. The pain on hip/thigh region depends on number of patients. Furthermore this pain depends on the height of the surgeon. In conclusion the study shows the musculoskeletal disorders of the surgeons and these disorders are depending on the number of patients are attending the surgeon.

Nutalapati et al., (2009) introduced consequences when dentists work wrongly. The study is related with personnel, equipment and environment in the work area. In dentistry, they can cause back pain, neck pain and shoulder or arm pain while repetitive tasks are done. Static posture, forceful work or lack of sitting often can also cause the problems. If they do more repetitive neck, hand and arm movements it may leads to neck and shoulder demonstration. Also repetitive and forceful movements can cause carpal tunnel syndrome. Dentists happen to have low back discomfort in order to work numerous studies. Psychosocial factors can affect dentists in such a way that they can feel less confident about their future. If dentists are preventing low back pain and injuries which is related between work equipment, they should be aware about which equipment gives maximum benefit. Their study focuses on reducing stress of dental work by redesigning the work station and correct posture with healthy work practices.

In their study, Maryam et al., (2012) determined MSDs among general dentist and specialists in north of Iran. Ninety two dentists (59 male, 33 female) of 158 dentists have agreed the consent form. The study consists of three questionnaires which the first one is based on self-administrated information such as sex, age, job satisfaction, and their major tasks and time of post. In addition, job satisfactory evaluation is based

on several parts which are lightening, satisfaction of work environment, staff, unit equipment and dentists' chair. The second questionnaire is provided to determine MSD complaints by the Nordic Musculoskeletal questionnaire. The survey investigates nine body parts which are neck, shoulder, upper back, lower back, elbows, hands, thighs, knees and ankles.

The RULA questionnaire is used as the third part of the study which concerns the working posture, scoring system and action level of risks. All observed data are analyzed by SPSS and group differences are calculated by Chi-square technique. Logistic regression method is used for obtaining individual risk factors and health status in work. Some results are obtained by RULA questionnaire. Frequency of musculoskeletal pain is found in specific body section such as neck, shoulder, knee, etc. According to observations 24 dentists had no pain. According to several researches, pain increase as time goes by. Thanks to researches, %73 of dentists have a musculoskeletal pain. The obtained results are compared with the other studies which shows the age and sex is important for dentistry. Also there are ways to protect dentists from discomfort such as having a break after each operation and then doing some exercises like stretching or, by selecting ergonomically appropriate equipment.

Hui et al., (2006) study intended to reduce the disorders such as carpal –tunnel syndrome with new designs for scaling instruments among 24 dentists and hygienists. 8 custom-designed dental scaling instruments are applied with different handle shapes. Electromyography (EMG) is used to illustrate the muscle activity of two extensors and two flexors in the forearm. During scaling process, EMG and pinch force are recorded simultaneously. Amplitude probability distribution function (APDF) is applied to calculate for the EMG and pinch forces from recorded data. APDF function is included

in static, median, and peak values. In addition to that, thumb pinch force is also considered by pressure sensors.

Tool handle design influences the pinch force while working on dental scaling. Their study is considered in four different shapes; round, hexagonal, tapered round, and trapped hexagonal shape to find out which one needs low pinch force. Four shapes are tested with traditional 7mm diameter and 10mm diameter. Each tool had a sensor to measure force and weighted is 24g. Complete scaling with each instrument takes 2 min approximately. Productivity of instruments is measured by questionnaires. Diameter, shape and perceived productivity of instrument are evaluated by 1-5 scale. 0 is represented as the least; contrast and 5 is the most preferable one. Productivity is measure by painting plastic teeth before and after scaling. Statistical analysis is based on SAS system. EMG and pinch force values are analyzed with Analysis of variance with repeated measures (RMANOVA). For multiple comparisons, the tests done in Turkey are considered.

The study purposes to find relationship between tool handle shape and muscle load and pinch force. There were no statistically significances between eight instruments. In 10mm diameter group, lower values in EMG are associated with the tapered round handle which compared to the most commonly used round handle. At the end of their study, dentist's instruments caused some disorders such as carpal-tunnel syndrome. In order to reduce the risk factors, the new designs can be useful. Dental personnel should be careful for instrument selection.

Alexopoulos et al., (2004) purposed the relationship between individual characteristic, physical, psychosocial, and different endpoints of disorders in low back, neck,

shoulder and hand/wrist. The study is considered by questionnaires and Nordic standardized questionnaire in Greece. And also the relationship between musculoskeletal disorders and work related risk factors are investigated. One criterion of the questionnaire for dentists is that the dentists should have at least one year experience. 490 dentists are selected randomly at which 430 of them responded. Job history, individual characteristic (age, anthropometry, gender, family situation, education level, duration of employment, and previous job history), physical and psychosocial risk factors at work (repetitive movements, awkward posture, static position, arm abduction, and tool vibration), general health, status, and the occurrence of musculoskeletal complaints are included in self-administrated questionnaire.

Four point scale ('seldom or never', 'now and then', 'often', and 'always') is used in questionnaire survey. Also the study is rated with Borg-scale rating system. Rating system is started with 6 (very light) till 20 (very heavy). Job demands are analyzed with 10 questions with four -pointed scale. Health status is determined by 13 questions which are related that respiratory, stomach, complaints, regular headache, and tiredness. Total sum is represented by worker's actual health situation. Need for recovery is also identified by some questions which are tiredness after work, fatigue, lack of concentration, interest to other people, recovery ability, and influence of work performance. Different end points are determined as musculoskeletal complaints in back, neck, shoulder or hand/wrist in the past 12 months, chronic complaints during at least 1 month, sickness absence, and medical care seeking.

Logistic regression analysis is used to identify potential risk factors and determine individual characteristic, physical and psychosocial risk factors at work, and health status. Odds ratios are calculated to define relationship between age and gender. SPSS

is used for data analysis. At the end of their study, hand/wrist complaints are the most important factors. Chronic complaints (%30), spells of absence (%16), and sought medical care (%32) are reported. Physical load is associated back, shoulder, hand/wrist pain without chronic complaint and sickness absence in hand/wrist region. Shoulder pain is affected by educational level and working without breaks. Age and gender is significant only for neck pain. Researches reveal the increasing of absenteeism due to the shoulder pain which is also related to living alone.

Patel et al., (2012) discussed the relationship between pain and dental work among dentists in Surat. The Local Indian Dental Association (IDA) has 600 dentists. 160 of them participated in the study. Data are investigated by Epi Info (2002) Software with 95% CI, $p<0.05$. 154 dentists are selected randomly for cross sectional survey. For their study investigation; 63.6% of dentists have at least one discomfort such as neck or back or shoulder or combination of them. In pre-coded questionnaire consist of gender, age, weight, seniority, and pain existence. 75.5% back, 42.9% neck, and 22.5% shoulder pain were observed. Wrist and leg disorders are also investigated from another similar study. Interestingly, pain rate is increased when people start this profession. According to another study, 47 dentists out of 49 had got pain after entering this profession. When we mentioned aggravate pain, prolonged sitting position can cause this pain (95.9%). The study determines three types of category which is associated with pain. 42 dentists did not demand to change posture while treating (mild category), 44 dentists changed their posture (moderate category), 14 dentists compelled to take rest in between (severe pain).

At the end of the study, some notations are found statistically. The correct posture, break for few minutes, muscle relation exercises, analgesic drugs, and complete rest

for a day can help to relieve their pain. These notations are demonstrated by another study statistically. Their study presumes that dentists should not ignore their pain because this is the very first step to get rid of the pain. In addition, when dentists are educating, correct posture should be taught as an education for decreasing discomfort. Regular exercise and physiotherapy are found helpful for dentists' health.

In their study, Moen and Bjorvatn (1996) investigated musculoskeletal symptoms among dentists in a dental school in order to make improvements to their work environment. The study choses dentists in dental school because they have same type of working, fewer patients, and more variation in their work unlike the other dentists who are not working in dental school. Cross-sectional study is performed in Norwegian University and consists of dentists, office workers, and dental auxiliaries (dental technicians, technical staff). Office workers and dental auxiliaries are selected as reference group. They have no direct contact with patients. 139 dentists answered to the questionnaires. Age, sex, type of work, environment period and occurrence of symptoms (neck/head/shoulder/wrist/back) are included in their study. Regarding statistical analysis X^2 test is used to make a comparison between groups. After that Fisher's exact test is used. Odds ratio is calculated with %95 CI to determine frequency of positive answers in dentist group for female and male dentists and Stepwise Logistic Regression analysis is used to define relationship between occurrence of symptoms and age, sex and employment.

As a result of X^2 test, there was no significant difference between age and employment period for dentists and reference group. But regarding sex, there was a significant difference between dentists and reference group. So, logistic regression analysis is performed for each symptom. Sex and occurrence of symptoms from

head/neck/shoulder/arm are associated to female more than male. Pain recorded in head region in female dentists is more than male. Result of Logistic regression analysis, age, occurrence of symptoms and employment period did not show variable which is significant.

In conclusion, there were some differences in female and male dentists and references group same as previous studies. These differences may be related to headache, neck and shoulder pain. Consequently, there were no high frequently musculoskeletal disorders for dentists who work in dental school. Because low number of patient, various work task are existed. Nevertheless, female dentists have more discomfort from the neck region than male dentists.

In their study, Pargali and Jowkar (2012) focused on correlation with neck, lower back pain and risk factors. With using sampling method 90 dentists are randomly selected in order to ask to complete self-administrated questionnaire. Age, gender, seniority, job history, any disorder report about neck and lower back region, physical risk factors, duration of work time, dentist's chair, working posture during treating with patient, and work tasks are included in questionnaire survey. In one part just related with neck and lower back region which are categorized as "sudden rotation of cervical or lumbar spine", "direct trauma to the neck, back or head", "carrying heavy objects", and "unknown factors". Also pain frequency is categorized. Ten point visual analog pain scales is categorized by mild, moderate, and severe that is calculated to obtain severity of pain. Also in their study, they asked to receive any treatments to participants such as physiotherapy, drugs, no treatment and exercise. SPSS is used to analyze data and X^2 test or Fisher exact test are applied to compare frequency.

As a result of questionnaire study, 82 dentists are answered to the study. 66 dentists had pain after begun profession. 59 dentists had more pain during work. Lower back pain is shown in 27 dentists, 23 dentists had neck pain, and 10 dentists had both disorders. So far, some dentists' pains are associated to awkward and wrong movements according to questionnaire. None of risk factors had any value which is shown significance effect on musculoskeletal disorders. According to the study, majority dentists are not performing any exercise to prevent musculoskeletal disorders. %19 dentists got rid of their pain with physiotherapy. Gender did not make a difference for musculoskeletal disorders. Their study could not find any relationship between work- related risk factors and musculoskeletal disorders.

Pedro et al., (2011) determined the prevalence of dentists in Brazil who are at higher risk than the general population and other occupational categories among Brazilian dentists, doctors, lawyers, and the general population. Morbidity information is taken from National Household survey/ 2003. Information is included in demographic, housing, educational, income, and work-related data. Main characteristic of their study is based on gender, age, income, and their education level. Age is investigated in two parts (20-39, 40-59). 287 dentists, 517 physician, and 688 lawyers are investigated. Lawyers are selected as reference group. When they are compared, health status of each group, general health perception is considered in two parts as very good, good, regular, bad, and very bad. Also sickness in 2 weeks is also asked and they want to know that if occupational activities interrupted due to their health problems.

These three subdivisions are investigated in dentists, physicians, lawyers and general population. As a result, back pain is reported significantly more for dentists in comparison with physicians and lawyers. Interestingly there was no significant

difference in back pain statistically but there was slightly difference among dentists and general population when they are compared according to self-reported information. Arthritis and tendinitis are shown more among dentists than physicians and lawyers. Back pain is more in male dentists than female dentists when they are compared with physicians and lawyers according to stratified analysis. Arthritis is 3 times higher in male dentists than among female dentist when compared with physicians. And also arthritis is highly more in male dentists than female dentists comparing with lawyers. Besides, tendinitis is alike in each group with respect to gender. The study suggests that all professions should be aware of own health status. For male dentists, back pain and arthritis are risk factor.

Tzu-Hsien et al., (2012) examined risk factors for musculoskeletal disorders among dentists in Taiwan. Risk factors are evaluated for all body segments. Their study focuses on investigation of musculoskeletal disorders to evaluate risk factors in 9 body segments among Taiwan dentists. Questionnaire is applied in 197 dentists with Nordic musculoskeletal questionnaire body parts are divided by 9 parts (neck, shoulders, upper back, lower back, elbow, wrists/hands, hip/thighs/buttocks, knees, and ankles/feet) as an anatomical diagram and information such as gender, age, seniority, working conditions, work task durations, number of dental assistants, duration of being in a bent position, and using hand pieces included.

There were three professional groups; Association of oral and maxillofacial surgeons (AOMS), the association of Family Dentistry (AFD), and Taichung County Dental Association (TCDA) for evaluating Nordic musculoskeletal Questionnaire. Microsoft excel is used for database design. Data is analyzed using SPSS version 13.0 Software. Various risk factors are compared with Chi-square test. As a result of questionnaire

survey; BMI is calculated according to height and weight information. 59 of dentists work in a specialty, almost half of them using one assistant, the other half part use two dental assistances. Most common disorders were shoulder pain (75.1%), follows neck pain (71.6%), and lower back pain (66.5%).

In 9 body parts, dentists rated their disorders according to segment. “0” means that there is no pain in any segment, “9” means that musculoskeletal disorders are shown in each body segment. As a result of the study, 10 minutes is found an important factor. For example, if dentist is forward bending more than 10 minutes while treating one patient it causes musculoskeletal disorders. Giving breaks each 10 minutes suggested to dentists based on one study result. Nevertheless it never happened by dentists. Also the study compares their disorder prevalence with other countries. Multiple comparisons show that for each common disorder, Taiwan dentists are also at high risk. The study purposes, there should be practical and effective modifications to prevent musculoskeletal disorders among dentists.

Frieda et al., (2005) intended to collect all data which is related to occupational health effects among Flemish dentists. Statistical analyses performed by Statistica 5.1. Hearing test group is consisted of 13 dental students who performed in 1993. And they are performed again in 2008 for new test. Left ear and right ear are compared by Wilcoxon matched pain test. For sensory test 10 female and 10 male are selected randomly. These dentists are divided in 4 groups with respect to their practice years. And two point discrimination test, thermal sensory test and light-touch test are applied for both hands in each group. Questionnaire survey is used in 388 participants. %55.7 of them male and the rest is female. General age rate is between the ranges of 40-49.

Low back pain, orthopedic disorders, vision problems, occupational infections, allergies, diminished sensitivity of the fingers and auditory disorders are reported disorders among dentists. According to comparison of same group in different years, in left side, greater hearing loss investigated among right handed dentists. Result of sensory test of the fingertips, tendency is observed in two point discrimination ability with the number of years. As a result, low back pain and vision loss reported. Working environment stress level is calculated 7 point on the range between 0-10. Further studies should define relationship between various health effects and practice of dentistry.

Külcü et al., (2010) assessed the frequency of neck and low back pain in dentistry. Second aim is to investigate risk factors which cause neck and low back pain among dentists, students and nurses in dentistry. 206 participants (dentist %27, student %23 and nurse %13) are selected randomly for cross sectional study. Data are collected by special questionnaire. General information such as age, gender, height, weight, marital status, years at work, physical exercise, and cigarette smoking are included. Also there were another questions which is related to work positions and on duration. These questions are scored by Likert Scale with 5 points.

Neck pain disability index (NPD) consist of 10 parts, 7 of them interest in daily activities, 2 parts related to pain and 1 parts with concentration problems. Each part is scored range between 0-5. 5 mean that higher degree of disability. Roland-Morris lower back pain questionnaire (RMQ) consists of 24 questions. High scores show the high degree of disability. Visual analogue scale VAS (0-10) is evaluated neck pain disability index (NPD), Roland-Morris lower back pain questionnaire (RMQ). Working conditions and assessed parameters relationships are investigated by

Spearman correlation coefficient. Different age groups (below and above the age of 25) are evaluated by Student t test, Mann white, and chi-square tests. Lastly, differences between specialization groups are determined by Kruskal-Wallis variance test and chi-square tests.

As a result, there is a significant different between working hour in week and prevalence low back pain when walking and standing. Low back pain and neck pain are found during treating for all positions. Also there is no significant different among specialization. Neck pain disability index was higher in young dentists than older dentists. Consequently, working hour and position are important factors on neck and low back pains among dentists. Sitting position is more favorable than standing while working. Training is an effective way to reduce risk factors in dentistry.

Abdulwahab, (2010) assessed the work-related complaints in neck, shoulder, and back regions, also to determine risk factors which are associated with complaints. 139 participants (78 male, 58 female) are included in cross-sectional study. Questionnaire is modified thanks to previous studies which are consisted such as gender, age, type of dentistry, frequent breaks, right posture, complaints (neck, shoulder, and back pain), analgesic-use, exercise, seniority, field of dental practice, and number of hours worked per day and per week. And also questionnaire is separated due to their work situation such as working in public and private hospitals, and private clinics.

Lastly, questionnaire included correct posture image and explanations of correct posture for each subject while treating which are shown like fill in the blank and multiple choice styles. Dentists should have 2 years of experience in their own profession to be selected for survey. SPSS and Microsoft excel software are used to

analyze data. X^2 test is applied to find differences between discrete data. Mann-Whitney and U test (non-parametric test) is used to determine continuous variables. 116 dentists had frequent breaks while working, 20 of them did not. 100 dentists thought that their posture is correct during work, 36 of them did not. 108 dentists had back pain experience in past 12 months.

This pain is distributed as mild, moderate and severe pains. 80 dentists had neck pain experience during the last one year same as back pain.10 dentists had sought treatment for shoulder and neck pain. 50 dentists used medicine to prevent pain. 70 of dentists did exercise regularly 51 of them did not. But there is no significant difference between working days loss and the number of days of back, shoulder, and neck pain between males and females. As a result of the study, back pain is found the most common complaints among dentists.

Neck pain and shoulder pains are followed as mild pain level. Gender did not show any differences with considering musculoskeletal disorders. Specific exercises are not performed by dentists. Strengthening exercises may support back, forearms, neck, and wrist and hand region. Study presumes that regular exercises make dentists strong and healthy.

Zoidaki et al., (2013) found relationship between work and psychological risk factors and personnel characteristic among dentists who work in Greater Athens area. They have some musculoskeletal disorders which are combined with repetitive movements, and psychosocial load (working under time pressure, monotonous work, fast working pace, and lack of recovery) factors. Cross sectional method and self-administrated questionnaire are used to provide some results.

Personnel characteristic (age, gender, BMI, waist perimeter), employment history, dental equipment, personnel habits, job habits (shape and diameter of periodontal instruments, endodontic instruments, assistant, chair, work position, working breaks, using mirror), perception of psychosocial demands, physical job demands (repetitive/ monotonous movements, strenuous work postures, prolonged sitting and standing, arm abduction, force demands, exposure to vibration), general health status, need for recovery, effected body region and frequency of musculoskeletal disorders are included in survey which are asked 80 dentists (41 female, 39 male) with %40 respond rate. Evaluating physical job demands 4 point scale used (seldom/never, sometime, often, and always).

General health status is observed with 8 questions. And observation of the workers needed recovery is based on 11 questions. Nordic standardized questionnaire is used and identified some relations such as; if dentist have musculoskeletal disorders in one year prevalence, it continued every day and lasted time was at least one month. In addition that complaint forced to dentists at least 1 day off work and they needed seek medical care. In one week prevalence it continued for at least few hours. According to results, at least one musculoskeletal disorder is observed in %83 dentists at one year prevalence. %54 dentists reported monotonous/repetitive movements and strenuous back postures are seen in %70 dentists. Also %38 dentists needed medical help for discomforts of the cervical/shoulder and back region.

Chronic pain in the cervical region is related to oral cavity. Hand-senso-neural disorders are increased by dental assistant absence and use manual handled endodontic instruments. Shoulder region is affected by free time activities. When compare with smokers and non-smokers, at the end of day smokers needed more recovery rather than

non-smokers. As a result of their study, gender did not make any difference. %62.5 dentists used ergonomic chair with back support. Sitting position was more preferable for young dentists than older dentists. Four handed dentistry was low. Weekly working hours are greater for male dentists than female dentists for over 40 hours. Nevertheless, women worked for less than 30 hours/week compared men. When dentists performed root-canal with their hands, hand-senso-neural disorders was shown 3.4 times significantly higher than motor endodontic instruments. Chronic cervical pain is related to age and job years. Age is also associated with reporting musculoskeletal disorders in hand/wrists. Hand disorders are 8 times greater for female dentists rather than male dentists. Result of logistic regression models, %26.2 45 years old female dentist had wrist/hand pain. Carpal tunnel syndrome is more observed in female dentists than male dentists. In shoulder region pain is observed 4 times higher dentists who spent spare time being passive instead of spent their time being active. If dentists want to get rid of these disorders, they should modify their personnel habits and take training to learn correct posture while treating.

Mostamand et al., (2013) discussed some alteration about head posture before dentists didn't have any suffer. 41 (21 women 20 men) dentists are consisted of survey. They worked in private dental clinics in Isfahan. There were some criteria such as they should not have any neck trouble or trauma during last 6 months, more than 40 and less than 30 years old dentists are excluded in survey, and they should have more than 5 years less than 15 years' work experience. Present study used to control group which is consisted of tailoring, hair dressing, and typing or any job performed in a same way with dentists. Criteria are valid for control group.

Main hypothesis was that the cervical curve should be different between two groups. Second hypothesis was that the cervical curve should be equal between male and female dentists. Also the practice experience years (5-8, 8-12) should make significant difference in dentists group. For data analyzing SPSS is used. Finding statistically differences between two groups, independent sample t-test is used. Pearson correlation test is applied to detect relationship between cervical curve and quantitative variables (age, weight, and height). According to results, there were no significantly differences between both groups and also cervical curve of dentists and control groups. Conversely, there was significantly difference between cervical curve and gender. Male dentist's curve was greater than female dentists. Nevertheless, in control groups there was no significant difference between gender and cervical curve. Also practice years and cervical curve did not make any difference in dentists group. Lastly, there was difference between cervical curve and the height of dentists. There was direct proportion.

Linear regression model and least squares method are used to assess difference of height between men and women working as dentists. Same approaches did not apply for control group because of there was no any difference. As a result of the study, there were no differences between dentists and control groups due to cervical curve. The head posture alteration was not sufficient enough to generate pain sensations among dentists.

Newell and Kumar (2004) tried to reduce musculoskeletal disorders with making intervention ergonomically among orthodontists. 5 studies surveying are summarized in their study which is related with reports of musculoskeletal disorders among general dentists and orthodontists. The study results are compared by previous studies results.

Correlations are found by previous studies such as job demands between orthodontist and general dentists. For example general dentists should work deep inside in patient's mouth, but orthodontist just concerns about teeth surface. Because of this reason, general dentists have more musculoskeletal disorders rather than orthodontist.

32 orthodontists (23 male, 9 female) included in questionnaire survey. Attended orthodontists have same homogeneous characteristics (education level, social and economic status). Self-administrative questionnaire consisted of demographic details (age, height, weight, seniority, weekly job duration, sitting duration, and hand dominance). Nordic standardized questionnaire used to measure prevalence of musculoskeletal disorders. Excel database is used to entering all data. For finding any difference between categorical variables, X^2 test is performed. Paired t-test is used to define correlations between gender and body segments. SPSS is also performed to statistical data calculation.

As a result of the study, occurrence of symptoms in 12 months is calculated statistically for each body segment. Low back, neck, and shoulder are found significantly more than the other body parts. Gender does not make any difference. In Nordic questionnaire, low back, neck and shoulder regions are investigated by some questions such as ever had low back trouble, low back related accident, changed jobs due to trouble, total numbers of days having low back trouble in the last 12 months and trouble in the last 12 months. Trouble reduced work activity, trouble reduced leisure activity, total number of days of work prevented, sought professional treatment, and trouble in the last 7 days are subheads which are examined in trouble in the last 12 months.

Consequently, high prevalence of musculoskeletal disorders is shown in low back, neck and shoulder regions among orthodontists. Their study recommendation is awareness of risk factors, education, redesigning, correct posture and ergonomic interventions are important in order to reduce musculoskeletal disorders among orthodontists.

Dong et al., (2006) compared pinch force while scaling among dental students and experienced dentists. There are two types of jobs (periodontal scaling and root-planning) which are led to increasing CTS among professions. These jobs require high pinch force. For researches, selected dentists should have at least 2 years of experience in dental scaling also the dental students should have less than 2 years of experience. Scaling is performed in patients from the same clinics in San Francisco. Special designed instruments are provided during scaling.

For measuring thump pinch force, designed pressure sensor is attached to surface of instrument. 6-axis load cell is used to measure the forces and moments at the tip of the instruments. Gracey number 11 curette tips are used for scaling. Scaling is performed in 8 different areas in surface of teeth. Force is converted with the load cell and pressure sensor data. Fz represents pull and push a force, Fp represents pinch force. Ft is calculated by geometric sum of two moments in order to estimate the force applied perpendicular to the tooth surface during scaling. 10 seconds window is randomly selected to calculate Fz, Fp, and Ft and define the history for each tooth with amplitude probability distribution functions. SAS is performed for statistical analysis. RMANOVA is used to find alterations of gender, experience, and tooth is on the summary force measures.

Tukey test is investigated differences. Pinch force and instrument tip is analyzed with linear regression methods. As a result of their study 12 dental providers (6 dentists, 6 senior- year dental students) and 12 patients are recruited to the study. Gender did not made any differences between force measures according to RMANOVA results. Experience is not made significant effect on median and peak pinch force. Also gender is made significant difference between experiences. Tooth area and gender had some interactions according to research. In the study thump pinch force is investigated in peak, median, and static. Also force along and force perpendicular to the long axis of the instrument at the instrument tips are investigated among students and dentists. Comparing of dentists and dental students, dental students applied more force than dentist during scaling. Although, dentists applied high median force according to instrument tips. Dental students and dental hygiene students should know how to use instruments correctly. Training programs may be useful to be effective during work.

Payal et al., (2013) found prevalence of low back pain, neck pain, and wrist pain among dentists practicing in Madhya Pradesh, India. And identify relationship between symptoms and working conditions as a second aim. 250 out of 4000 general practitioners and specialists are selected according to meet the inclusion criteria. This criteria was about who has Indian citizenship with at least 1 year of work experience. Also few dentists are excluded who had low back pain, neck or wrist pain before joining dentistry or had trauma and disease. 213 participants returned the questionnaire survey. Special questionnaire which is consist of age, gender, height, body weight, marital status, years at work, physical exercise, specialty, any systemic disease.

Working positions (sitting or standing while working) and durations (the frequency of breaks per day, and break durations, the weekly morning hours and number of patients

seen daily) are considered in survey. In addition that working conditions and tendencies (work with/without assistance, direct/indirect oral cavity vision, process of viewing through mirror, wrong posture while treating) and painful conditions (low back pain, neck pain, and/or wrist pain) are investigated in one year prevalence. Lastly 5 other questions are existed which are related to measures undertaken regarding the painful condition such as consulted with specialist/general physician/physiotherapist. 30 participants are included in pilot study. The survey's understandability is checked by 3 experienced dentists. X^2 test is used to compare different groups of experimental parameters such as gender, age- groups, working conditions. SPSS and MSTAT-C software are used for statistical analysis. 83.10% had at least one musculoskeletal disorder in one year prevalence. 57.75% dentists had low back pain which is shown most frequently followed by neck pain (31.17%) and wrist pain (17.84%).

There is slightly difference in low back pain between male and female dentist. This disorder is shown in female (65.29%) and male (51.69%). The study consisted of 41.31% specialists and 58.69% general practitioners. When comparing two groups there was no significant difference in musculoskeletal pain. Participants are divided by 2 groups according to their age older than and younger than 30 years. There was no difference when comparing on this basis of age difference. 54% dentists are worked with direct vision. According to prevalence of low back pain and neck pain are highly shown among group who prefer to work with direct vision. Musculoskeletal complaints are greatly present among dentists who work without any break between jobs. 54% dentists are followed some exercises for low back relaxation.

Remain dentists who did not follow any exercises low back pain is shown highly. 84.98% dentists are accepted to perform bending or twisting movements while

working but 61.5% of them believe that if they care their posture while working their work will hamper. Standing position is preferable for 31.92% dentists. Low back, neck and wrist pain are found significantly higher in group who prefer standing position while working.

As a result of their study, back, neck, wrist and low back pain are revealed because of some inappropriate situation in working area. The study suggests dentists should prefer sitting position while working; they should avoid prolonged awkward postures and follow some exercise such as fitness. In direct vision should practice by dentists because this is more preferable rather than direct vision. Education of dental students on ergonomics and posture is too important to reduce disorders.

Kar and Mullick, (2012) defined environmental design importance to reduce musculoskeletal disorders among dental professions. Their study also emphasizes importance of tools and technology to reduce musculoskeletal disorders among dentistry. This is a research and development project which is consisted of analysis, synthesis, and evaluation. Two types of user interviews were taking into account which consisted of during work and after work. During work interviews are explained about how dental work is performed to find possible solution or some improvements about environment problems.

After work interviews consisted of highlighted problems of the environment and also discussed during work conditions. Shadowing is a method of enquiry which is conducted in two dental offices in Atlanta. 6 participants are included the study. In order to improve environment and redesign of tools, their office investigated whether equipment and task fit or not for users. X-rays, dental scaling and polishing,

examinations, and performing surgery frequencies are taken into account. Workspaces are photographed and videotaped during and after use and separated according to posture and activity. First result is tools: there is needed to ergonomic hand tools with grips to provide neutral body posture.

Second one is seated: upper body and arm should be supported with extra material in seated position. Third one is environment: spatial design and lack of environment fit relationship is identified. According to the study there were some differences and commonalities between hygienists, assistances and dentists which are helped to design for dentist's seat, dental hand tools and dental work environment. Some specific interventions are revealed such as padded gloves help to grip hand tools easily. Environment needed to lighting, storage movement, seating, and treatment technologies.

Design reduced to hyperextension, poor posture, and excessive force application. Computer Aided Design (CAD) software is used to design concepts for seating, tools and environment. Prototypes of equipment are visually used in focus group. To investigation of all redesign environment and tools, 8 (3 dentists, 3 dental assistance, 2 dental hygienists) participants are invited to review and offer feedback. They like the padded gloved to get more grip and also extra arm support idea is found good and effective. Lastly environment changes are found good like easy access to storage. They like the arrangement of storage spaces around work zone based on user requirements and feedbacks.

Full scale model is consisted of more accurate dimensioning; material finish and physical usability depend on user responses as a second round. In second phase, tools

and equipment are used to redesign work environment. These tools helped to test user and take feedback such as like, dislike or improvements. Proposed design solutions are revealed. First one is related with tools' redesign regarding usability of weight and grip. Also new design padded gloves are tested in terms of effectiveness. Second one is seating in order provide elbow rest which is built with minor modifications by users. Third one is environment which is found positively by users. As a conclusion of first aspects is environment can affect health status. Second aspect is the user-centered issues can help to create good design, inspire new ideas which provide to get success of the design. The last aspect is design process which is done by studies. New design can prevent long term health problems.

Palliser et al., (2005) defined prevalence of musculoskeletal disorders and psychological distress among New Zealand dentists. 524 out of 1562 participant are selected and questionnaire is sent. Musculoskeletal symptom questionnaire (MSQ) is used to evaluate symptoms on body segments in one year and one week prevalence. General work stressors are described in National Institutes of Occupational Safety and Health (NIOSH) is considered in survey. Questionnaire consisted of 5 areas which are; perceived control, intragroup conflict, mental demands, responsibility for people, and job requirements. Likert scale is use to evaluate discomforts among participants. Work related stressors are investigated which are time related, job related, income related, staff and technical related, and patient related stressors. At the end of Likert scale all scores are summed up.

Likert scale had three type of level; high, medium, and low. Demographic variables are also investigated. Data entered into a computer the analyzed with SPSS. Stressors and health outcome are compared with using X^2 test as statistical analysis. Also the

study received ethical approval from the Otago Ethics Committee. Firstly their study invited 524 participants, 19 of them retired, 80 of them declined and 12 dentists did not answer to the questionnaire survey. Remaining was 413 dentists the study answered from 82% (74% male, 25% female) of dentists. Taken sample is not significantly different from New Zealand dentists in terms of age, gender, and ethnicity. 248 of them used assistance while working. 249 dentists cared about recommended position while treating. Fully adjustable stool is used by 139 dentists. A sample working year was less than 20 years. For identifying affected areas, 9 body segments are defined to evaluate symptoms in one year prevalence.

Neck, lower back, shoulders, and wrists/hands are found the most common disorders. Lower back pain prevented normal activities. Symptoms are shown in 4 body segments among 218 of dentists in one year prevalence. For previous week, 220 dentists had experienced symptoms in 4 body segments. Dentists are rated each general work related stressor on the NIOSH instrument which are perceived control (283), ıntragroup (19), mental demands (374), responsibility for people (196), job requirements (25). For identifying specific work related stressors rank system is used. Patient having a medical emergency in surgery is ranked as highest from 322 dentists.

Younger dentists are suffered more than older ones regarding musculoskeletal disorders. According to dentists, mental demands selected as the highest general work-related stressor. Psychological disturbance is demonstrated with high scores for dentistry specific work related stressors. As a conclusion, to prevent disorders, occupational stressors psychological disturbance and musculoskeletal discomfort should be considered.

2.4.2 Dental Hygienists

Åkesson et al., (2012) revealed greatly difference between dominant and non-dominant hand. Dominant hand tasks are required for motor coordination, holding air spray, suction and mirror. Non-dominant hand is using for getting good view of operation like assistance. All tasks exposed static loads of pinch grip with different demand. Aim of their study to determine physical workload and compare the exposure to some other occupational female groups with same methods. 12 right handed female dental hygienists selected randomly from 6 different dental offices. Standardized Nordic musculoskeletal questionnaire used in order to determine musculoskeletal disorders among 51 female dental hygienists. Results of questionnaire survey, disorders are seen in neck (82%), shoulders (73%) and wrists/hands (51%) region for the one year prevalence.

Dominant hand is more affected than the non-dominant hand on the other hand shoulder symptoms are found bilaterally. Dental hygienists worked in a chair side position in order to reach perfect visual while working. When periodontal and prophylactic tasks are performed by hygienists, physical work load in neck and upper limbs are recorded continuously as well as coffee and lunch time are included in records. Dental hygienists' works are commonly: using power tools such as ultrasonic devices, scaling, polishing, and auxiliary tasks. All records are investigated by ANCII-file to separate work and breaks also separate analysis of the work into three tasks. EMG is used to record upper trapezius and extensor muscles of the forearms in order to normalize muscular activity. Muscular load is determined as static, median and peak.

For recording flexion/extension and lateral flexion of the head and elevation of the upper arms are measured by triaxial accelerometers. Reference position of the head is defined as when subject was standing positioned. Also reference position of the upper arm is identified when subject seated. The 1st, 50th and 90th percentiles are presented. 1st percentile is used for determine backward position. If angle is 1st so, there was extension. For lateral flexion 10th and 90th percentiles are represented as extreme positions. Biaxial electrogoniometers are used to calculate wrists angles. Extended, median and flexed positions are presented 10th, 50th, and 90th respectively.

Wilcoxon matched-pairs signed rank test are performed in order to make comparison between work and breaks also between three work tasks. As a result of muscular load is investigated in 12 female dentists. Trapezius muscular rest is found statistically significant for each 10th, 50th and 90th percentile. The higher loads are shown in manual scaling and machinery on the trapezius muscles. Head flexion and lower head and upper arm velocities are found. Neck and shoulder region are affected by more prolonged and stable positions such as manual scaling and machinery dental tasks. If they use ultrasonic scaler their load of right forearm extensor muscles can be reduced.

However there was no significant effect on 10th percentile load of muscular rest. When comparing manual scaling and machinery, forearm extensor muscles are more affected with manual scaling for the 50th and 90th percentile. And also in 50th percentile, manual scaling and machinery showed higher load than auxiliary tasks. Manual scaling on average for the 10th, 50th, and 90th percentiles showed 1.4 higher loads of right side trapezius muscles than left side. For right forearm extensor muscles on 50th percentiles, on average three work tasks are measured 1.6 times more load than left side. For the 10th percentile machinery and manual scaling had 1.8 times more load.

As a result of wrist region, statistically difference found between work and breaks. Right wrist movements were twice during work than breaks. When performing right wrist machinery, lower velocity is recorded rather than auxiliary and scaling tasks. There were no variables regarding right and left wrists which are shown statistically significant. Some results have emerged with their study such as; ultrasonic devices can reduce the right forearm extensor muscle load. Interventions should be evaluated for reducing physical workload and musculoskeletal disorders.

Melanie et al., (2013) revealed musculoskeletal disorders among Australian dental hygienists. At the beginning of the study, participant information (work habits and musculoskeletal disorders) are received by hygienists. And self-reporting survey is included 54 questions which is associated with Nordic Standardized Questionnaire. In the questions, social habits, qualifications and education, work habits and musculoskeletal symptoms are included. Body segments are divided by 11 parts with aid of diagram to identify disorders clearly when participant give information about any experienced musculoskeletal symptoms.

Logistic regression analysis is used to define relationship between body regions and pain. The study is performed with 560 dental hygienists. Some of them are tobacco users, half participants are drink alcohol regularly. Some relationships are found such as; neck musculoskeletal disorders are more likely in shoulder disorder and lower back disorders. Also shoulder pain is associated to lower back disorders. Cross-sectional study is used to reveal musculoskeletal disorders among dental hygienists. Interestingly not only work related tasks are risk factor for musculoskeletal disorders among dental hygienists also home life, psychosocial factors can affect negatively to their disorders. Musculoskeletal disorders' result may need the reducing of work hours

or leaving the profession. Dental hygienists should pay more attention to pain, because it affects daily life.

2.4.3 Dental Students

Linda et al., (2008) investigated the relationship between musculoskeletal symptoms and tasks. Potential risk factors are determined as static posture, repetitive and forceful movements. This cause is defined multifactor by the World Health Organization (WHO). In order to apply the study, 4 dental schools are chosen which have the same clinic work environment and workload. The chosen universities are not provided with the assistance of dental students. Their study compares the second, third and fourth year of dental students. 670 responses are obtained and %12 had discomfort experiences or exist illness previously therefore these dental students are not included in questionnaire which consists of 360 male, 230 female students. 212, 201, and 177 are taken from second, third, and fourth year, respectively.

Nordic standardized questionnaire is used with single and multiple choice questions then the questionnaire's reliability is checked. To give information about dental work environment, their working area and working system should be considered for investigation. Their study is analyzed in two parts, phase 1-2. First one is related to investigate with the work related musculoskeletal symptoms in three groups (second, third and fourth year of dental students). Phase 2 includes the third and fourth year dental students because they are interested in real patient. All observed data is analyzed by SPSS and Chi-square method. According to survey of phase 1, % 61 of dental students have discomforts related to work which are neck, shoulder, back and hand. There is a significant difference according to age group which is less than 29 years of age and equal or greater than 29 years age.

Considering the researches, the third year has higher pain in neck, shoulder and lower back comparing to the second and fourth year dental students. Regarding to phase 2, %78 dental students have discomfort which is related with equipment utilization (dental stool, intra-oral lighting and patient treatment chair), work efficiency and general health (experienced discomfort such as headache, eyestrain and unusual fatigue).

The study purposed that, the working environment should be redesigned for dentist's health. Because % 94 of third and fourth year students used rear delivery system and they have a discomfort also % 47 of students sometimes/never reach hand piece tools because of their locations. Their study also suggests four-handed dentistry (working with own assistance). It can decrease stress, fatigue and may also increase productivity and working age.

Khan and Chew, (2013) determined of the prevalence WMSD among dental students in their clinical and non-clinical years. Second aim is to find relationship between WMSD and work characteristic on clinical dental students. 5 Malaysian dental schools included to their study. Control group consisted of first and second year of dental students. Questionnaire is given to three dental lecturers for getting feedback and making modification to questionnaire. Pilot is tested in two phases. In first phase; questionnaire study modified according to panel comments and feedbacks which is done with 4 dentists. In second phase; group consisted of 15 dental students, 9 of them reported lower back discomfort, and 7 and 6 students reported neck discomfort and hand/fingers pain, respectively. 3 students reported lower shoulder pain and 4 of them reported forearms discomfort. Lastly elbow discomfort is shown in 1 student.

Questionnaire study formed in 4 sections such as demographic characteristic (gender, type of university, ethnicity, and right or left handedness), working environment and practicing characteristic (sitting position, instrument handling, using dental mirror, and frequency of working hours), taught ergonomic, and complaints. Data are entered and analyzed in SPSS. Chi-square test and binary logistic regression are used to assess relationship between variables. As a result of their study; 410 and 158 clinical year students and non-clinical year students included, respectively. Clinical year students and non-clinical year students compared between each other and there was significantly difference which is concerned with WMSD in body parts. According to clinical students %72 female and %20 male dentists had symptoms at least one region of body.

As a result of chi square test, female dentists have more WMSD than male dentists. To identify the risk of common work tasks, chi square and logistic regression analyze test were used. When investigate the work environment; reaching for instruments without strenuous movements, forceful movements to perform task, bending and twisting of the neck are considered to reported musculoskeletal disorders due to 4 common work tasks. For sitting positions, there was no significantly difference between lower back pain and height of the chair. Nevertheless, lower back pain and using comfortable work stool with back support are associated by each other. %78 students said that stool was comfortable during work. %34, %9, %43, and %14 of them reported “often”, “very often”, “seldom”, and “never” for using back support while sitting, respectively.

Instrument handling is divided by 4 parts such as forceful movements, work being done with arms above shoulder height, strenuous movements, and 4 handed dentistry.

There were significantly differences between work done in clinics with arms above shoulder height and lower shoulder& forearms. Also forceful movements are associated with discomfort of lower shoulder and forearms. Significant association between neck and upper back discomforts and bending and twisting movements is found by statistical analysis. Hand and finger discomfort are evaluated by Hosmer-Lemeshow goodness fit test.

Working hours may increase finger and hand disorders. At the end of the study, 6 questions are asked which is related to teach ergonomic. According to their study, neck and lower back are at risk factor. The study suggests that before starting treatment students should do relaxation movements for their arm, also support the lumbar region and elbow.

In their study, Yousef and Al-Zain, (2009) conducted to determine dental students' position while they practiced in King Abdulaziz University. According to 6 year undergraduate program, first 2 years are related to basic science subjects. In the third year, operative dentistry is starting with practicing plastic teeth in order to provide training for students. Dental students' practice includes some tasks such as operative, periodontal, endodontic, pedodontic and prosthetic on the following years.

In their last year they can treat completely in Comprehensive Care Clinic sessions (CCC). Questionnaire study included 295 (176 females, 119 males) dental students from third year through the sixth year. Data collected randomly and over three-week period. Students are observed one time. There is no assistance in university. Survey based on 67 (28 males, 39 females) of third year students, 60 (30 males, 30 females) from fourth year, 91 (36 males, 55 females) from fifth year, and 77 (25 males, 52

females) of sixth year students. Third year students' postures are observed while they were practicing with plastic teeth.

The postures of 4th year students are taken during operative clinical sessions. In this year they were practicing with patients once per week. Fifth year students' postures are observed when they are operating endodontic and fixed prosthesis in random manner. All work tasks are performed in their 6th year so the study also investigated their posture while treating with patients. The patients' chair position (normal, high, low, and/or in an upright position) are investigated as well as dentists' chair position with the types of normal, high and low limits.

In addition, elbow height is considered if they are in same level, above or below level. Students back position also another important factor for evaluating in order to determine their positions like straight or with bending. Also while they are working, vision was important point to whether direct vision or indirect vision. The study considered about pain history in neck and back region of dental students. As a result of the study, the participant are investigated in 4 different sessions such as operative dentistry session with 187 students, endodontic session with 85 participants, fixed prosthesis session with 17 participant, and periodontics session with 6 students.

To find relationship between gender, position and clinical year of the study Chi- square test is performed. Regarding patients' chair position is statistically analyzed for each year to reveal the positioning. %43 and %33 of them placed patients' chair within normal limits and higher than the normal level, respectively. There was a significantly difference related with positioning and gender. In 4th and 5th year female dental students highly positioned within normal limits than 3rd and 6th years. In 4th year, the

number of male students who placed patients' chair within low position was significantly higher than year 3rd, 4th and 5th. In year 6th few numbers of male students positioned patients' chairs with upright position.

Significant difference is found between clinical year of the study and patients' chair positioning. When comparing 4th between 3rd, 5th and 6th years of students, 4th year of students showed significant difference rather than others in pooling task. According to students' chair level, %85.4 of students used their chairs with normal levels. %8.1 used with higher than normal level, and %6.4 used with lower than normal level. There was significantly difference between students' chair adjustment and gender. Also gender is showed differences. Most of 4th year female dental students adjusted their chairs within normal levels, most of males adjusted lower than normal levels.

In addition to clinical year and students' chair adjustment are showed difference. Regarding students' elbow level significant differences found between males and females. For example, in 4th and 6th year students, gender and elbow positions are showed difference. Also clinical year and elbow position are associated each other. %33 of their elbows was below the level of quadrant treated and %11.2 of students' elbow was below the level of the tooth. Gender and back positions did not make any difference but almost %50 students bent their backs while practicing. When compared 5th and 6th with 3rd and 4th year students, significantly differences are shown. Dentistry is using direct and indirect visions. In their study students approach the operative field using direct vision (%74.6) and indirect vision (25.4). While performing operation %50 of students approached maxillary arch directly however 3 male students used magnifiers. After working hour, students especially female dentists suffered from neck or back pain region. As a conclusion, the study suggests that dental

students always be aware of their postures and also they should correct and evaluate themselves while performing clinical tasks.

Madaan and Chaudhari, (2012) defined musculoskeletal disorders and relationship risk factors between musculoskeletal pain among the dental students of 3rd, 4th year and interns, at the MGM Dental College, Navi Mumbai. Null hypothesis is musculoskeletal disorders are not showing among dental students also hypothesis is include information such as; selected students and interns should be in their 3rd and 4th year. In addition to that, there were some criteria which should be excluded from the survey such as the students who have history of hospitalization and absent on the day of survey distribution.

In questionnaire study, 230 students participated. Self-administrative and close ended questionnaire are used presence of pain, awareness regarding to correct posture, areas of the body affected by pain, clinical setting and practices to reduce pain variables are included in questionnaire survey with 10 tick-box format questions. On the other hand demographic variables are considered. Data are entered in Microsoft Excel Program (2010) software than analyzed with Chi-square (X^2) to find any significant difference between discrete data. 186 (3rd year: 65, 4th year: 64, and interns: 57) out of 230 participants recorded musculoskeletal pain while practicing. 44 participants said that they were aware of their posture. And they think they had correct posture during clinic practice.

13 participants had musculoskeletal disorders regarding vibrating instruments such as air rotor, micro motor, hand pieces or ultrasonic scaling unit. Their study also investigated dental practices which is gave maximum pain during practice according

to students' answers. Results are analyzed by Chi- square test to get relationship between dental practices and musculoskeletal pain. Maximum pain is seen hand region followed by wrists and lower back based on participants. 131 participants had varied work posture while practicing. Large number of participants (145) reported cervical flexion in order to obtain good vision while working. 58 participants were feeling comfortable when they are working.

There were 3 types of practicing positions. 169 of them selected sitting forward in the working stool, 51 participants sit in the middle and 12 participants sit backward while operating. Lastly, 12 of them are doing stretching exercises after working hours. 2 of them sought medical help because of existing musculoskeletal pain. As a conclusion, large numbers of dental professionals do not care their health situation. They continue to work with no ergonomic or unhealthy equipment. It may cause musculoskeletal pain for their future. As a result of their study risk factors which are associated to musculoskeletal disorders identified.

Risk factors are included prolonged positions, vibrating tools, performing flexion or cervical torsions, inadequate operating stools, and lack of exercises. Musculoskeletal pain is found multifactorial in origin. Their study suggests dental professions should be careful while they are working and they try to reduce some musculoskeletal disorders with using appropriate dental instruments and doing exercises for relaxation after working hours.

2.4.4 Gender Studies

Hebo et al., (2013) investigated the relationship between pinch grip strength among middle-aged female dentists. Hand grip strength is associated with anthropometric factors and also the study investigate relationship between body mass index (BMI) and

hand grip strength among overweight women dentists. Their study is observed in 295 female dentists who are aged between 45-63 years. Questionnaire is used to extract information about joint pain and hand load in free time activities. Pinch strength is measured by the Martin Vigarimeter in order to reach the realistic and valid results. By calculating the grip strength, sitting positioning is investigated in subject with back support.

Subject's hand should be positioned on table at 90 degree. They are given a ball to contract in order to obtain the highest reading pinch which is presented as the pinch strength. Cut off point is the lower 25th percentile which is used when the low pinch strength is calculated for both hands. Regarding to defined hand osteoarthritis (OA), radiograph are taken from participants who are blinded to the age. According to the study, common 6 tasks are identified in addition to work history information and are collected from all participants (at the ages; 25-34, 35-44, and 45-54). The aim is to obtain the working hours per week and find the highest loading tasks which are dental filling and root treatment. Also cluster analysis is done to determine the work history.

There are three types of clusters which are low, moderate and high variation. Low variation is related to the dentists who spend their time in work with doing restoration and endodontic. Moderate variation is related to the dentists who spend their time doing with prosthodontics, periodontics and surgical treatments different from the first one. Last one is defined variable work tasks. This is applied by investigating 45-54 years old female dentists.

Effectiveness of age is calculated by logistic regression models. Odds ratio is regulated for BMI which is based on measured weight and self-report height. At the end of their

study, it is obtained that more hand load increases risk of low pinch grip strength. Female dentists who had low variation work history are associated with low pinch grip strength with right hand independent age and OA symptoms. Same approach is used on left hand but there is no such a relationship for left hand.

Åkesson et al., (1999) investigated the musculoskeletal disorders for 5 years period among dental personnel with different methods such as Nordic questionnaire, Borg's pain ratings and physical examination. Participants are consisted of 88 dental personnel (29 dentists, 29 dental assistance and 30 dental hygienists) and 27 referents (nurse). Questionnaire is focused on 5 body parts. Shoulders, neck symptom, duration of pain and leisure time activities are included in the questionnaire. Age, duration of employment and weekly working hours, body weight, height, hand dominance and smoking habits are also queried.

Borg's pain rating is used in 0-10 interval which 10 defines the presence of the strongest pain. Rating is done in 9 different body parts. Results are represented as no pain $\leq 2 <$ pain. Also Fisher's test is applied as statistical approach. According to the researches, wrist and hand symptoms are frequently shown in dentists. Ache, pain and discomforts are increased in recorded 12 months and previous 7 days. During the past 7 days, there is a significant differences between dental personnel and the referents in neck/shoulder region. Dental personnel have symptoms in shoulder/wrist/hand region over the past 12 months. Regarding to the observations, some results are obtained for all participants in each observed body parts.

The physical examination is compared with each other such as the region which is loaded with a high pain or diagnoses for whom in year 5. 3 dental personnel are

diagnosed with different status that which are not included in the statistics while work executing. In conclusion, sensitivity and specificity of present pain are detected for past 7 days and 12 months as finding and diagnose in 111 female dental personnel. According to data, sensitivity is higher in the past 12 months than the past 7 days regarding the 6 parts of body. The higher pain is experienced for elbows and hip than the other body parts for past 7 days in diagnosing part. These two methods help to identify the present musculoskeletal disorders. Presented study shows that the dental workers are exposed in a risk.

Solovieva (2006) investigated the relationship between work tasks and finger osteoarthritis (OA) because dentistry has use frequently high manual force which may led to OA in points. The study's purpose is to determine if work tasks are related to localize OA in any finger or finger has an OA because used commonly. Their study consisted of 291 middle-aged female dentists in Finland. Practitioners, specialists and private practitioners are constituted participants. For evaluating age and participant's health data are defined by radiologists with radiographs which are taken from both hands from female dentists.

Finger OA is defined by 0= no OA, 1= doubtful, 2= mild OA, 3= moderate OA, 4= severe OA. If radiograph is read 2 to 4 grade then OA is shown in finger. Questionnaire is used to reveal effector factors such as anthropometric data, occupational exposure, daily manual activities, family history, and smoking history. Also BMI (Body mass index) is calculated based on self-reported height and weight information. 6 work tasks are identified to relevant their priority.

Means of total time, hours with patient, and hours of the main work tasks per week are considered in age of 25-34, 35-44, and 45-54 years by General Linear model to find significant difference. Multivariate test is also used. Cluster analysis with K-means algorithm is used to determined work tasks during work history. This analysis investigates the relationship between age factor and 5 dental work tasks with chi-square test. 3 cluster is defined due to their task variation such as cluster 1 (high variation) is consisted of 96 dentists, cluster 2 (moderate variation) is included 64 dentists, and cluster 3 (low variation) is consisted 13 dentists.

Then Fisher' exact test is applied to compare OA for both hands. OA existence and dental work tasks relationship is observed by Logistic regression analysis with some factors like BMI, smoking habit, hand required tasks, age, seniority, years in clinical work. All analyses are performed with SPSS. There were no differences between right and left hand which is related OA. At the end of the study there is such a relationship between work tasks and OA in the joints of thumb, index, and middle finger among of female dentists.

Finger OA is increasing by low variety work tasks. Their study presumed that localized OA in finger is associated to dental work task history. They can prevent from OA in finger by avoiding monotonous works. They should prefer high variety work tasks instead of low variety work tasks.

Åkesson et al., (1997) determined potential risk factors such as muscular activity, postures and movements, of the neck, shoulder, and wrists regions among female dentists at the most common work tasks. 12 right handed dentists are selected from group of 25 dentists which is included in previous studies. Six of them had a history

of definite neck and shoulder disorders. The other six dentists had not disorder history. Age, employment time, weekly working hours, anthropometric data such as height, weight, body mass index, hand length, right forearm and upper arm length, eye height above seat, and elbow height above seat factors are considered.

Current level of symptoms in neck and upper limb region are assessed by 100mm visual analogue scale. At the end of scaling there was no difference in the average ratings for the elbow and hands in both groups. When comparing the muscular strength and mobility in head and wrist regions for both groups, weak tendency to a lower head mobility and lower wrist mobility are observed among disorders group. All dentists had assistance and dentists were in a sitting positioning while treating. The recordings are taken from general practice dentistry which is consisted of filling or tooth cavities for each patients in dentist's regular work place with same equipment and instruments.

For measuring muscle strength of shoulder muscles are taken by strain gauge force transducer for upper arm and elbow joints in standing position. Lasting time is around 3-5s. Maximal voluntary contraction was denotes the maximal force and torque. For measuring of flexor muscles of the forearm, hand grip force is measured by strain gauge force transducer while seated. Extensor muscles of the right forearm muscles are measured by same measurement while seated and with flexed elbow and forearm in semi pronated position. Visual feedback of exerted force is shown on a digital display for all the force measurements. Muscular strength is measured based on hand grip, wrist dorsiflexion, and shoulder abduction. Electromyography is used to measure muscle activity of upper trapezius muscles and flexor and extensor muscles of the right forearm.

In this case amplitude probability function is used. EMG is amplified and filtered. All signals which are taken by EMG recorded on an FM tape recorder. Noise level is determined as the minimum RMS (root mean square) value. RVE (reference voluntary EMG activity) calculated as the median RMS value during RVC (reference voluntary force). For measuring trapezius muscles MVE (maximal voluntary EMG activity) is recorded. Subject was seating and standing during RVC. Also to calculate forward and sideways bending of head Triaxial accelerometers are used. This measurement took 16mins while subject seated in a straight position with lumbar spine support for calculating maximal mobility.

To determine flexion and deviation angles of wrists biaxial electrogoniometers and data loggers are used which was taking 20min. As a result of the study, higher load for the right trapezius and left trapezius are compared between each other, after all slightly differences are found. More than %1 dentists rested, few dentists rested more than %10, and nobody rested more than %50 according to trapezius muscular rest. There was found difference between flexor and extensor based on forearm load. More than %1 dentists rested, few dentists rested more than %10, and nobody rested more than %50 according to forearm muscular rest.

Differences are found which is based on drilling and dental works in both group and left and right sides according to normalization of EMG. For head movements, motion range for sideways bending is slightly lower than for forward and backward bending. Measurements are taken during dentists work in upper or lower jaw by amplitude distribution function with different percentiles. Result of wrist positions and movements, sizeable differences found between right and left hands.

The right hand was found more dorsiflexed and more radially depend on deviation angles. Low repetitiveness, more pauses and low velocities are more shown in left hand. Consequently, when comparing the subjects with and without disorders load level of trapezius muscles did not show any difference. According to their study dentists affected by high load of trapezius muscles bilaterally. The tudy suggested that dentists should use functionally designed instruments. And they should keep the ergonomic principles while working.

2.5 Posture and Physiology of Dentists

Musculoskeletal disorders are associated to narrow work area and inflexible posture among dental professionals. Neck, back and shoulder or arm pain (81%) are the common disorders among dental operators (Nutalapati et al., 2009). Neck and upper limbs disorders demonstrated as common disorders among dentists. Musculoskeletal disorders are greatly seen because of number of potential risk factors such as constrained postures, positions close to extremes, steep forward bending of the head, repetitive movements, high static muscle and joint load, and lack of pauses. As a result of experiencing stress and repetitive activities, discomfort can be seen. Wrists and hand regions are found more common disorders among female dentists rather than males (Åkesson et al., 1997). There was a clear difference between left and right hand which is found by Hagberg and Hagberg (1989).

Forward head posture is associated by gravity, wrong posture during treating, and inappropriate postures while sitting positions (Åkesson et al., 1997). Forward head posture was one of the reasons of neck pain among dentists who exceeded 15 years. It is clinically important to get rid of neck pain when the correct posture is found for head position. Some work related factors increase neck disorders such as prolonged static

neck positions and repeated movements of neck which are demonstrated. For low back pain, symmetric body posture can cause disorders (Külcü et al., 2010).

Dentistry includes forceful movements, high degree of visual and manipulative elements. One hand was using for forceful movements and the other one was using as support and using dental mirror. Dental profession requires visual activity, lateral bending of the spine, flexion of the neck, and the shoulder and pronation of the forearms (Kar and Mullick, 2012). Early retirement may be related with musculoskeletal disorders because almost 2 out of 3 dental professionals have experience work related pain (Madaan and Chaudhari, 2012). Appropriate work area, suitable instruments, and correct posture are so important factors to reduce possible risk factors. Correct posture prevents some disorders that should be established early in the dental career while practicing. Dentists are not properly educated about correct posture and practice.

There are some specific exercises to prevent injuries such as stretching head & neck, body strengthen exercises, hand, neck, shoulder exercises and full back release which should performed by dentists in order to prevent musculoskeletal disorders (Pargali and Jowkar, 2010.).

Dentists used to consider patient's comfort since now however, nowadays, dentists have become aware of their occupational hazards.

Chapter 3

METHODOLOGY

3.1 Questionnaire

In the literature, several surveys were used to examine musculoskeletal discomfort. The Nordic Musculoskeletal Disorders Questionnaire (NMQ), designed and funded by Nordic Council of Ministers, was developed to define the musculoskeletal disorders. This questionnaire includes questions which are related to body segments to clarify musculoskeletal symptoms and defines the frequency of musculoskeletal disorders. NMQ allows the comparison of complaints such as neck, low back, shoulder, and general complaints regarding epidemiological studies (Kuorinka et al., 1987).

In order to obtain prevalence of musculoskeletal disorders, the Nordic standardized questionnaire which consists of gender, age, height, weight, hand dominance, years of practice, working hours weekly and percentage of the day spent sitting information, is collaborated as a demographic information. Regarding the categorical questions such as troubles (ache, pain, discomfort) in any body part, during the whole lifespan, during the last 12 months and during the last 7 days are also investigated in this questionnaire (Kuorinka et al., 1987).

The survey used in this thesis is uniquely prepared to investigate the disorders among dentists with the illustration of the external factors by the Borg Scale. Standardized Nordic Questionnaire (SNQ) was applied with approved questions by other articles,

which were answered by dentists to recognize symptoms in an ergonomic or occupational health context (Åkesson et al, 2012). The survey questions were reviewed and approved by Eastern Mediterranean University Ethics Council. Before distribution of questionnaire survey to dentists, a pilot study was conducted to confirm all questions' understandability for asking right questions and obtaining the correct answers.

Dentistry profession has such tasks which may lead to cause musculoskeletal disorders. Beyond the questions included in NMQ, previous syndromes and health in dentistry problems were considered. Survey has 22 multiple choice questions which ask the occurrence of disorders in neck, shoulders, upper back, wrists/hands, lower back, hip/tight, elbows and knees in past 12 months and the last 7 days among dentists. This survey is designed to identify specific areas of fatigue and pain in body segments.

The survey includes demographic variables as individual factors such as age, gender, years of practice, operating time on patient (min), and working hours per week, hand dominance, smoking and alcohol habits. Height and weight information are also considered to obtain body mass index. Working place, working conditions are also questioned to make sure about if the work place's standard also supports human health.

3.1.1 Gender

According to Thanathornwong et al., (2012) study, neck disorders have some causal relationship between gender, repetitive and forceful movements, posture, vibration, computer work and psychosocial factors. Gender is an effective factor for having musculoskeletal disorder as well as age, genetic factors etc. (Garbin et al., 2011). Statistical differences are found between ages and work-related to musculoskeletal

disorders among female students (Khan and Chew, 2013). Male dentists were reported for more back pain and discomforts than female dentists (Alexandre et al., 2011).

3.1.2 Age

In order to obtain valid results from survey, age should be taken into account because lots of risk factors can be related to age (Rabiei et al., 2012). WMSDs can be seen because of some factors such as age, body mass index (BMI), level of training, and state of knowledge in a profession (Thanathornwong et al., 2012). The prevalence of OA can be related with age, family history, and high BMI (Solovieva, et. al.,2006).

3.1.3 Height & weight

Work-related musculoskeletal disorders can be related to age, body mass index (BMI) (Thanathornwong et al., 2012). Personal characteristic information such as weight, height is needed besides other questions (Zoidaki et al., 2013). With more weight, more pressure is applied to the human skeletal structure.

3.1.4 Years of practice

In dentistry, the impact of practice years is taken into consideration. Neck pain is found due to forward head posture as an reason among dentists who have 15 years job experience or more (Mostamand et al., 2013). With the ages, there is a correct proportion between musculoskeletal pains (Alexandre et al., 2011).

3.1.5 Physical demands of dental practice

All undesired discomforts' source is related to posture while dentists treat the patient. Monotonous, repetitive movements, prolonged and static positions, forceful movement and vibration tools can be seen in dentistry in order to clarify and determine disorders source. The relationship between occurrence of musculoskeletal disorders and working positions in dentistry has been found (Moen and Bjorvatn, 1996). Also

the relationship is found between asymmetric body posture and occurrence for lower back pain (Saxena et al., 2013).

3.1.6 Working time with patient (min)

According to job stress and task demands, dentists have toughness. Each task can have different durations based on patient situation. Working time with patient information is needed for determining the expected time for prolonged, forceful, and repetitive movements which is known as resource of disorders.

3.1.7 Working hours per week

Having the musculoskeletal disorders can be related to exceed of working hours weekly. In order to determine working hours per week which could be appropriate or not should be defined and standardization can be provided with respect to the information.

3.1.8 Practice type

This profession can be done in clinics, private clinics, and university environment. According to working place, working conditions the differences based on job variety and task demands are seen. In general practice, they spent more time for treatment with patient rather than other dentists those are working in one specialization. In general practice, dentists effort more when they are treating (Moen and Bjorvatn, 1996).

3.1.9 Area of specialization

As mentioned before, profession is separated as endodontic, orthodontics, prosthetic dentistry, oral surgery, periodontology, oral diagnosis, treatment, pedodontics. Each of them should be taken into consideration for defining task demands. Besides, specialization is needed to investigate disorders among dentistry.

3.1.10 Hand dominance

The questionnaire survey includes hand dominance information. In dentistry, the dominant hand is preferred when using main equipment and applying forceful movements. When investigation was done, hand dominance is an important factor which should be considered (Alexandre et al., 2011). Some individual factors are included in questionnaire in Åkessons' study. Hand dominance factor was the one of the important factor (Åkesson et al., 1999).

3.1.11 Number of dental assistants

In literature, almost every paper suggests that working with assistant is an effective way to reduce musculoskeletal disorders in dentistry. Although it is not enough to get rid of disorders such as neck, shoulders, or arm pain. After evolution of 4 handed dentistry, still disorders are shown in up to 92% among dental operators (Saxena et al., 2013).

3.1.12 Days worked per week

This question is needed for showing the impact of practice habits on musculoskeletal complaints. All these variables are used to obtain statistical results. This question is needed to identify the relationship between occurrence of musculoskeletal disorders and the days worked per week.

3.1.13 Family situation

Living alone or living with friends and relatives has differences to prevalence of pain among dentists. Condition of living alone is more difficult than living with friends/relatives. Also it can affect the occurrence of musculoskeletal disorders. Regarding the neck and shoulder pain, living alone is found significant. Also when we consider the risk factors for sickness absence due to shoulder and hand/wrist pain, the most important factor was related to living alone (Alexopoulos, 2004).

3.1.14 Weekly exercise habit

Questionnaire survey considers the weekly exercise habits. According to literature, this profession needs regular exercises. It can avoid having discomforts in body segments. They stated, “Those dentists who do not find time for exercise, sooner or later will have to find time for illness” (Droezæ and Jonsson 2005).

3.1.15 Taking break between patients

In the literature, for relaxation, dentists should take breaks between patients. Because prolonged and static posture damages the body. They should be aware of importance of breaks. This question is asked to dentists to reveal their working habits (Garbin et al., 2011).

3.1.16 Smoking & alcohol

Regarding personal habits and health, smoking has an important role of human musculoskeletal system. While investigating, this factor should not be overlooked. According to some epidemiological studies, the relationship is found between smoking and musculoskeletal pain in body segments including back pain. In terms of measure of fatigability, smokers have more fatigue in muscles rather than non-smokers. Most of smokers can have vasoconstriction, cellular hypoxia, immune suppression, delayed revascularization, defective fibrinolysis or other physiological mechanisms that impair their nutrition or structure. The nicotine lowers the pain threshold or alters pain perception in musculoskeletal tissues. Also smokers and even ex-smokers can have less tolerance for painful mechanical muscle pressure than non-smokers (Zoidaki et al., 2013).

Smokers or ex-smokers and non-smokers are compared and found statistically 2.6 times higher need for recovery those dentists who were smoker rather than non-smokers at the end of working day (Zoidaki et al., 2013).

Alcohol is harmless for dentists because it causes some destruction with time. Fatigue and higher need for recovery can be seen in those dentists who use alcohol regularly (Zoidaki et al., 2013).

3.1.17 Disorder occurrences in the past 12 months & 7 days

Disorders existence is considered among dentists. If dentist doesn't care about his/her own health it may be worse. Chronic diseases can cause musculoskeletal disorders, but it may not be connected to the profession. To distinguish this, the survey was asked about the occurrence of the disease.

3.1.18 Survey Sample

The participants in this research were selected randomly from universities, hospitals, and dentists offices from Antalya, Turkey. The participants were the professionals who work on public or private dental clinics and in universities.

3.1.19 Survey Response Data Collection

Contact numbers, websites and mail address were used to communicate with dentists. All data were collected from Survey Monkey (http://surveymonkey.com) to perform statistical analysis and some questionnaires were distributed by hand and filled by dentists in their clinics.

3.2 Electromyography (EMG) Experiment

Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by skeletal muscle (Kamen, 2004). EMG is performed using an instrument called an electromyography, to produce a record called an electromyogram. An electromyography detects the electrical potential generated by muscle cells (US National Library, 2011) when these cells are electrically or neurologically activated.

Surface ElectroMyoGraphy (sEMG) is a non-invasive technique for measuring muscle electrical activity that occurs during muscle contraction and relaxation cycles. Surface electromyography is widely used in Ergonomics studies in the workplace, job risk analysis, product design and certification.

In this study, SEMG data were collected from dentists during patient treatment in order to understand which activities and posture are related to the musculoskeletal discomfort that the dentist experience. MyoTrac Infiniti, model SA9800 was used to collect muscle activities in this research. This SEMG device has two channels, which enable to collect data from two different muscle groups at the same time. All signals were A/D converted at 512 Hz which were then transmitted and then we can obtain the data for analyzing the statistical method.

Six muscle groups were selected for muscle activity investigation. These are; hand/wrist (flexor retinaculum), elbow/forearm (flexor carpi radialis), neck (posterior upper trapezius), shoulder (posterior deltoid), upper back (rhomboideus major), and lower back (sacropinalis).

SEMG experiment was conducted on 3 dentists, and in order to collect data from all six muscle groups, the experiment was repeated three times (the device has two channels). In SEMG study, randomly selected dentist were examined to identify muscle activity for each task which they performed. However, one condition which must be taken into account was the patient privacy. Permission was required to take photos and video captures of the patient while the dentists were operating.

All measurements were obtained from the dental clinics with similar working conditions. Each examined dentist had no assistant whilst treating patients. It was also observed that their instruments were different. Dentists have been using different adjustments based on their job tasks and patients. Moreover, environmental factors such as lighting, ventilation, and temperature were kept at a normal level while taking data from dentists. The clinic's environment is kept in an optimal range with the following parameters; Artificial illumination of 10,000 lux, the room temperature of 20-25℃ and 20%- 60% of humidity (Choi et al., 2006).

The following figures show the sEMG study applied to the dentists while treating patients. Due to the patients' rights and preferences of dentists, it was not possible to take photo from operation. The exact positions of electrodes are shown within circles. With the permission of some patients, the following figures give a better understanding of how the sEMG study was done.

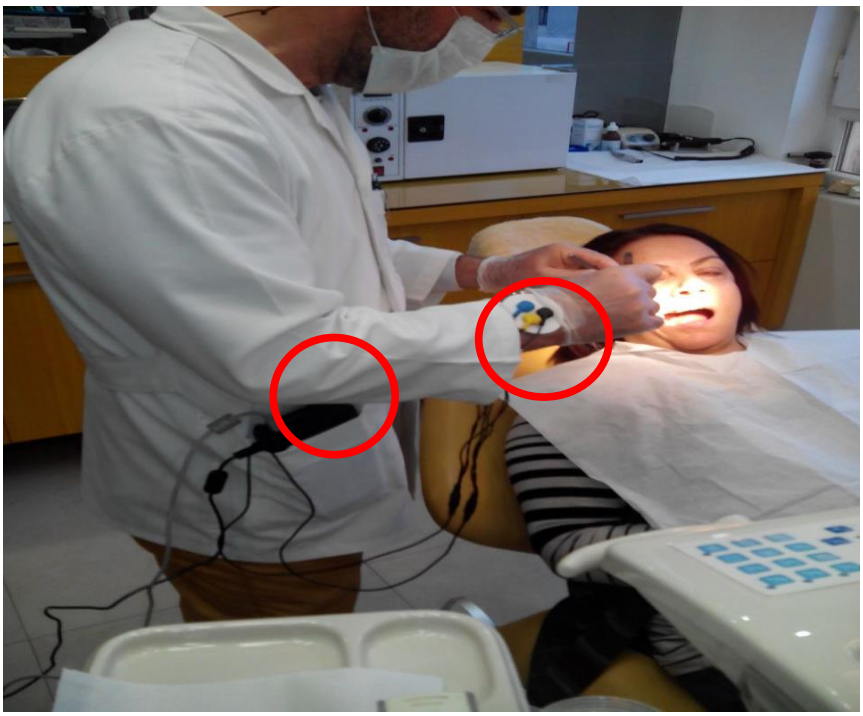

Figure 1. Placement of sEMG electrodes on hand/wrist (musculi lumbricales manus) and forearm (extensor carpi radialis)

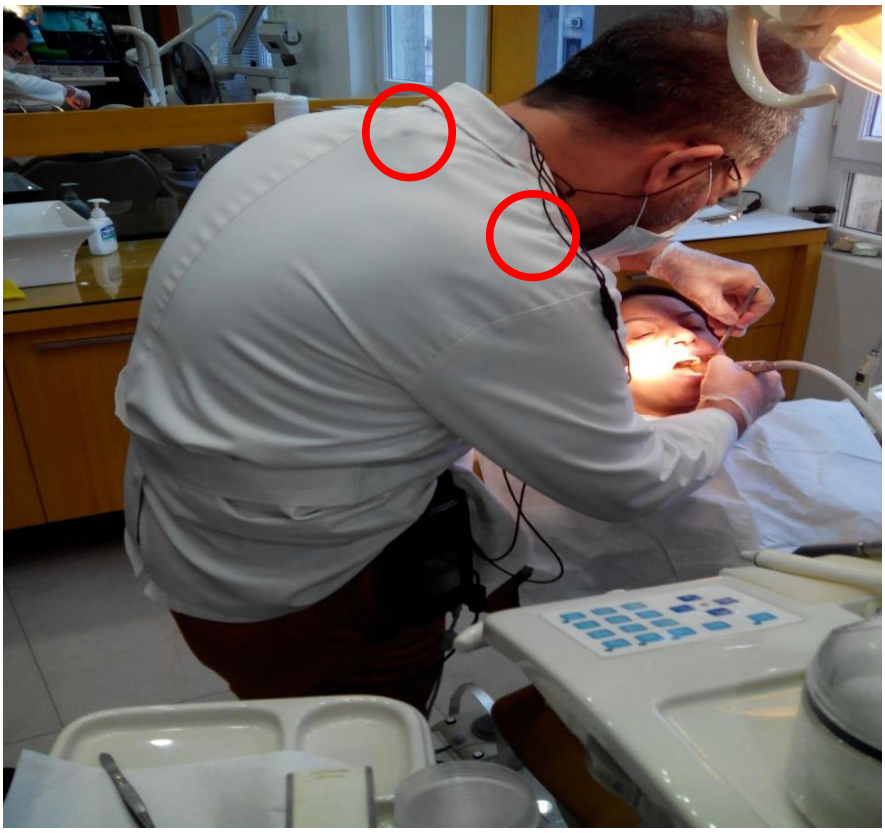

Figure 2. Placement of sEMG electrodes on shoulder (posterior deltoid) and neck (posterior upper trapezius)

Figure 3. Placement of sEMG electrodes on upper back (posterior upper trapezius) and lower back (sacropinalis)

3.3 Data Analysis

In our research, collected data were included grouping variables and predictor variables. Due to this reason Discriminant Analysis was applied to determine whether a set of variables is effective in predicting category membership. Discriminant analysis is a statistical analysis to anticipate categorical variable by one or more continuous variable.

In our research, Discriminant analysis was constructed from the data collected through the questionnaires to identify statistically significant factor(s) which contribute(s) formation of the WRMSDs.

ANOVA analysis was also used to analyze the results which were obtained from sEMG experiment and to determine the risk factors of work related musculoskeletal disorders.

3.4 Research Hypothesis

The following shows the parameter of the hypothesis introduced in this thesis.

i: the number of muscle regions. {i: 1= hand/wrist, 2= forearm, 3= neck, 4= shoulder,5= upper back, 6= lower back}

j: the number of job tasks applied by dentists in 20 minutes. {j: 1= dental filling therapy, 2= tooth cleaning, 3= fixed prosthodontics, 4= tooth extraction, 5= endodontic, 6= dental examination, 7= removable prosthodontics }

z: the number of dentists. {z: 1,2,3}

μ_{ijz}: The median frequency (MDF) electrical activity in the muscle i, for job j, by dentists z.

H_0: $\mu_{ijz} = \mu_{ijz}$

H_1: $\mu_{ijz} \neq \mu_{ijz}$

In the hypothesis, each dentist was identified by the z value. When the dentist was performing a task which was defined by j parameter, the corresponding muscle group was taken into account. The muscle group were defined by i parameter. This leads to obtain the MDF of the certain dentist related to his/her corresponding task and muscle region.

For instance when a dentist is performing task j, the corresponding activity in muscle group of i is measured by using the sEMG device. When the same dentist performs other task, again the same group of muscles is measured. By using this hypothesis, we are able to obtain the workload pressure on the muscle groups and come up with suggestions in order to decrease the workload for each task.

Chapter 4

RESULT

4.1 Questionnaire Results

The gender distribution of the number of dentists who responded to the survey was analyzed to obtain the gender differences in the musculoskeletal system in order to take the potential impact into account. According to the results, out of 67 dentists, 42 (64,62%) of them were male and 23 (35,38%) were female. There are 2 hops which show the dentists whom did not answer specific question.

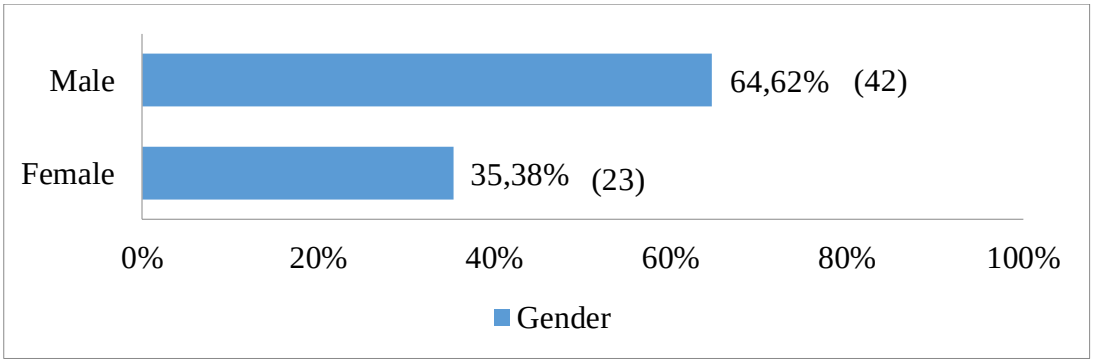

Figure 4. Gender distribution of the respondents (Responded: 65, Hops: 2)

Survey of dentists who had completed the age range of 19 subjects (28.79%) was seen as 41-50 years. 9 people between the ages of 21-30 and 60 years and older participated in the survey was 4 people.

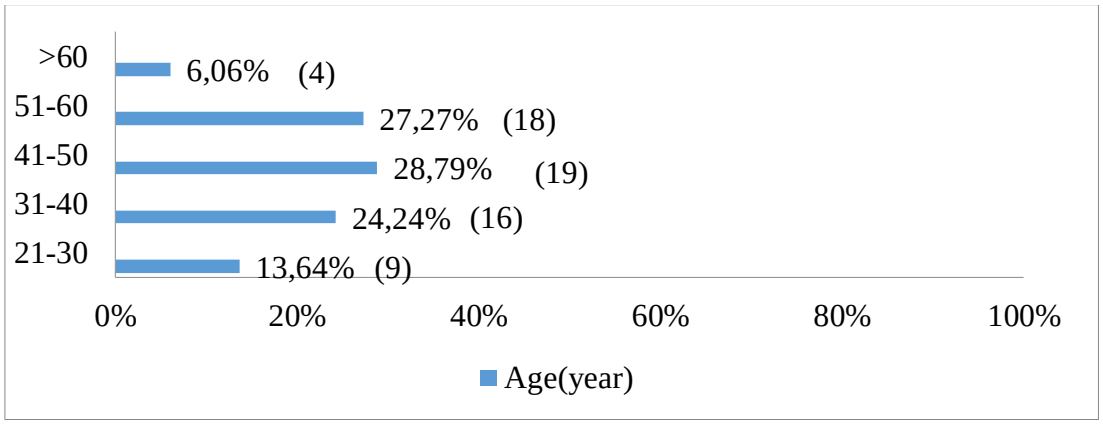

Figure 5. Age distribution of the respondents (Responded: 66, Hops: 1)

24 respondents' (35,82%) height were in between 171 cm- 180 cm. 22 of them were male and 2 of them were female. Half of the participated men in the survey study were in 171-180 height range and with the general weight range of 71-80 and then, 91-100kg respectively. 52, 17% of the participated female was in the height range of 161-170 cm and weight range of 61-70 and then, 51-60 kg respectively.

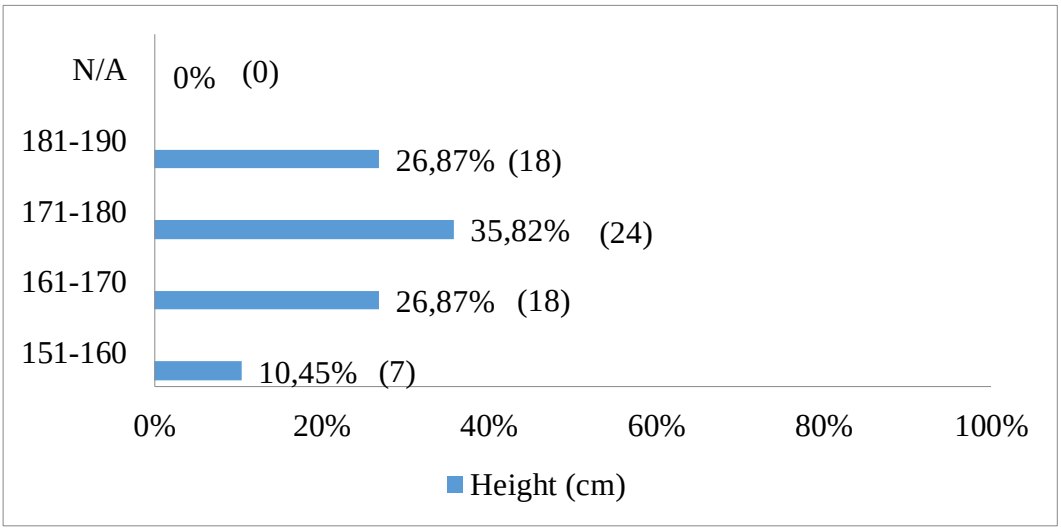

Figure 6. Height distribution of the respondents (Responded: 67, Hops: 0)

According to survey results from 67 people, 17 people's weight was between 71 and 80 kg. 14 were men, three of them were women.

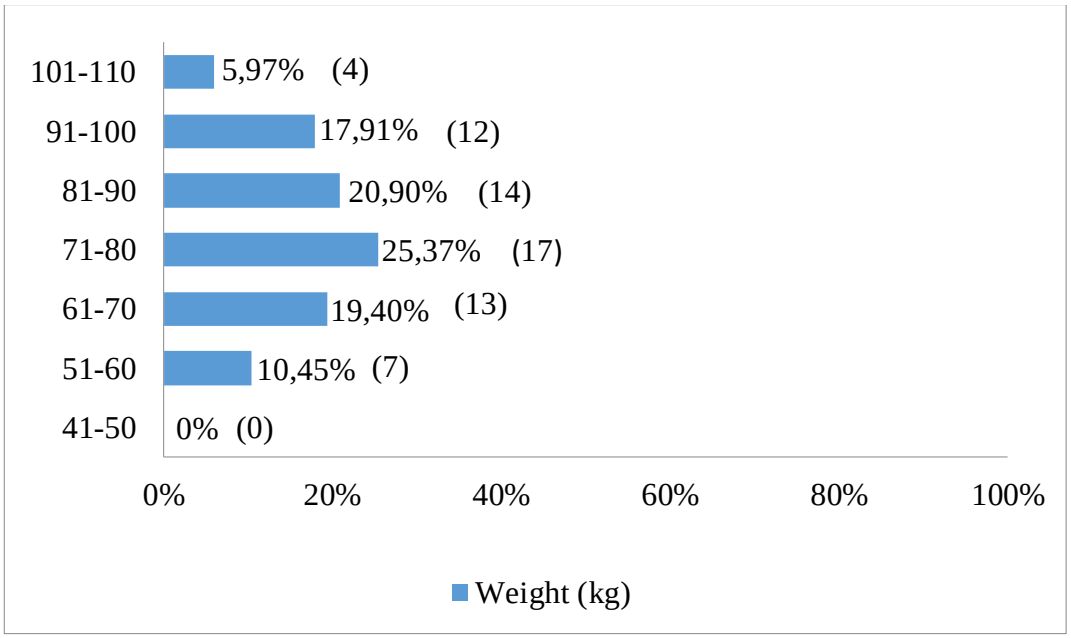

Figure 7. Weight distribution of the respondents (Responded: 67, Hops: 0)

According to survey, the most selected years were 21-30 years by dentists whom have been performing between 21 years and 30 years. Only two dentists, had performed for more than 40 years.

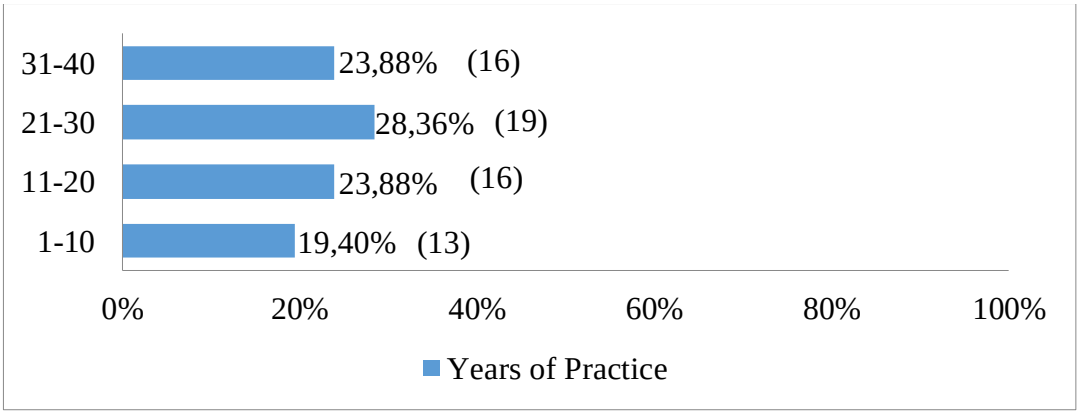

Figure 8. Distribution of the respondents' years of practice (Responded: 67, Hops: 0)

Figure 8 illustrates that prolonged standing and sitting positions were the most common physical demand of dental practice for 58 (86,57%) dentists while performing. Following this, the second and third most common physical demands by

50 dentists were monotonous/ repetitive movements (74,63%) and hand force (62,69 %), respectively.

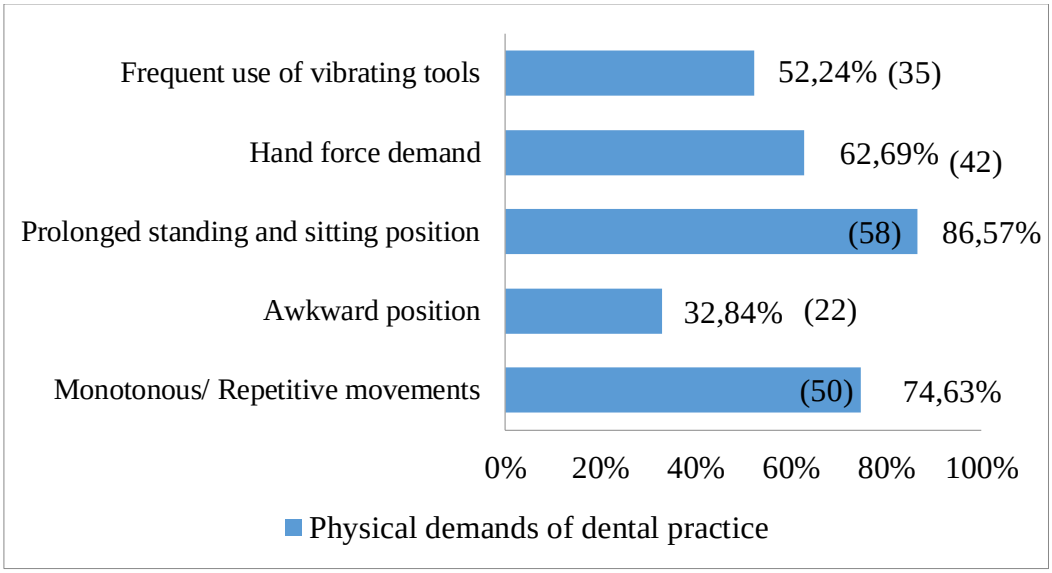

Figure 9. Physical demands of dental practice distribution of the respondents (Responded: 67, Hops: 0)

23 (34,85%) of dentists treat the patients between 21-30 and 31-40 minutes durations. 6 (9,09%) dentists treat their patients between 11-20 or more than 50 minutes. Just 8 dentists were using 41-50 minutes for treating their patients.

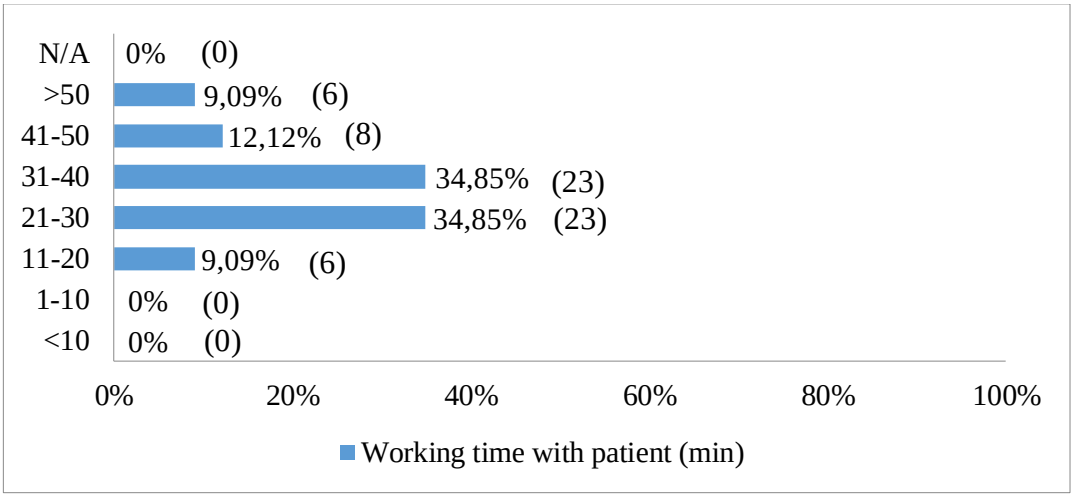

Figure 10. Working time with patient distribution of the respondents (Responded: 66, Hops: 1)

31-40 hours weekly was the most preferred working schedule by 29 dentist's responses. 41 to 50 hours and more than 50 hours were selected by 12 dentists. Only one recording was made by one dentist who works less than 10 hours.

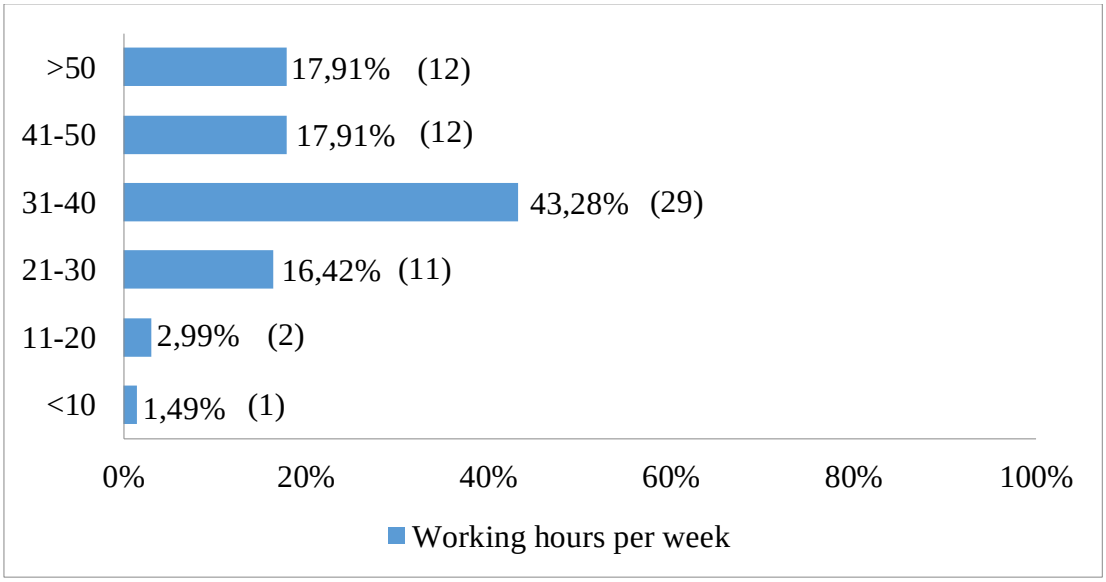

Figure 11. Distribution of the respondents based on working hours per week (Responded: 67, Hops: 0)

Distribution in a population of dentists: 3 (17,65%) and 5 (29,41%) of them were Periodontics and Orthodontics, respectively. 1 (5,88%) person was working in Pediatric dentistry and Endodontic and 4 (23,53%) dentists were participants as Oral and Maxillofacial Surgery. The rest of them participated the study as Prosthodontics.

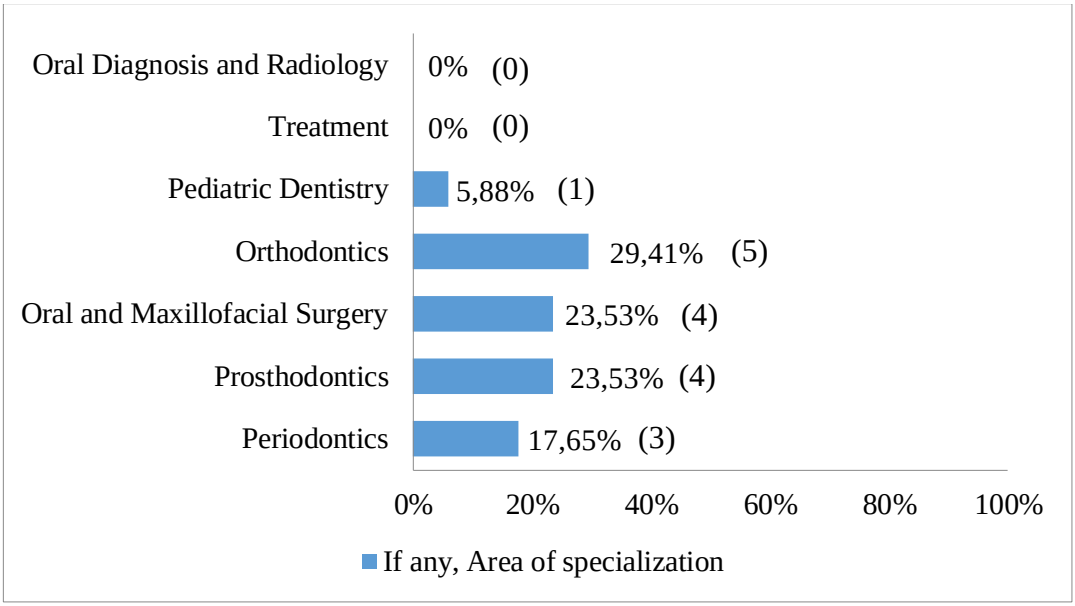

Figure 12. Distribution of the respondents' area specialization (Responded: 17, Hops: 50)

In this study, 98,51% of dentists were using the right hand. Out of the 67 dentists, only one dentist was left handed.

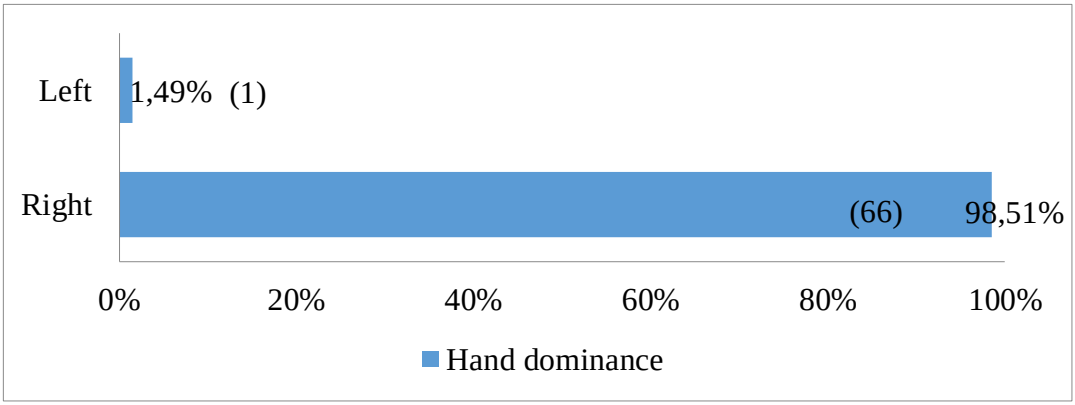

Figure 13. Distribution of the respondents' area (Responded: 67, Hops: 0)

By referring to the obtained results, assistant was not required for 16 dentists out of 67. However, 47 dentists were working together with an assistant and 4 dentists have been working together with 2-5 assistants.

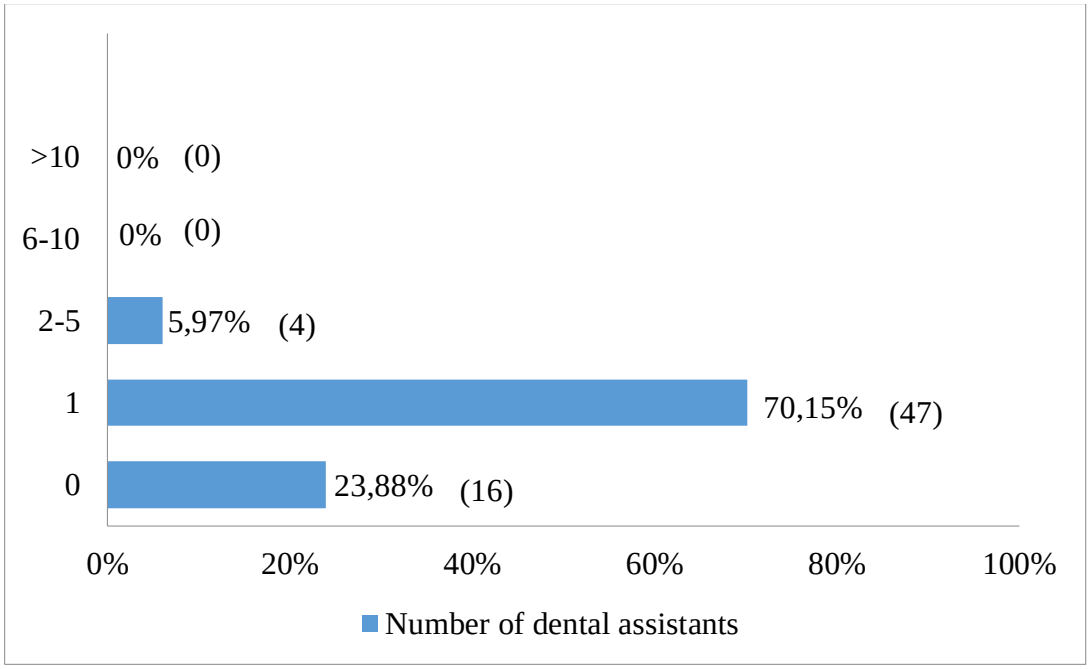

Figure 14. Assistant usage distribution (Responded: 67, Hops: 0)

Based on the obtained results, 26 dentists were working 7 days a week.

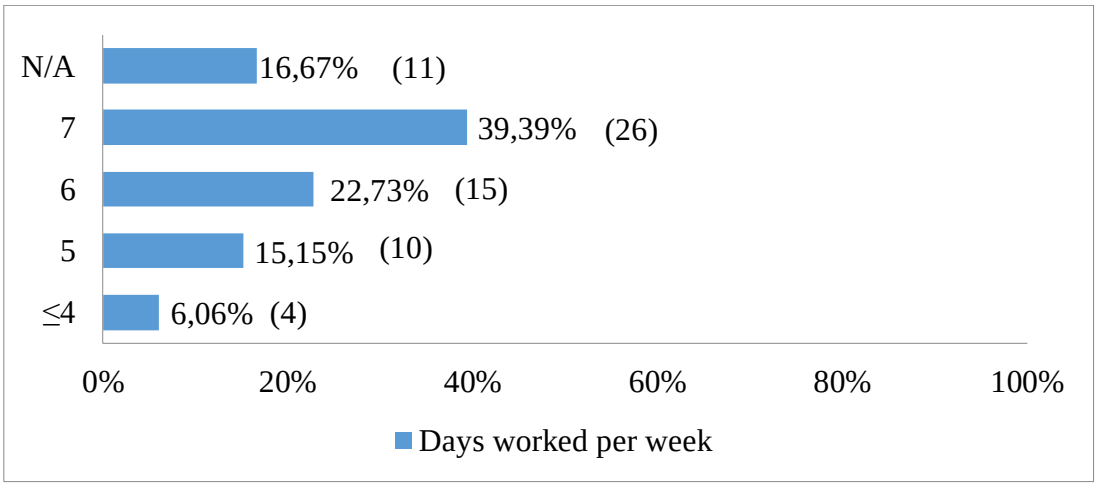

Figure 15. Distribution of days per week (Responded: 66, Hops: 1)

When the life conditions of the dentists were considered, 57 of them were living with the relatives / friends. The rest of them were living alone out of 62 responses.

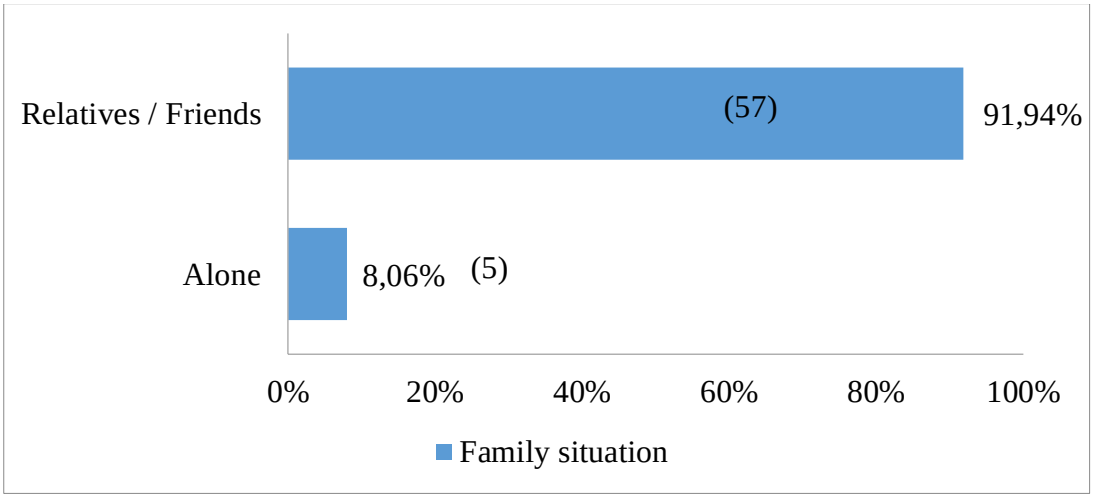

Figure 16. Family situation distribution of respondents (Responded: 62, Hops: 5)

In addition, dentists were asked about the times they exercise weekly. As the result, more than half of dentists did not do exercise at all and 12 dentists exercised once a week. 8 have emerged as the number of dentists who exercised twice per week. 6 people exercised 3 times in a week and 3 dentists also exercised 4 times in a week. The rest 2 dentists regularly exercised 5 and 7 times in a week, respectively.

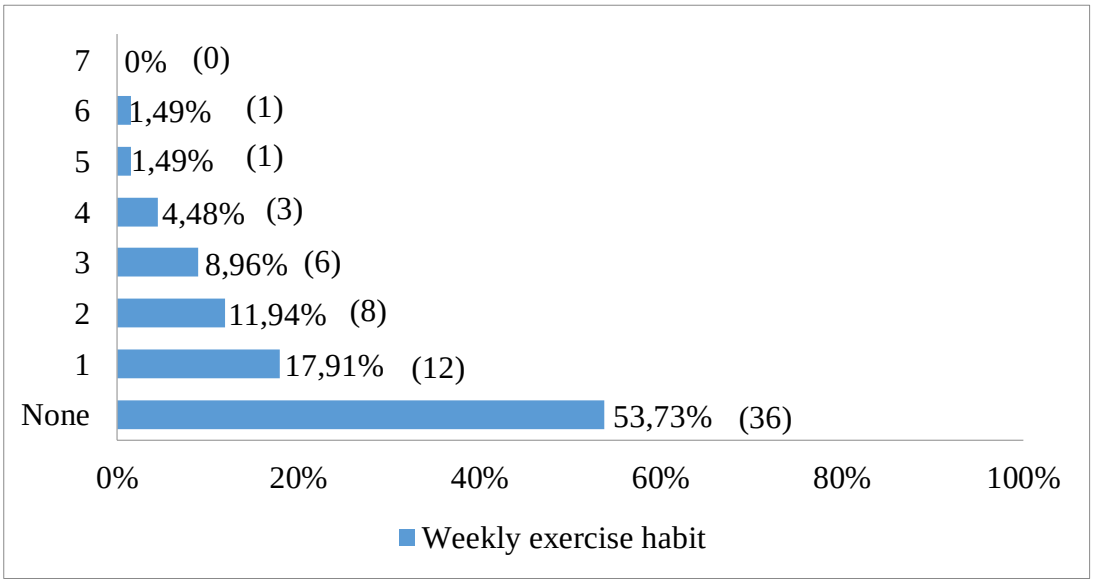

Figure 17. Distribution of weekly exercise habit (Responded: 67, Hops: 0)

The following figure shows the dentists who took breaks between treatments. In this response, 27 dentists continued operating without any breaks and 40 dentists gave a break between treatments.

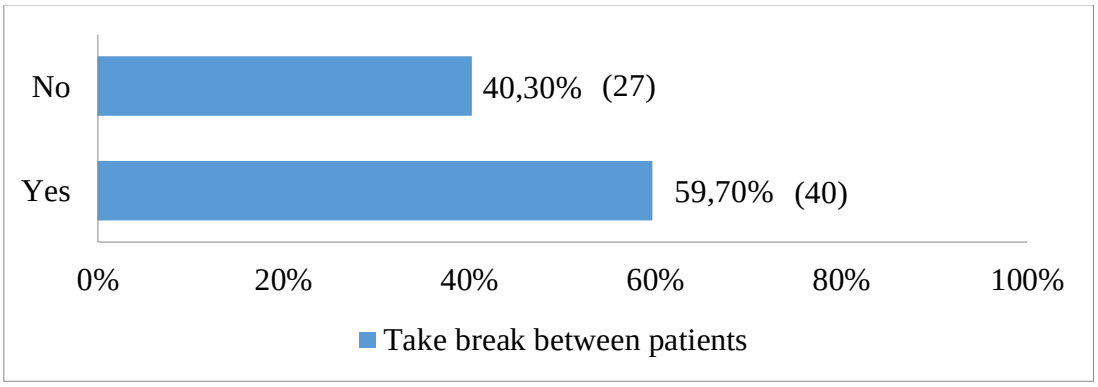

Figure 18. Take break between patients distribution of respondents (Responded: 67, Hops: 0)

10 dentists smoke and the rest do not smoke among 67.

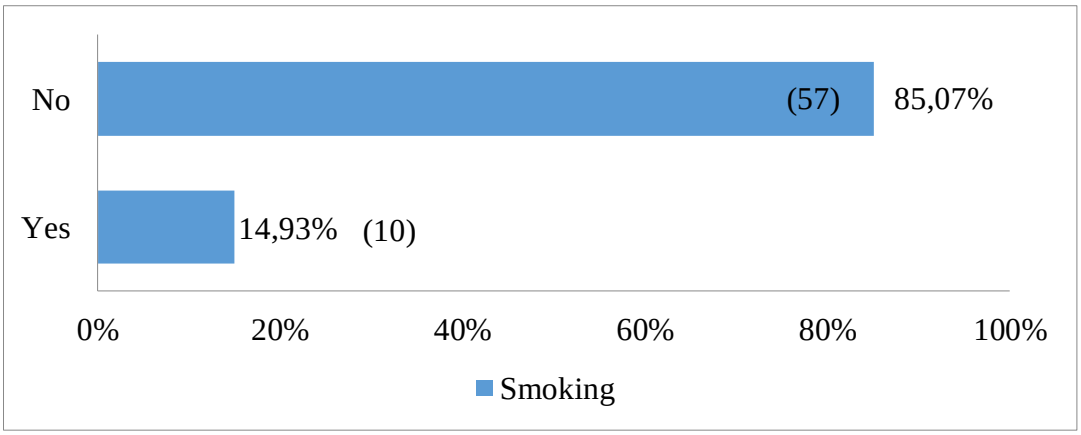

Figure 19. Distribution of smoking habit among respondents (Responded: 67, Hops: 0)

18 dentists drank alcohol in daily life while 48 of them did not. Only one dentist did not answer this question. Figure 20 shows the consumption of alcohol distribution.

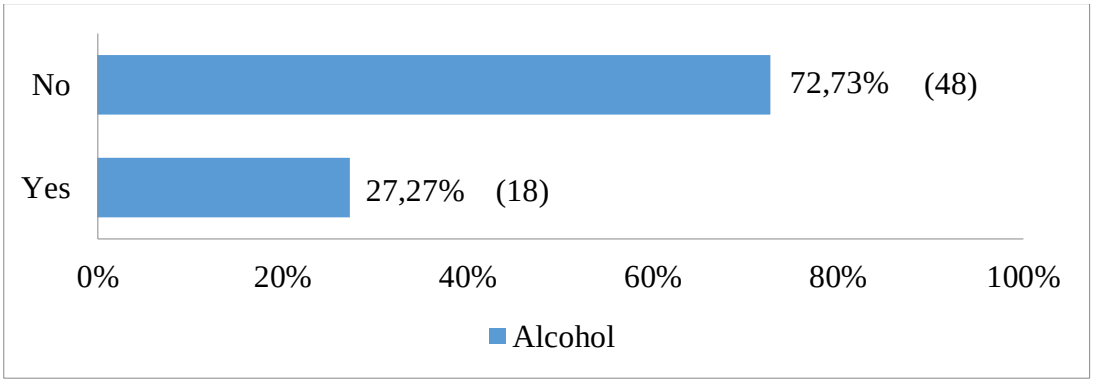

Figure 20. Distribution of alcohol usage among respondents (Responded: 66, Hops: 1)

Stress levels in the environment are shown in the figure 21 based on the scale assessment by 67 dentists. Most dentists stated as 5 out of 10 stress levels as indicated on the scale (0 = No stress, 10 = unbearable stress).

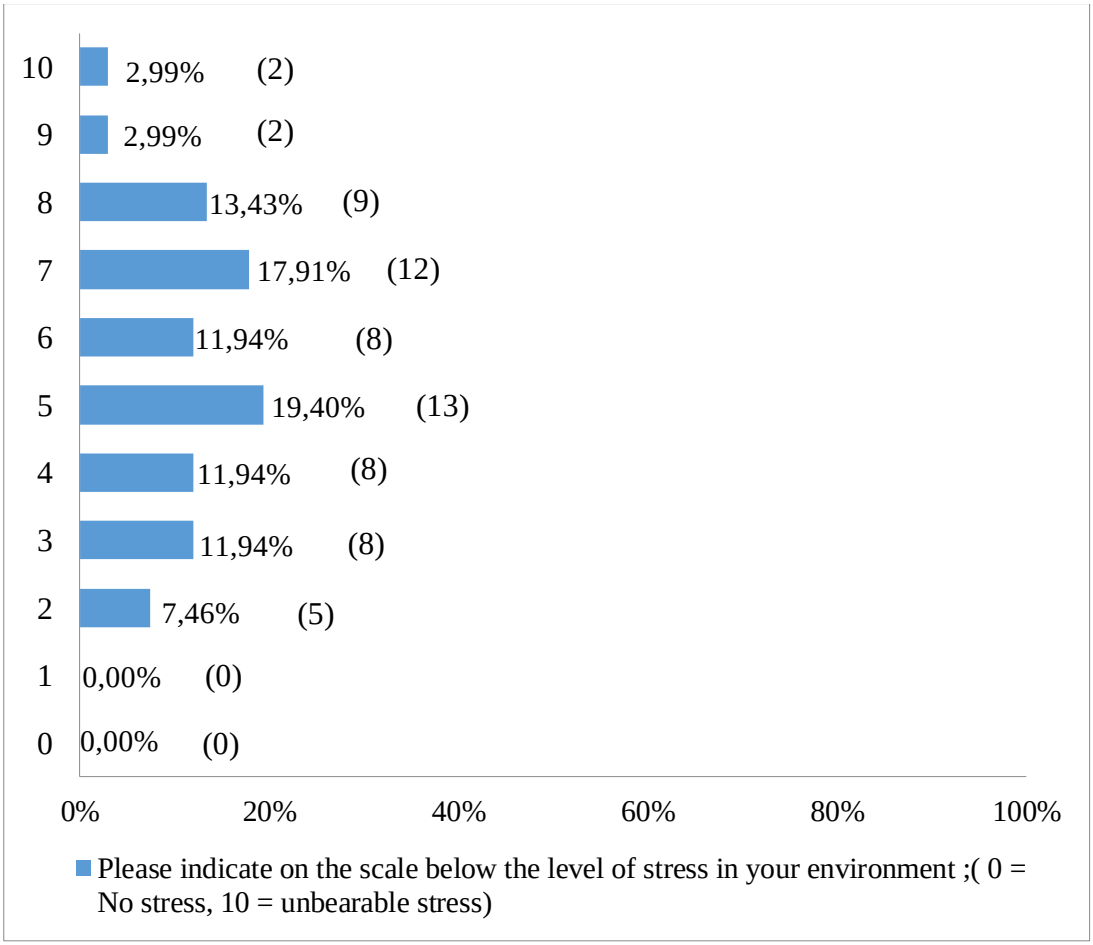

Figure 21. Distribution of stress level in their environment among respondents (Responded: 67, Hops: 0)

According to the scale, we obtained how much demand is required for their hobbies as much as physical demand of hobbies were considered on scale as shown in figure 22 above. (0= none, 10= very high). The most stated one was 5 by dentist based on their physical demand of hobbies.

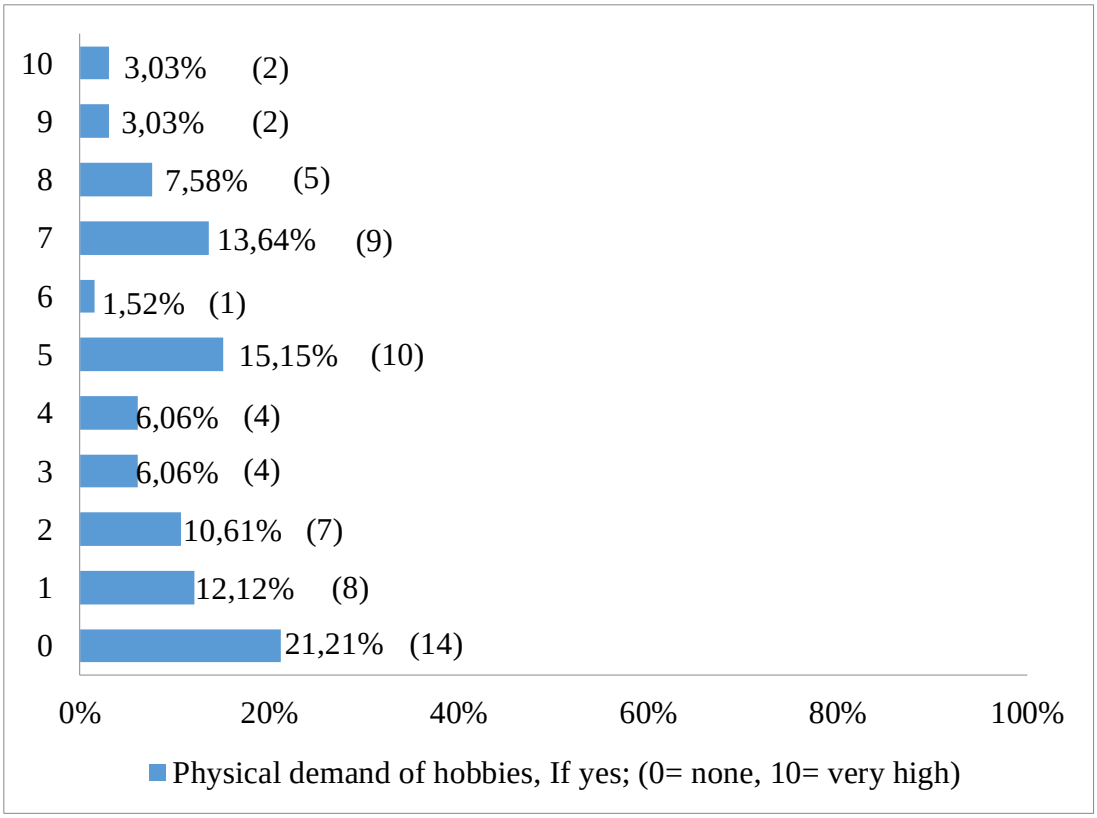

Figure 22. Distribution of physical demand of their hobbies among respondents (Responded: 66, Hops: 1)

After obtaining the required information, the most performed typical work tasks were identified by dentists based on questionnaire survey. According to the results, Dental filling therapy was selected as the most common job task which was performed by dentists weekly with 50 responses. Following this, tooth cleaning and fixed prosthodontics were selected as the second most frequently performed tasks with 35 responses. If we look at the first 5 common tasks, we can say that the tooth extraction as 4th and 5th was selected as Endodontic with 31 responses.

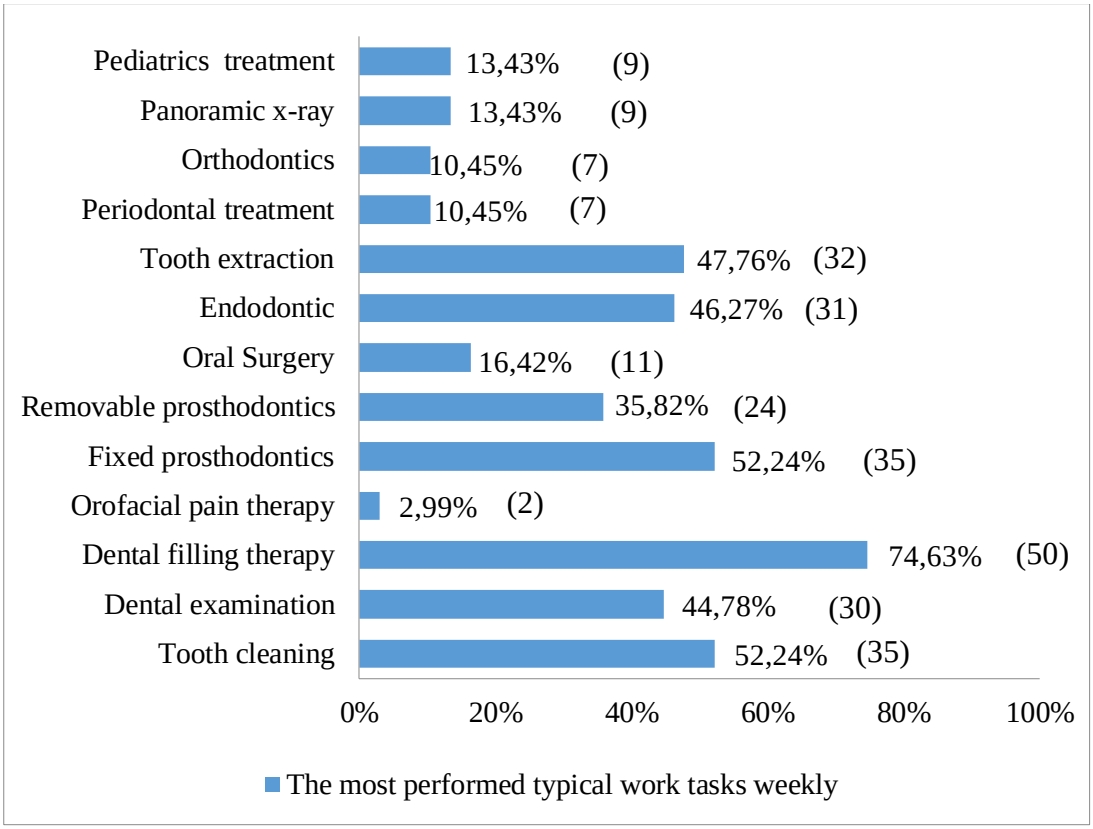

Figure 23. Distribution of the most performed typical work tasks weekly (Responded: 67, Hops: 0)

Table 1 shows the distribution of the occurrence in the past 12 months which can be related with chronic complains with sickness absence, medical care seeking, and symptoms preventing normal activities in some body parts. The number of chronic complains information required in order to exclude the results of the survey analysis to obtain real work related musculoskeletal disorders.

According to the results, the most common discomfort seen in the wrist/ hand region which was obtained from 18 dentists. Following this, upper back disorders were seen in 13 dentists. The distribution of discomfort occurrence in the past 12 months is shown in table 1.

In addition, 8 dentists had medical care seeking in their lower back and wrist/hand. Also some symptoms can influence their normal activities by considering the results, 7 dentists who had symptoms which prevent their normal activities in lower back and wrist/ hand areas.

Table 1. Distribution of discomfort occurrence in the past 12 months among respondents (Responded: 64, Hops: 3)

	Chronic complaints	Complaints with sickness absence	Medical care seeking	Symptoms preventing normal activities	Total Responded
Neck	%64,29 27	%35,71 15	%14,29 6	%9,52 4	42
Shoulders	%68,75 22	%31,25 10	%15,63 5	%15,63 5	32
Upper back	%61,11 22	%36,11 13	%8,33 3	%8,33 3	36
Lower back	%53,85 14	%42,31 11	%30,77 8	%26,92 7	26
Wrist/ Hand	%46,15 18	%46,15 18	%20,51 8	%17,95 7	39
Hip/Thigh	%46,15 6	%46,15 6	%23,08 3	%7,69 1	13
Ankles/ feet	%58,33 14	%41,67 10	%16,67 4	%8,33 2	24
Elbow	%38,46 5	%61,54 8	%30,77 4	%0,00 0	13
Knees	%52,00 13	%44,00 11	%16,00 4	%8,00 2	25

When the discomfort occurrence in the last 7 days is considered, it is seen that some dentists suffered from non-chronic disorders which was more related to shoulder disorders which was almost equal in female and male dentists. In addition, the results

show that the diseases in neck, upper back, lower back, leg, knee, elbows and wrist regions were seen more among male dentists rather than female dentists. Also hip disorders were found the least common diseases for male dentists and for female dentists feet/ankle disorders can be named as shown in table 2.

According to the survey study, the most common disease among dentists was upper back disorder for the both genders, and the most common diseases for preventing normal activities were wrist/hand.

By considering the results from the occurrence of the last 7 days, it was seen that men dentists were more affected rather than female dentists. According to this, it was seen that the number of male dentists who precipitated in the survey study was more than female dentists.

Table 2. Distribution of disorders occurrence in the past 7 days among respondents (Responded: 47, Hops: 20)

	Chronic complaints	Complaints with sickness absence	Medical care seeking	Symptoms preventing normal activities	Total Responded
Neck	%63,16 12	%31,58 6	%5,26 1	%10,53 2	19
Shoulders	%66,67 12	%22,22 4	%11,11 2	%11,11 2	18
Upper back	%41,67 10	%58,33 14	%8,33 2	%8,33 2	24
Lower back	%66,67 10	%46,67 7	%13,33 2	%20,00 3	15
Wrist/ Hand	%37,50 6	%43,75 7	%6,25 1	%31,25 5	16

	Chronic complaints	Complaints with sickness absence	Medical care seeking	Symptoms preventing normal activities	Total Responded
– Hip/Thigh	%60,00 6	%40,00 4	%30,00 3	%10,00 1	10
Ankles/ feet	%66,67 8	%41,67 5	%16,67 2	%8,33 1	12
Elbow	%14,29 1	%85,71 6	%14,29 1	%0,00 0	7
Knees	%53,85 7	%38,46 5	%0,00 0	%7,69 1	13

When the discomfort occurrence in the last 12 months is considered, it was seen that non-chronic discomfort in hip/elbow origins were almost equal in both female and male dentists. In 12 months scale, the problem in in neck, upper back, lower back, leg, knee, shoulder and wrist regions were also more common in male dentists rather than females. In addition, the least common discomfort for male dentists was related to hip region and for female was related to feet/ankle, knee and lower back regions. According to the survey the most common discomfort among both genders could be related to wrist/hand regions.

When we consider the knee region in the population of the survey study, 72.73% of male dentists were affected rather than female dentists and 71% of male dentists had non-chronic discomfort in their neck. Regarding the population who had discomfort, male dentists had more area in this scale such as in shoulder with 70%, upper back with 69, 23%, lower back with 81, 82% and ankles/ feet with 80% percentages respectively.

By considering the results from the occurrence of the last 12 months, it was seen that men dentists were more affected rather than female dentists. According to this, the number of male dentists who precipitated in the survey study was more than female dentists as shown in table 1. By an average it was seen that almost all dentists were in the risk of musculoskeletal injuries.

4.2 Discriminant Analysis

The Discriminant analysis was used to reveal significant relationship between work-related musculoskeletal discomforts and dentists. There were dependent and many independent variables which were not give reliability without Discriminant analysis.

In order to select grouping variable (dependent variable), first analysis was selected as occurrence discomfort in the last 12 months for each body region. Second statistic was related with occurrence disorders in last 7 days for specified body points. Also, predictor variables (independent variables) were selected from rest of the questionnaire question for both statistics.

Discriminant analysis has been sustained by using SPSS 19 software.

4.2.1 Discomfort occurrence in the last 12 months

Discriminant analysis is used to find significant factors. Grouping variable is selected as discomfort occurrence in the past 7 days among respondents. The other values are accepted as independent variables. Discriminant analysis is performed separately for disorder occurrence in last 7 days and last 12 months. Neck, shoulder, wrist/hand, upper back, lower back, knees, ankles/feet, hip/thigh, and elbow regions are considered and analysis is applied one by one. In table 3 we see the significant factors for wrists/hand region. All data was obtained from result of questionnaire survey.

Table 3. Standardized Canonical Discriminant Function Coefficients for wrists/hand

	Function		
	1	2	3
Physical_Demands_of_Dental_Practice	20.486	2.583	.032
Work Tasks	-8.217	2.660	.244
Physical_demand_of_hobbies	19.433	5.319	.342
Alcohol	7.641	.545	.947
Stress_level	5.864	.526	.273
Weekly_exercise_habit	.171	-2.750	-.401
Take_break_between_patients	-24.977	9.766	-.373
Days_worked_per_week	7.722	-7.201	-.402

Table 4 shows the significant factors for shoulder region. Discriminant analysis is performed to find relationship between disorders and factors.

Table 4. Standardized Canonical Discriminant Function Coefficients for shoulder

	Function			
	1	2	3	4
Physical_Demands_of_Dental_Practice	8.012	.361	.648	.503
Work Tasks	2.951	.608	.599	1.012
Physical_demand_of_hobbies	4.721	.097	.788	.698
Alcohol	1.965	.222	.497	.281
Stress_level	-4.945	.812	-.580	-.252
Weekly_exercise_habit	-2.846	.724	.598	-.327
Take_break_between_patients	-3.310	-.430	-1.207	.136
Days_worked_per_week	3.678	.071	.289	-.758

In neck region some factors are defined as a significant factors. The coefficients are shown in table 5.

Table 5. Standardized Canonical Discriminant Function Coefficients for neck

	Function		
	1	2	3
Physical_Demands_of_Dental_Practice	5.142	3.366	2.127
Work Tasks	3.868	1.762	1.615
Physical_demand_of_hobbies	7.945	2.262	3.293
Alcohol	-3.833	.506	-.870
Stress_level	-.436	-1.872	-1.282
Weekly_exercise_habit	-5.228	-1.325	-1.761
Take_break_between_patients	-2.602	-.798	-1.327
Days_worked_per_week	-.231	.944	-.125
Family_Situation	8.193	.129	2.461

When the upper back region is considered, disorders occurrence has a relationship with this significant factors and nine significant factors are shown in table 6.

Table 6. Standardized Canonical Discriminant Function Coefficients for upper back

	Function		
	1	2	3
Physical_Demands_of_Dental_Practice	-.570	7.370	.852
Work Tasks	.860	4.638	.397
Physical_demand_of_hobbies	-1.524	9.366	1.245
Alcohol	2.139	-1.422	-.245
Stress_level	-3.042	-3.527	-1.078
Weekly_exercise_habit	5.915	-5.665	-.683
Take_break_between_patients	1.098	-2.008	-.749
Days_worked_per_week	4.477	-.319	-.234
Family_Situation	-6.633	6.331	.853

Table 7 shows the significant factors for lower back region. This significant factors are defined according to disorder occurrence in the last 12 months.

Table 7. Standardized Canonical Discriminant Function Coefficients for lower back

	Function		
	1	2	3
Physical_Demands_of_Dental_Practice	9.729	5.198	1.849
Work Tasks	4.641	1.959	1.549
Physical_demand_of_hobbies	9.926	3.845	3.901
Alcohol	-3.935	-3.749	-2.055
Stress_level	-4.674	-3.984	-1.167
Weekly_exercise_habit	-7.075	-4.439	-3.735
Take_break_between_patients	-3.362	-.218	.436
Days_worked_per_week	-1.067	.488	-.710
Family_Situation	8.193	4.321	4.104

When we consider the knee region among dentists the result shows that there are eight significant factors which affect the formation of disorders.

Table 8. Standardized Canonical Discriminant Function Coefficients for knees

	Function		
	1	2	3
Physical_Demands_of_Dental_Practice	15.731	-.999	.113
Work Tasks	4.834	1.309	1.172
Physical_demand_of_hobbies	4.475	.615	.186
Alcohol	8.228	2.511	.548
Stress_level	-9.496	1.990	-.685
Weekly_exercise_habit	3.118	.089	-.314
Take_break_between_patients	-10.390	-1.152	-.197
Days_worked_per_week	2.637	-.543	.729

Ten factors are seen as significant factor for hip/thigh region. Although In literature, gender is a significant factor for disorders occurrence, but table 9 shows the otherwise according to the study.

Table 9. Standardized Canonical Discriminant Function Coefficients for hip/thigh

	Function	
	1	2
Physical_Demands_of_Dental_Practice	3.477	1.868
Work Tasks	.014	1.182
Physical_demand_of_hobbies	.337	2.731
Alcohol	-.930	.249
Stress_level	-3.705	-.191
Weekly_exercise_habit	-.629	-1.022
Take_break_between_patients	1.072	-1.815
Days_worked_per_week	1.835	-1.174
Family_Situation	.076	1.765
Dental_Assistant_Usage	2.338	-.867

For considering ankles/feet region, some variables are identified as significant factors.

Table 10 shows the significant factors which are related with disorder occurrence

Table 10. Standardized Canonical Discriminant Function Coefficients for ankles/feet

	Function	
	1	2
Physical_Demands_of_Dental_Practice	6.966	1.365
Work Tasks	4.324	.409
Physical_demand_of_hobbies	4.974	2.114
Alcohol	-.759	-.296
Stress_level	-12.670	-.171
Weekly_exercise_habit	.122	-1.637
Take_break_between_patients	7.488	.211
Days_worked_per_week	3.523	-.596
Family_Situation	-.245	1.910
Dental_Assistant_Usage	2.428	.151

Lastly, table 11 shows us the result of discriminant analysis. There are ten significant factor which are affecting disorder occurrence.

Table 11. Standardized Canonical Discriminant Function Coefficients for elbow

	Function	
	1	2
Physical_Demands_of_Dental_Practice	.026	-1.242
Work Tasks	.764	.434
Physical_demand_of_hobbies	.787	-.844
Alcohol	-.110	.160
Stress_level	1.775	-.030
Weekly_exercise_habit	-1.203	.433
Take_break_between_patients	-1.556	1.049
Days_worked_per_week	-.991	.519
Family_Situation	1.473	-.691
Dental_Assistant_Usage	-.348	.462

4.2.2 Discomfort occurrence in the last 7 days

Discriminant analysis is used to define significant factors based on result of questionnaire survey. The following tables show the significant factors for body regions among dentist. Table 12 shows the significant factors for wrist/hand region. Gender is also included as significant factor.

Table 12. Standardized Canonical Discriminant Function Coefficients for wrist/hand

	Function
	1
Gender	15.040
Age(year)	28.070
Height(cm)	11.019
Weight(kg)	1.891
Practice_years	-15.744
Physical_Demands_of_Dental_Practice	.896
Working_time_with_patient(min)	3.054
Working_hours_per_week	5.388
Area_of_Specialization	3.902
Dental_Assistant_Usage	4.087

Significant factors for shoulder region is seen in table 13. The highest coefficient is shown in gender variable.

Table 13. Standardized Canonical Discriminant Function Coefficients for shoulder region

	Function		
	1	2	3
Gender	2.243	2.641	.958
Age(year)	-1.289	2.097	1.638
Height(cm)	-.602	.130	.637
Weight(kg)	.671	.919	.102
Practice_years	2.763	.316	-1.694
Physical_Demands_of_Dental_Practice	2.580	-.457	.097
Working_time_with_patient(min)	-2.490	-.593	.847
Area_of_Specialization	-2.158	-.563	.108

For neck region, some significant factors are found which affects discomfort occurrence in the last 7 days. The highest coefficient is shown in gender variable.

Table 14. Standardized Canonical Discriminant Function Coefficients for neck

	Function
	1
Gender	15.040
Age(year)	28.070
Height(cm)	11.019
Weight(kg)	1.891
Practice_years	-15.744
Physical_Demands_of_Dental_Practice	.896
Working_time_with_patient(min)	3.054
Working_hours_per_week	5.388
Area_of_Specialization	3.902
Dental_Assistant_Usage	4.087

When we consider upper back region, there are many significant factors regarding to the discomfort occurrence in the past 7 days which differ from last 12 months.

Table 15. Standardized Canonical Discriminant Function Coefficients for upper back

	Function		
	1	2	3
Gender	-.161	3.039	2.083
Age(year)	7.033	-.703	2.496
Height(cm)	2.428	1.086	1.490
Weight(kg)	-1.519	2.525	.159
Practice_years	-6.221	2.980	-2.191
Physical_Demands_of_Dental_Practice	.558	-1.292	.205
Working_time_with_patient(min)	4.482	-1.381	.596
Working_hours_per_week	.257	-.757	.880

In table 16, significant factors are shown for lower back region. The highest coefficient is shown in gender variable.

Table 16. Standardized Canonical Discriminant Function Coefficients for lower back

	Function			
	1	2	3	4
Gender	18.412	-1.121	1.044	.607
Age(year)	2.324	-3.310	1.138	1.716
Height(cm)	14.392	.838	1.137	-.001
Weight(kg)	11.484	.179	.223	.702
Practice_years	18.106	3.231	-.655	-1.200
Physical_Demands_of_Dental_Practice	-5.262	1.014	.250	.580
Working_time_with_patient(min)	-2.912	-.807	.944	-.353

Nine significant factors are shown in table 17. These factors are identified for knees. Occurrence of knee discomfort has a relationship between these factors.

Table 17. Standardized Canonical Discriminant Function Coefficients for knees

	Function	
	1	2
Gender	19.115	2.379
Age(year)	-8.680	10.112
Height(cm)	.091	1.122
Weight(kg)	10.330	-1.474
Practice_years	23.045	-7.560
Physical_Demands_of_Dental_Practice	9.467	-.148
Working_time_with_patient(min)	-1.383	1.710
Working_hours_per_week	-14.822	1.956
Area_of_Specialization	-5.402	-1.592

Considering hip/thigh region, discomfort occurrence has a relation between these disorders which shown in below table.

Table 18. Standardized Canonical Discriminant Function Coefficients for hip/thigh

	Function		
	1	2	3
Gender	9.027	1.218	2.274
Age(year)	-22.872	13.407	2.002
Height(cm)	-.198	1.470	1.486
Weight(kg)	8.701	-.180	.301
Practice_years	27.941	-10.680	-.577
Physical_Demands_of_Dental_Practice	4.696	.148	-.631
Working_time_with_patient(min)	-4.086	2.987	-.170
Working_hours_per_week	-12.505	3.227	.262

Table 19 shows result of discriminant analysis for ankles/feet region. Significant disorders are shown in below. The highest coefficient is found in gender variable.

Table 19. Standardized Canonical Discriminant Function Coefficients for ankles/feet

	Function	
	1	2
Gender	19.115	2.379
Age(year)	-8.680	10.112
Height(cm)	.091	1.122
Weight(kg)	10.330	-1.474
Practice_years	23.045	-7.560
Physical_Demands_of_Dental_Practic e	9.467	-.148
Working_time_with_patient(min)	-1.383	1.710
Working_hours_per_week	-14.822	1.956
Area_of_Specialization	-5.402	-1.592

Discriminant analysis is applied on questionnaire survey results. Grouping variable is selected as disorder occurrence in the last 7 days. Table 20 shows that the significant factors for elbow region. Elbow region be affected by these significant factors.

Table 20. Standardized Canonical Discriminant Function Coefficients for elbow

	Function	
	1	2
Gender	4.131	5.041
Age(year)	8.986	9.486
Height(cm)	2.627	2.946
Weight(kg)	-2.258	.069
Practice_years	-6.034	-5.209
Physical_Demands_of_Dental_Practice	2.086	.456
Working_time_with_patient(min)	3.357	2.101
Working_hours_per_week	.316	1.257
Dental_Assistant_Usage	5.058	1.690

4.3 EMG Experiment Results

Out of 13 common tasks among dentists, the most common 7 of them were chosen for investigation due to their highest percentages as the most common tasks (Figure 23). The 7 most tasks (those above 35%) are listed as the following:

1 Dental filling therapy,

2 Tooth cleaning,

3 Fixed prosthodontics,

4 Tooth extraction,

5 Endodontic,

6 Dental examination, and

7 Removable prosthodontics.

Each task was studied within the first 30 minutes duration for the different muscle groups. Two group muscles are studied at a time for the duration of ten minutes while operating a certain task. After ten minutes duration, the group muscles is switched, respectively. The results were formed in an average way of the first 2^{nd}, 4^{th}, 6^{th}, 8^{th}, and 10^{th} minutes.

Three dentists participated in the sEMG experiment. The dentist's muscle groups were studied individually while performing each task. Therefore each dentist's muscle group's activities were measured in 42 steps. This yields the result of the whole six muscle groups for each different task. According to this, the parameters can be formed as the following.

4.3.1 Hand

Figure 24 shows 7 types of treatment for Dentist 1 during 10 min of treating a patient. 7 common tasks were selected as the most applied tasks based on questionnaire survey. Hand pressure on Dentist 1 shows in vertical axis (in μV) based on different work tasks. According to the figure 24 the highest pressure on hand was seen while dentist 1 was applying Fixed Prosthodontics than the other six tasks. Despite the high pressure has been decreasing steadily.

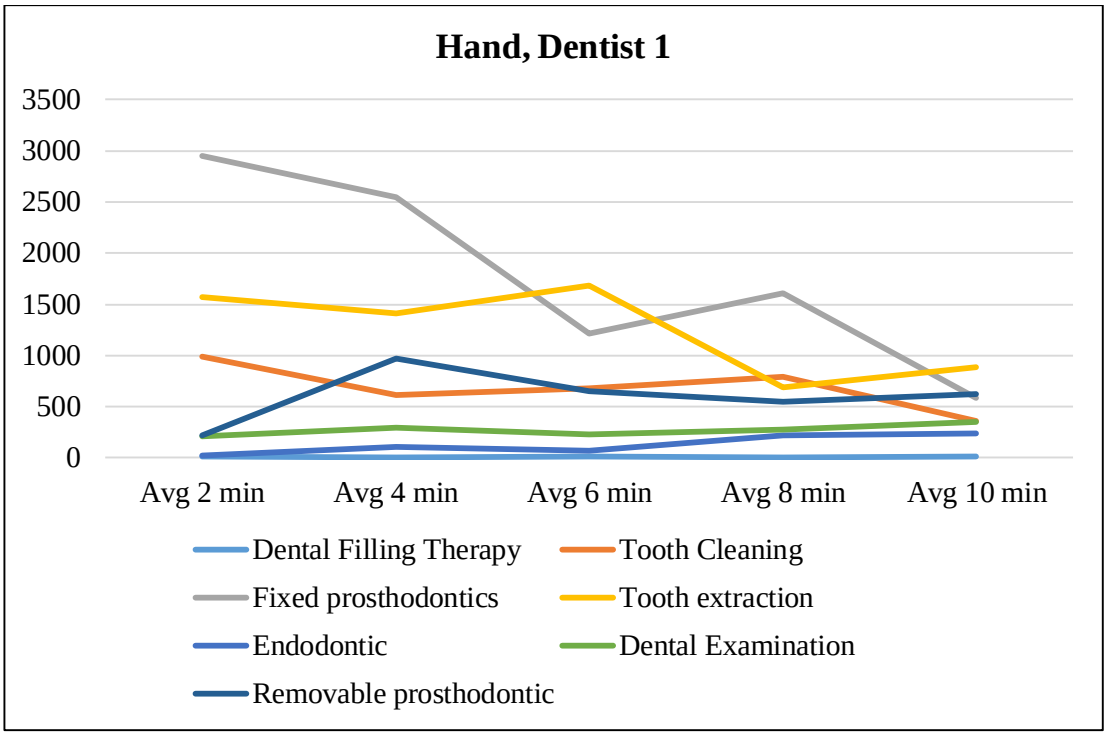

Figure 24. EMG activity at the hand of Dentist 1

Figure 25 shows seven different treatments while Dentist 2 was applying on a patient. Based on chart, high pressure was detected in while dentist 2 was applying dental examination and tooth cleaning. High pressure was not seen in the first 6 minutes of dental examination. But suddenly hand of Dentist 2 is exposed high pressure. Examination type can incur differences with other dentists' hand pressure with the same task. Endodontic and dental filling therapy did not make significant pressure on

hand. In tooth cleaning and tooth extraction the pressure during 10 min was decreasing after 4 min.

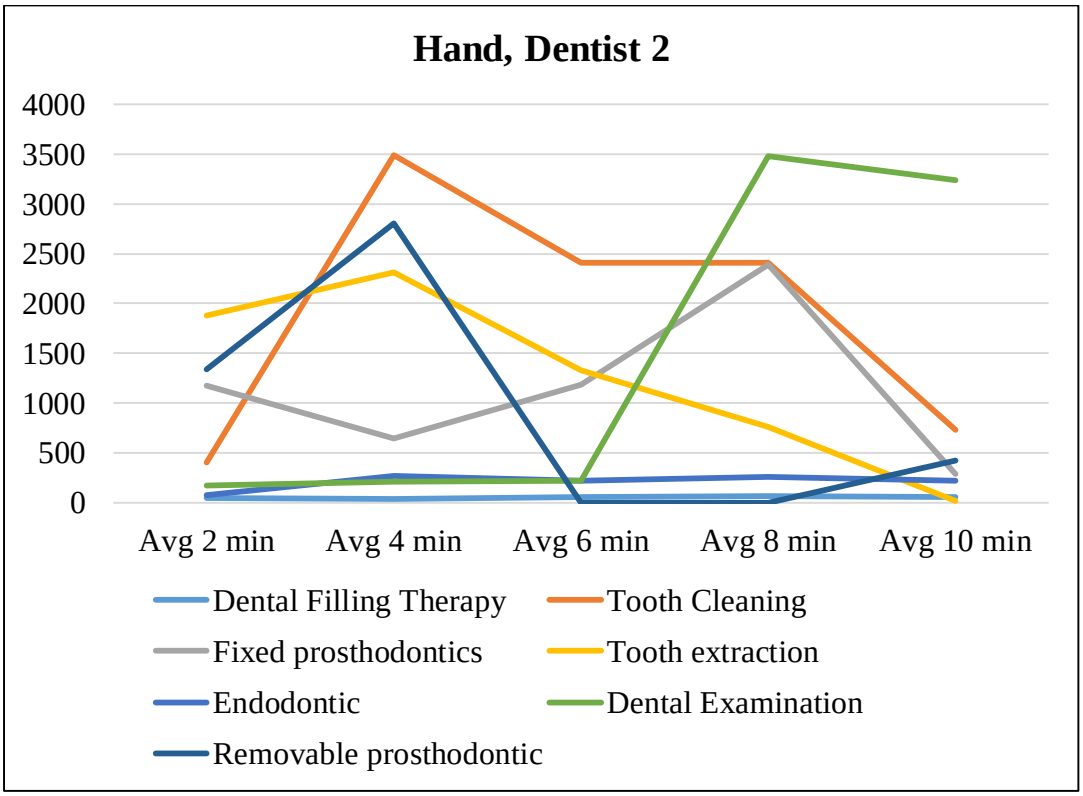

Figure 25. EMG activity at the hand of Dentist 2

The following figure shows the EMG activity of the hand on the dentist 3. Maximum hand pressure was seen for dentist 3 while dental examination was being applied as seen in Figure 26.

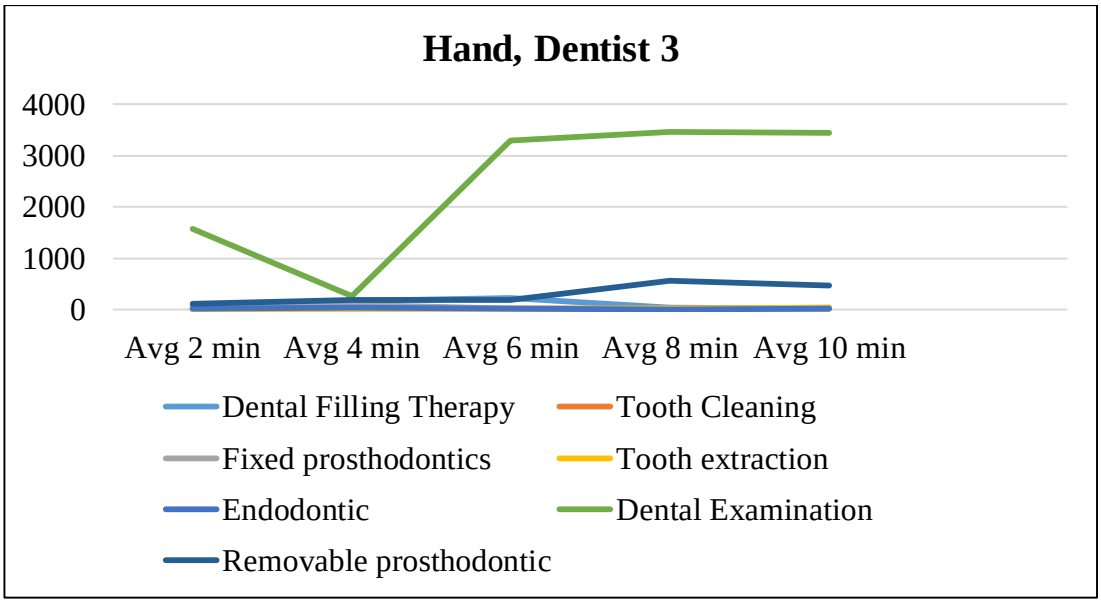

Figure 26. EMG activity at the hand of Dentist 3

4.3.2 Elbow

Figure 27 shows the pressure of elbow/forearm of dentist 1. The highest pressure was seen while he was applying Endodontic treatment. Following this, dental examination made significance according to the rest of tasks. Less pressure was seen in dental examination.

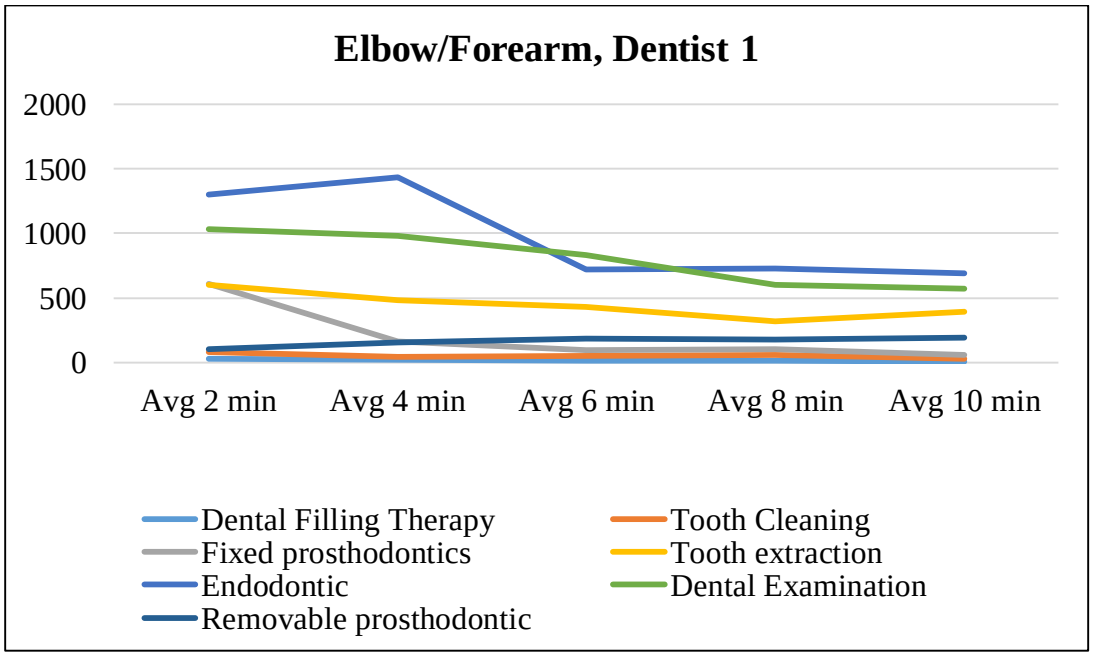

Figure 27. EMG activity at the elbow / forearm of Dentist 1

When we consider second dentist (figure 28), the highest pressure of elbow was seen in dental examination treatment. Between average of 2 minutes and 4 minutes the pressure of elbow was increased when she was applying dental examination. After average 4 minutes the pressure was almost constant but still it was the highest pressure when we considered the rest of the tasks.

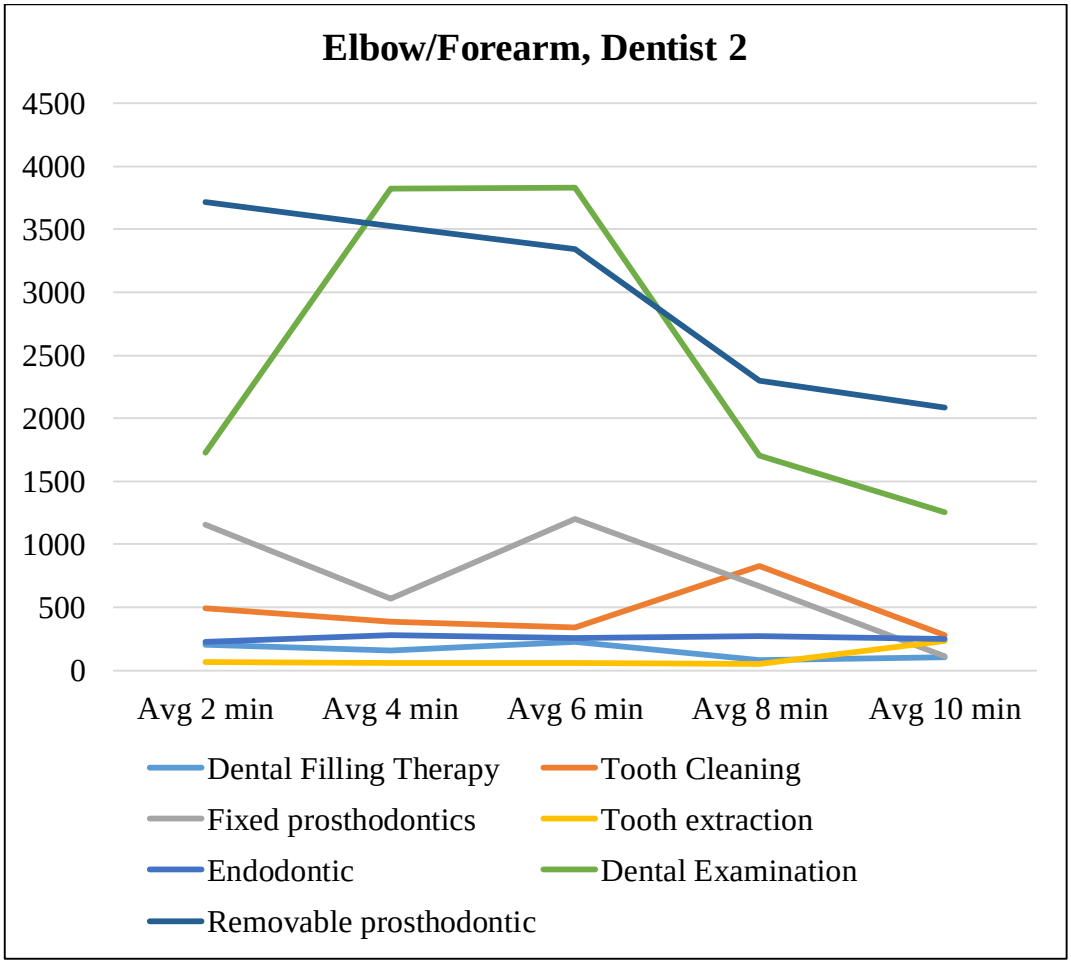

Figure 28. EMG activity at the elbow / forearm of Dentist 2

Figure 29 shows that seven different tasks which were applied on patients by dentist 3. Dental examination treatment made significance rather than the other tasks. After average 4 minutes the pressure on elbow/forearm was increased until average 6

minutes. Between average 6 and 10 minutes, the pressure was almost constant but still it was the highest pressure when we consider other jobs.

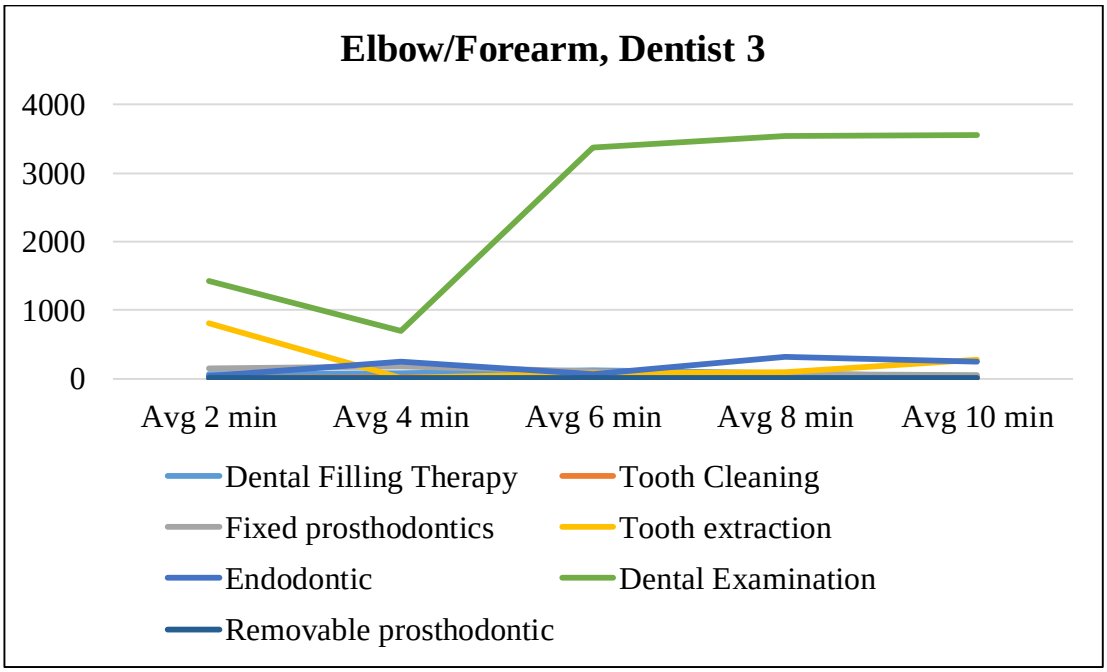

Figure 29. EMG activity at the elbow / forearm of Dentist 3

4.3.3 Neck

As the related chart to neck muscles shows while dentist 1 was treating work tasks on patients, it was shown that the pressure on neck when dentist was applying dental filling therapy, fixed prosthodontics, and removable prosthodontics. These were significantly more than that the lower back discomfort when applying the other job tasks.

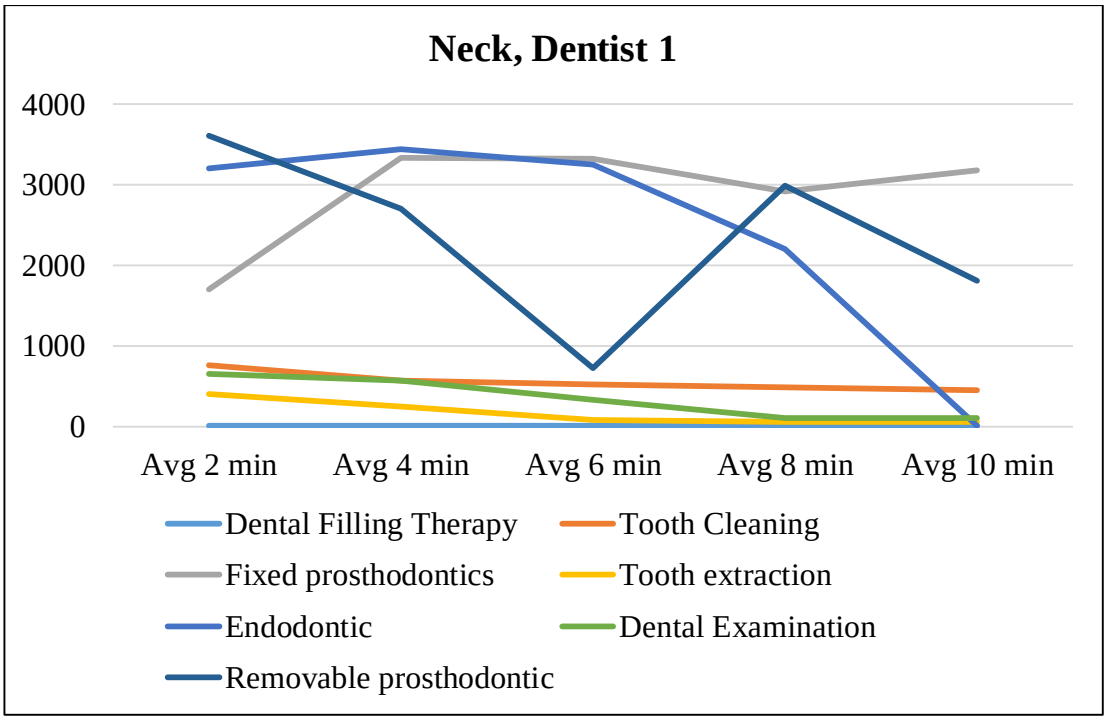

Figure 30. EMG activity at the neck of Dentist 1

When we consider pressure of neck for dentist 2 (figure 31), six work tasks were significantly more than the neck discomfort while applying removable prosthodontics treatment which was shown in figure 31. The most pressure on neck was seen while she was applying tooth extraction.

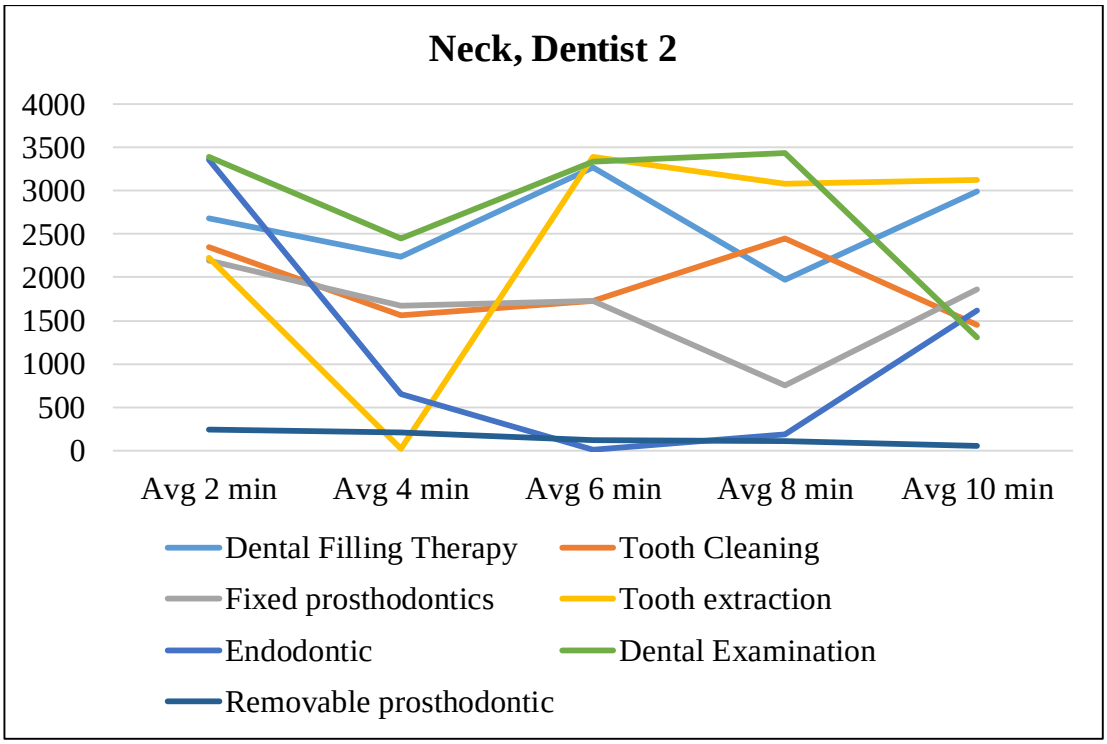

Figure 31. EMG activity at the neck of Dentist 2

Figure 32 illustrated neck pressure for dentist 3 while he was treating patients. When dentists 3 started tooth cleaning and dental examination the neck muscle fatigue was high and decreased with time. The highest pressure was shown while dentist was applying Endodontic treatment.

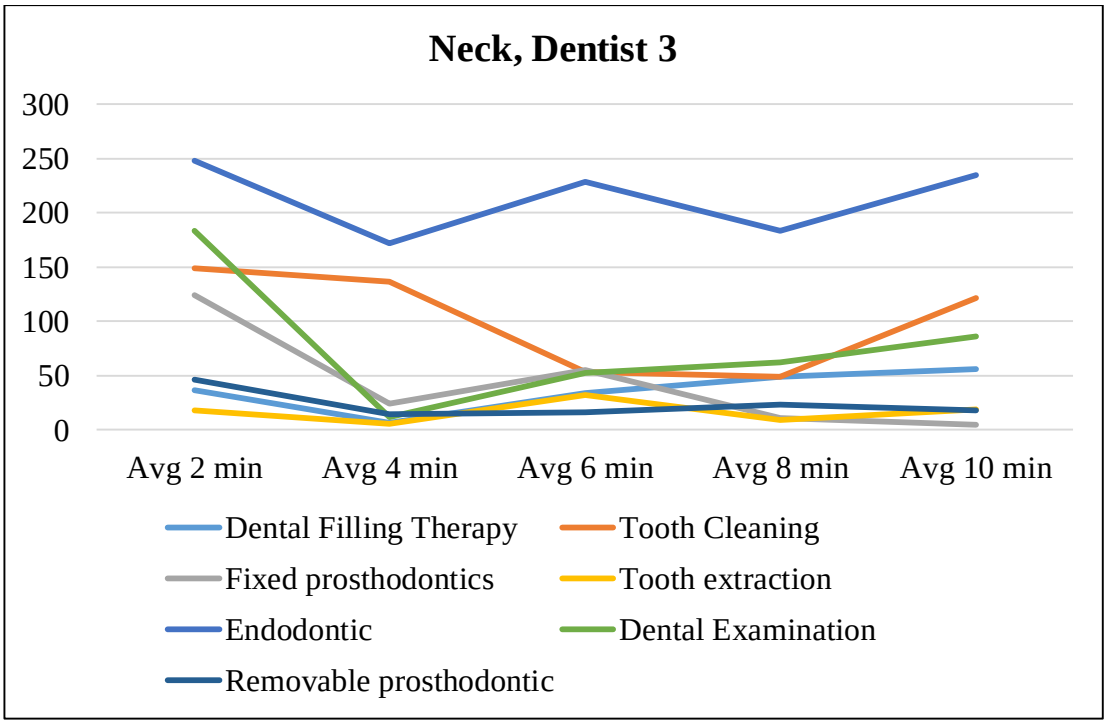

Figure 32. EMG activity at the neck of Dentist 3

4.3.4 Shoulder

The highest pressure of shoulder was identified as dental examination for Dentist 1 when he was applying 7 tasks. After average of 8 minutes the pressure on shoulder was increased as shown in figure 33.

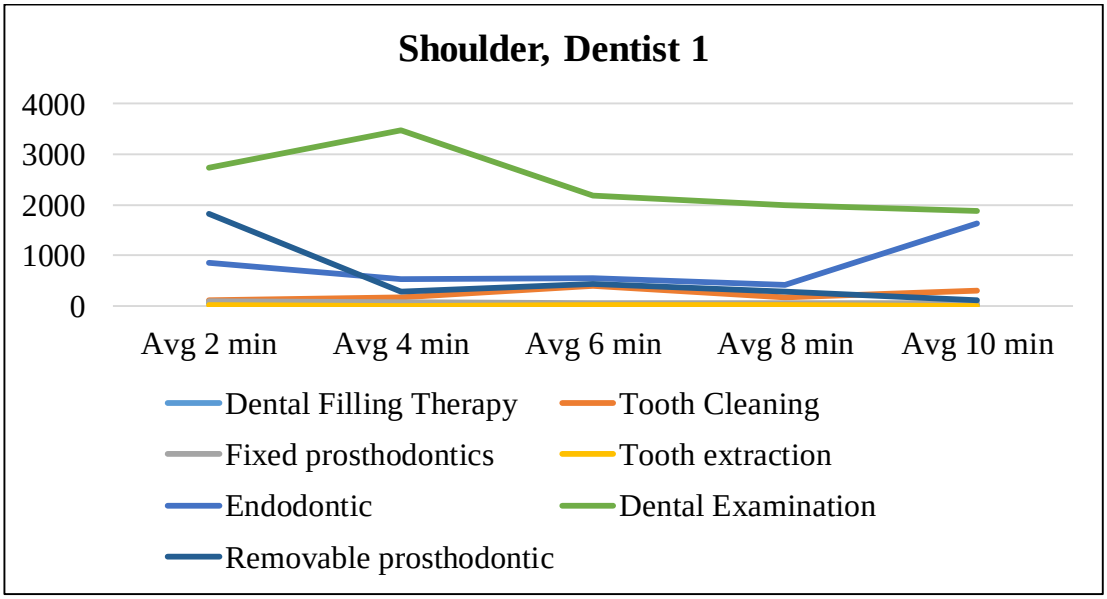

Figure 33. EMG activity at the shoulder of Dentist 1

The shoulder pressure on dentist 2 (figure 34) was almost constant on dental examination, tooth cleaning, endodontic. Other tasks decreased pressure during time. Lowest pressure is removable prosthodontics and the highest shoulder pressure on female dentist was seen in dental filling therapy and fixed prosthodontics. However fixed prosthodontics pressure decreases during time.

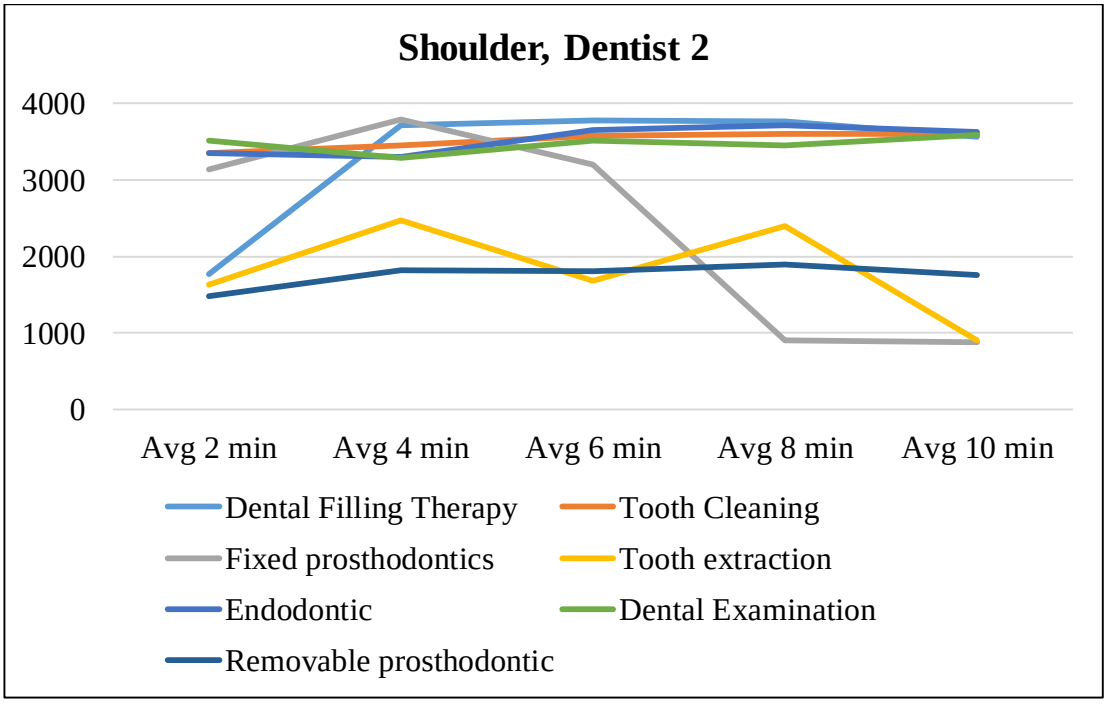

Figure 34. EMG activity at the shoulder of Dentist 2

When the pressure on dentist 3 (figure 35) is considered, after the average of four minutes, fixed prosthodontics was the highest pressure than other tasks such as endodontic or dental examination which almost had a constant pressure pattern.

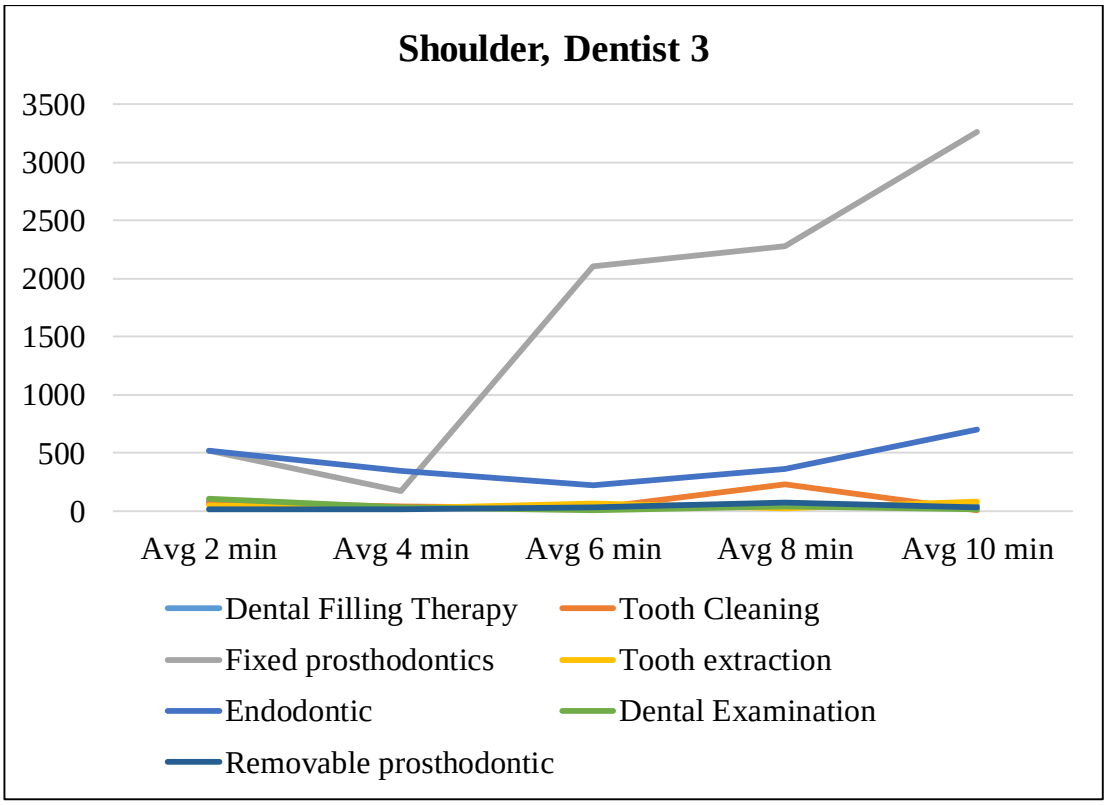

Figure 35. EMG activity at the shoulder of Dentist 3

4.3.5 Upper back

Figure 36 shows the upper back pressure on the first dentist. Although removable prosthodontics starts with a low pressure but with time it increased the pressure. Therefore as an average removable prosthodontics is having highest pressure after dental filling therapy and tooth extraction respectively.

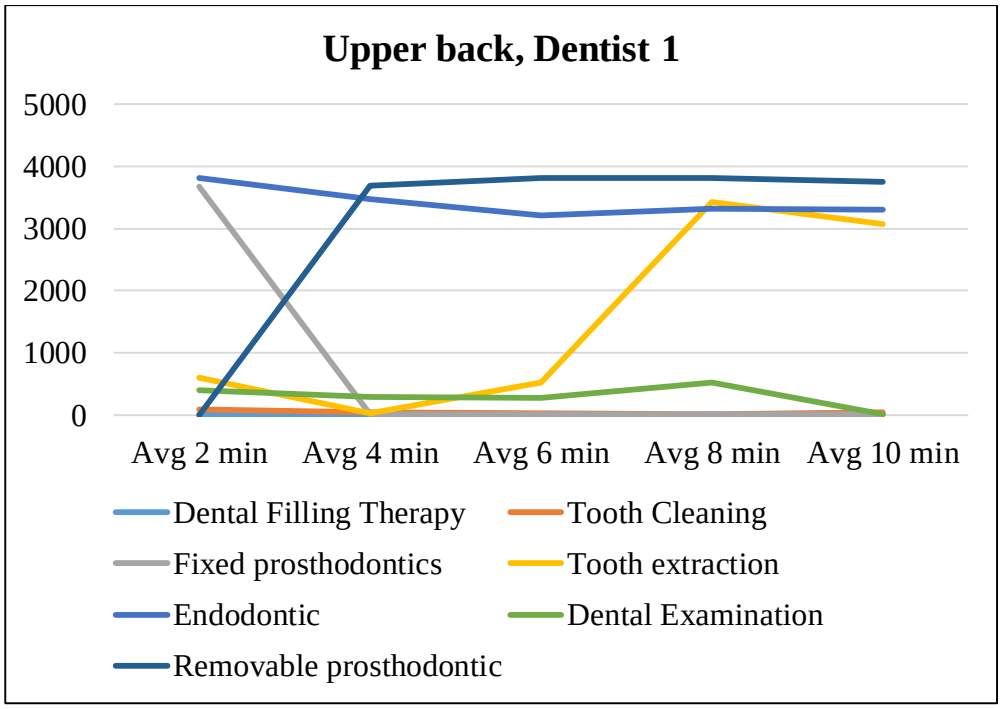

Figure 36. EMG activity at the upper back of Dentist 1

When the pressure on the upper back of the second dentist is considered, it is seen that dental examination has the highest pressure pick but as an average dental filling therapy had the highest pressure on the upper back as seen in figure 37.

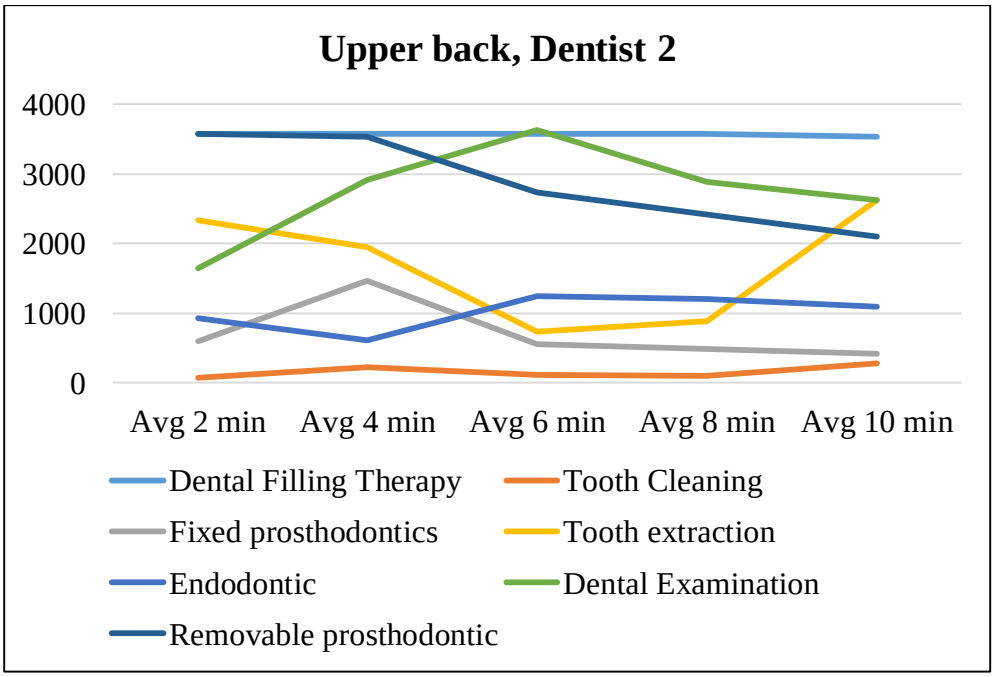

Figure 37. EMG activity at the upper back of Dentist 2

The upper back pressure applied on the third dentist is investigated and as a result fixed prosthodontics had the highest value as seen in the figure 38. Tooth cleaning applies the second highest pressure on the dentist which almost had the same value with fixed prosthodontics.

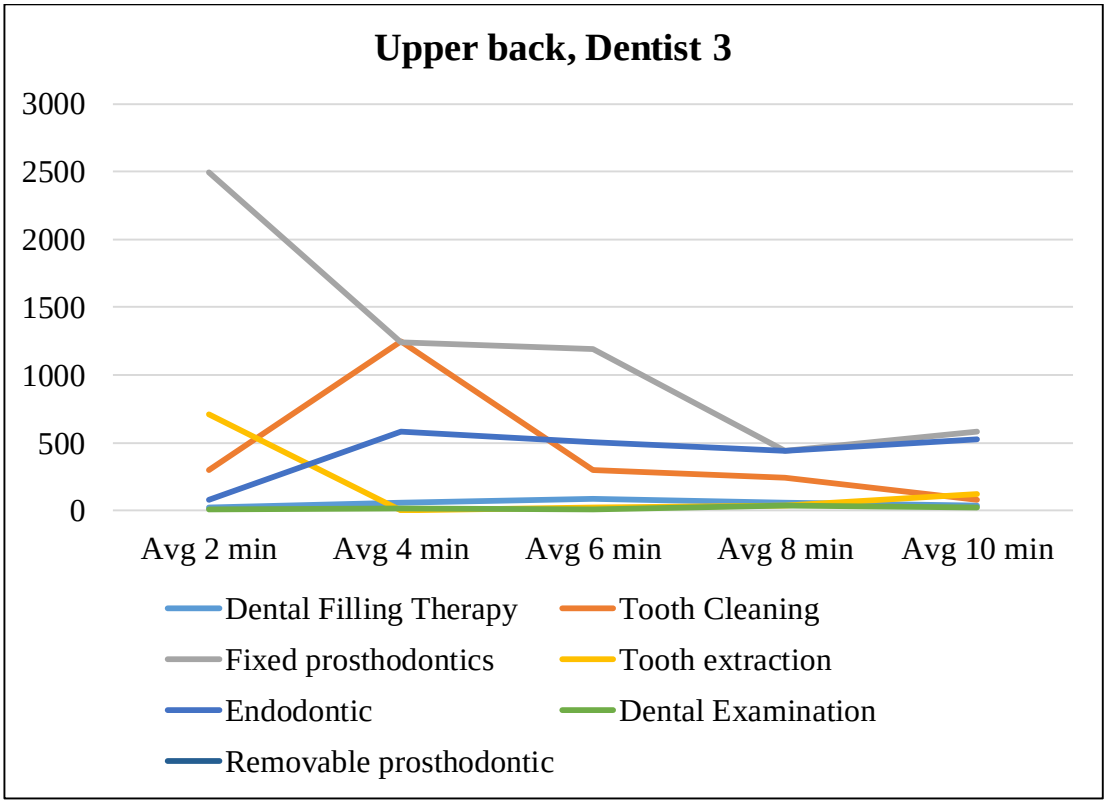

Figure 38. EMG activity at the upper back of Dentist 3

4.3.6 Lower back

The highest lower back pressure on dentist 1 was obtained to be removable prosthodontics. Although it drops with time, still it increases and results to be the highest value as an average. The second highest parameter is tooth cleaning which starts at low value but increases remarkably after the average of six minutes as seen in figure 39.

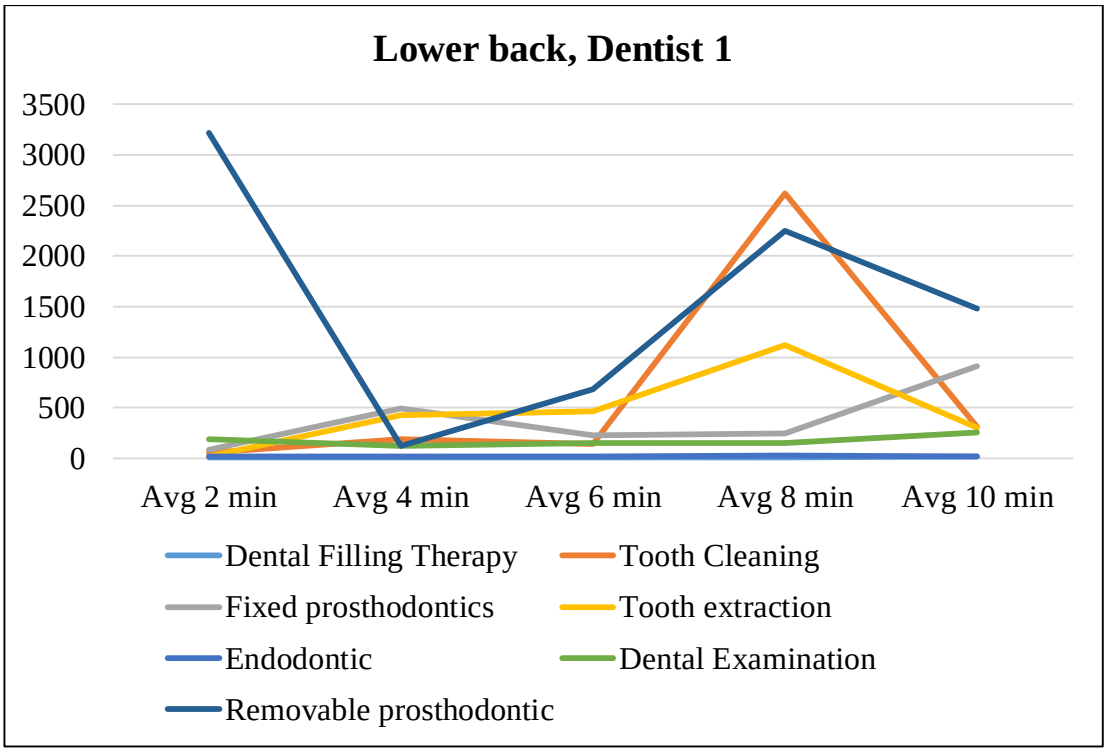

Figure 39. EMG activity at the lower back of Dentist 1

Dental filling therapy had the highest pressure pick on lower back of the dentist 2 (figure 40). It drops at the average of four minutes and increases and reaches its highest point at the average of six minutes. Fixed prosthodontics and dental examinations applied the highest pressure on the dentist after dental filling therapy.

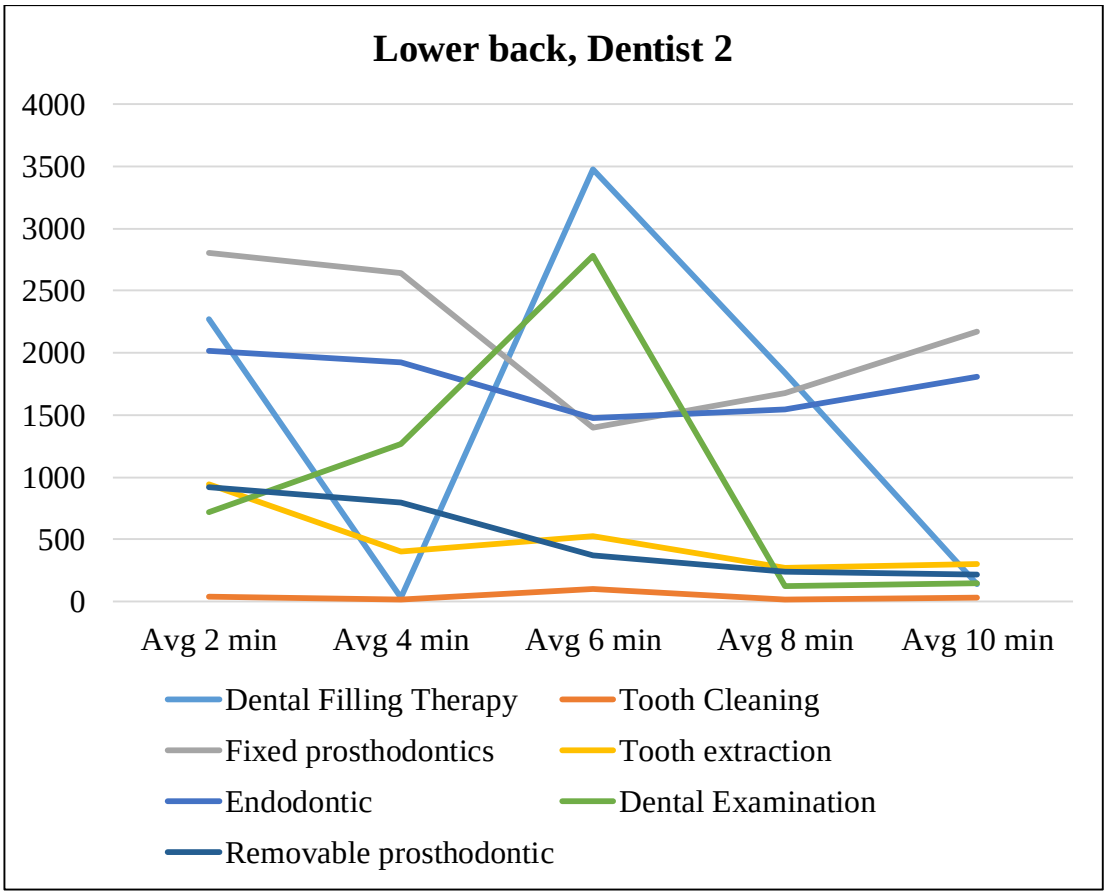

Figure 40. EMG activity at the lower back of Dentist 2

The highest pressure applied on the lower back of the dentist 3 was seen in fixed prosthodontics task which is remarkably higher than other tasks. It drops at the average of 8 minutes but again increases. After this task, dental examination has the second highest pressure on the dentist 3 (figure 41).

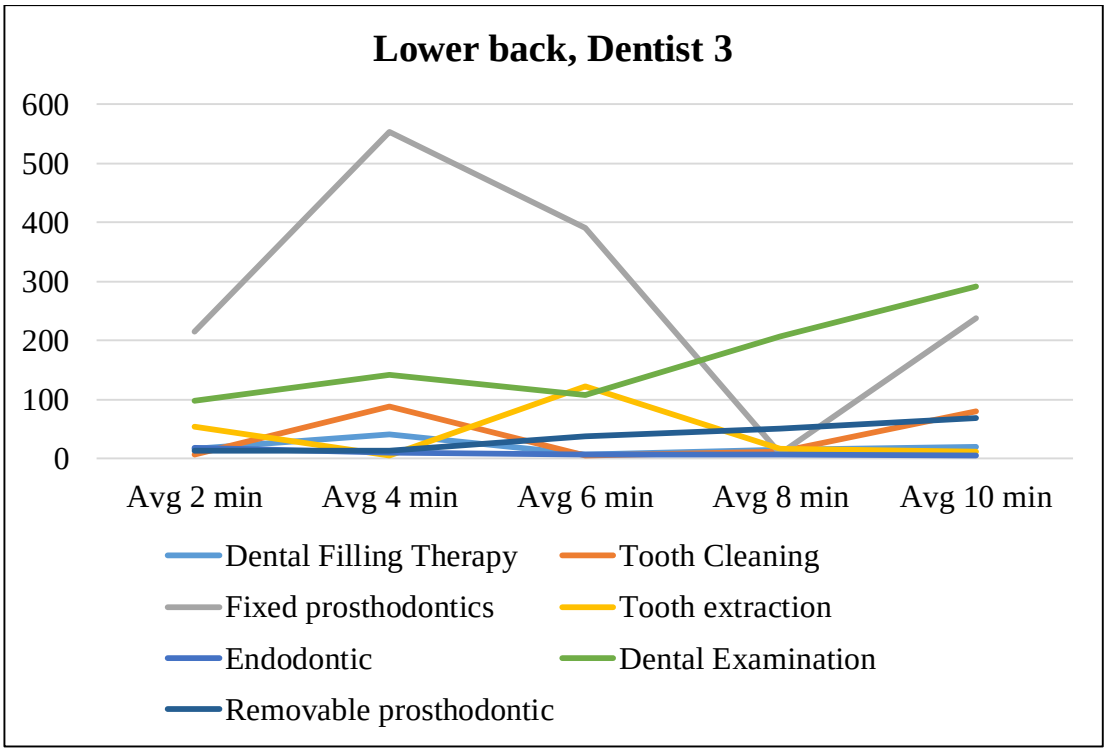

Figure 41. EMG activity at the lower back of Dentist 3

4.4 ANOVA Results

4.4.1 Dentists based on musculoskeletal strain on seven different dental tasks

Muscle activities were collected from sEMG for each 30 minutes interval. When we consider one muscle activity, the data were taken each 2 minutes in 10 minutes interval.

The test hypothesis (H_0 = The median frequency (MDF) electrical activity [in time] in the six muscle group does not differ) ANOVA table is applied for each dentist.

Table 21. EMG recordings for Dentist 1 while Dental Filling Therapy

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Upper back	12,44	6,53	11,48	13,16	17,34
Neck	4,91	3,18	4,22	4,16	4,38
Elbow/ Forearm	27,45	19,28	16,17	14,49	3,98
Hand/ Wrist	11,70	7,88	11,15	5,80	15,38

Lower back	12,29	6,94	13,10	8,47	15,61
Shoulder	57,99	12,40	16,36	16,67	17,67

Muscular activity of dentist 1 is shown on table 21 while applying Dental Filling Therapy. By considering six muscle groups activity of dental filling therapy based in table 22, it is seen that the hypothesis was rejected because F_0 is greater than $F_{critical}$ value (2,847 > 2,620). This means that dental filling therapy has discomfort effects on all six muscle groups of dentist 1.

Table 22. ANOVA results for Dentist 1, Dental Filling Therapy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	1124,743	5	224,9487	2,847302	0,037145	2,620654
Within Groups	1896,1	24	79,00415			
Total	3020,843	29				

Table 23. EMG recordings for Dentist 1 while Tooth Cleaning treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	990,10	614,26	677,27	791,28	363,57
Elbow/ Forearm	82,88	40,98	49,50	56,39	24,41
Neck	757,87	567,31	524,25	481,61	448,84
Shoulder	102,02	175,27	387,34	161,58	298,78
Upper back	85,49	37,62	24,39	11,45	40,05
Lower back	56,26	193,79	138,84	2621,8	312,98

Table 23 shows the EMG recording for dentist 1 while applying tooth cleaning. By considering six muscle groups activity based on table 24, it is seen that the hypothesis was fail to reject hypothesis because F_0 is smaller than $F_{critical}$ value (2,114 > 2,620).

This means that tooth cleaning treatment has no discomfort for all six muscle groups of dentist 1.

Table 24. ANOVA results for Dentist 1, Tooth Cleaning treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	2270278	5	454055,6	2,11497	0,098397	2,620654
Within Groups	5152478	24	214686,6			
Total	7422756	29				

Table 25. EMG recordings for Dentist 1 while Fixed Prosthodontics treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	2951,1	2549,8	1214,1	1605,3	585,56
Elbow/ Forearm	605,00	162,23	92,27	102,04	59,19
Neck	1696,7	3332,8	3319,0	2923,0	3181,8
Shoulder	94,12	79,79	53,17	58,70	52,90
Upper back	3675,2	8,67	7,85	11,82	11,21
Lower back	89,08	495,60	226,28	247,39	911,06

Table 25 shows the EMG recording for dentist 1 for fixed prosthodontics treatment task. Six muscle groups activity based on table 26 shows that the hypothesis was reject hypothesis because F_0 is greater than $F_{critical}$ value (8,635 > 2,620). This means that fixed prosthodontics treatment has discomfort for all six muscle groups of dentist 1.

Table 26. ANOVA results for Dentist 1, Fixed Prosthodontics treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	30598486	5	6119697	8,635778	0,000086	2,620654
Within Groups	17007470	24	708644,6			
Total	47605956	29				

Table 27. EMG recordings for Dentist 1 while Tooth Extraction treatment

Body Region	Minutes				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	1572,6	1414,2	1679,9	685,43	887,63
Elbow/ Forearm	597,37	484,43	428,24	320,21	390,52
Neck	405,36	242,15	83,89	60,91	57,27
Shoulder	6,84	5,70	9,22	12,34	6,10
Upper back	602,39	36,64	525,06	3427,3	3067,2
Lower back	18,87	423,12	461,67	1119,2	306,60

Table 27 shows the EMG recording for while applying tooth extraction treatment task. With the six muscle group's activity illustration on table 28, it shows that the hypothesis was reject hypothesis because F_0 is greater than $F_{critical}$ value (3,828 > 2,620). This means that tooth extraction treatment has discomfort for all six muscle groups of dentist 1.

Table 28. ANOVA results for Dentist 1, Tooth Extraction treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	9268303	5	1853661	3,828827	0,010831	2,620654
Within Groups	11619187	24	484132,8			
Total	20887490	29				

Table 29 shows the EMG recording for dentist 1 for endodontic treatment task. Six muscle groups activity based on ANOVA results as shown in table 30, shows that the hypothesis was reject hypothesis because F_0 is greater than $F_{critical}$ value (21,95> 2,620). This means that fixed endodontic treatment has discomfort for all six muscle groups of dentist 1.

Table 29. EMG recordings for Dentist 1 while Endodontic treatment

Body Region	Minutes				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	19,90	109,21	74,12	223,29	236,22
Elbow/ Forearm	1297,2	1433,2	723,28	728.36	687,05
Neck	3200,9	3439,2	3256,3	2201,5	4,72
Shoulder	855,82	524,42	551,37	412,64	1634,4
Upper back	3807,8	3470,7	3218,0	3327,1	3306,5
Lower back	18,69	21,23	23,62	24,53	16,60

Table 30. ANOVA results for Dentist 1, Endodontic treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	45675088,60	5	9135017,72	21,95	0,00000	2,620654
Within Groups	9987977,99	24	416165,75			
Total	55663066,59	29				

Table 31. EMG recordings for Dentist 1 while Dental Examination treatment

Body Region	Minutes				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	212,85	293,88	234,12	273,93	353,45
Elbow/ Forearm	1033,8	979,43	835,29	600,43	570.42
Neck	653,06	569,04	332,47	107,07	103,27
Shoulder	2730,9	3472,2	2182,8	1995,9	1877,8
Upper back	392,56	284,67	274,10	526,63	19,03
Lower back	192,00	124,92	148,09	153,53	257,31

Table 31 shows the EMG recording for while applying dental examination treatment. With the six muscle group's activity illustration on table 32, it shows that the hypothesis was reject hypothesis because F_0 is greater than F_{critical} value (39,254 > 2,620). This means that dental examination treatment has discomfort for all six muscle groups of dentist 1.

Table 32. ANOVA results for Dentist 1, Dental Examination treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	19070168	5	3814034	39,25408	0,000000	2,620654
Within Groups	2331905	24	97162,72			
Total	21402073	29				

Table 33. EMG recordings for Dentist 1 while Removable Prosthodontics treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	221,15	974,05	651,77	544,48	622,60
Elbow/ Forearm	98,60	153,88	183,22	173,58	189,00
Neck	3606,3	2699,1	728,54	2992,3	1804,1
Shoulder	1816,7	278,79	434,72	282,43	112,57
Upper back	4,75	3692,5	3817,6	3813,4	3760,5
Lower back	3219,9	127,87	681,33	2252,9	1479,4

Table 33 shows the EMG recording for dentist 1 while applying removable prosthodontics treatment. By considering six muscle groups activity based on table 34, it is seen that the hypothesis was rejected hypothesis because F_0 is greater than $F_{critical}$ value (6,226 > 2,620). This means that removable prosthodontics treatment has a discomfort effect on all six muscle groups of dentist 1.

Table 34. ANOVA results for Dentist 1, Removable Prosthodontics treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	32047277	5	6409455	6,226711	0,000778	2,620654
Within Groups	24704364	24	1029348			
Total	56751641	29				

Table 35. EMG recordings for Dentist 2 while Dental Filling Therapy

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**

Hand / Wrist	49,40	35,41	50,33	61,16	55,98
Elbow/ Forearm	202,76	156,44	224,03	78,71	104,16
Neck	2678,7	2234,8	3269,2	1967,0	2991,9
Shoulder	1770,1	3708,3	3778,0	3761,2	3562,1
Upper back	3574,3	3579,8	3579,6	3570,6	3536,1
Lower back	2269,7	32,68	3480,4	1837,3	137,57

Table 36. ANOVA results for Dentist 2, Dental Filling Therapy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	59541938	5	11908388	22,33715	0,000000	2,620654
Within Groups	12794884	24	533120,2			
Total	72336823	29				

EMG data shown in table 35 for six different muscle group. ANOVA table (Table 36) result shows that F_0 value is greater than $F_{critical}$. We supposed that hypothesis test is: mean musculoskeletal strain [in time] on body regions does not differ when dentist 2 was applying dental filling therapy. Since F_0 is greater than $F_{critical}$, hypothesis test is rejected. It means that dental filling therapy has significant disorders on group of muscles.

Table 37. EMG recordings for Dentist 2 while Tooth Cleaning treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	405,17	3494,4	2408,5	2406,7	728,26
Elbow/ Forearm	495,60	385,63	342,00	824,90	282,19
Neck	2354,5	1559,4	1732,5	2453,7	1452,9
Shoulder	3352,9	3449,7	3572,5	3600,8	3598,4
Upper back	73,55	228,63	118,72	101,00	274,50
Lower back	36,99	15,53	99,33	16,27	30,18

Table 38. ANOVA results for Dentist 2, Tooth Cleaning treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	46023491	5	9204698	28,36011	0,000000	2,620654
Within Groups	7789560	24	324565			
Total	53813051	29				

Table 37 shows EMG data for muscle group for dentist 2 in duration of 30 minutes when she was applying tooth cleaning treatment. The ANOVA table (table 38) shows that the F_0 value is greater than $F_{critical}$. In this case hypothesis is rejected. It means that tooth cleaning causes disorders on body regions for the second dentist.

Table 39. EMG recordings for Dentist 2 while Fixed Prosthodontics treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	1171,6	647,92	1181,9	2389,9	288,41
Elbow/ Forearm	1156,1	570,16	1200,6	667,11	115,20
Neck	2195,5	1670,8	1727,5	751,40	1863,1
Shoulder	3140,1	3792,5	3202,7	904,50	873,50
Upper back	593,11	1468,3	560,97	485,95	421,48
Lower back	2806,9	2639,8	1400,0	1676,4	2169,7

Table 40. ANOVA results for Dentist 2, Fixed Prosthodontics treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	12670312	5	2534062	4,224262	0,006768	2,620654
Within Groups	14397189	24	599882,9			
Total	27067501	29				

Table 39 illustrates that pressure of muscle group's data while dentist 2 was applying fixed prosthodontics treatment. In table 40 show us F_0 is greater than $F_{critical}$ value

which means that suggested hypothesis rejected (4,224>2,620). In this case fixed prosthodontics treatment has discomfort on muscle group for dentist 2.

Table 41. EMG recordings for Dentist 2 while Tooth Extraction treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	1882,2	2311,6	1332,9	761,63	11,77
Elbow/ Forearm	66,96	60,39	59,06	47,42	234,07
Neck	2229,6	16,60	3390,1	3084,9	3123,7
Shoulder	1627,1	2466,9	1678,9	2393,5	903,70
Upper back	2333,7	1944,4	735,23	886,49	2619,7
Lower back	942,93	400,14	523,44	269,14	299,86

Table 42. ANOVA results for Dentist 2, Tooth Extraction treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	18435253	5	3687051	5,582777	0,001502	2,620654
Within Groups	15850395	24	660433,1			
Total	34285647	29				

The result of table 42 F_0 (5,582) is greater than $F_{critical}$ (2,620) which means that hypothesis is rejected. Tooth extraction has sigificant influence of discomfort on muscle group for dentist 2.

Table 43. EMG recordings for Dentist 2 while Endodontic treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	70,64	270,09	221,76	257,12	222,90
Elbow/ Forearm	229,89	276,98	256,69	269,90	246,61
Neck	3358,4	654,68	4,92	180,30	1615,8
Shoulder	3347,9	3303,9	3650,9	3713,3	3621,1
Upper back	931,92	608,25	1246,7	1199,5	1096,7
Lower back	2016,8	1924,9	1476,0	1548,7	1810,2

Table 44. ANOVA results for Dentist 2, Endodontic treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	37732209	5	7546442	21,96567	0,000000	2,620654
Within Groups	8245347	24	343556,1			
Total	45977555	29				

According to table 43, muscles strains' data was collected while dentist 2 was applying endodontic treatment in 30 minutes time interval. Table 44 shows that endodontic treatment has significant discomfort on muscle groups because of the fact that F_0 is greater than $F_{critical}$ value. This means that suggested hypothesis rejected.

Table 45. EMG recordings for Dentist 2 while Dental Examination treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	174,33	209,23	223,00	3480,3	3240,1
Elbow/ Forearm	1728,6	3823,6	3831,1	1705,4	1255,6
Neck	3389,8	2449,6	3337,8	3442,5	1304,6
Shoulder	3510,5	3287,8	3515,2	3451,9	3589,4
Upper back	1642,0	2912,0	3631,0	2885,3	2628,2
Lower back	719,41	1266,7	2783,1	125,37	150,29

Table 46. ANOVA results for Dentist 2, Dental Examination treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	20940983	5	4188197	3,510959	0,015981	2,620654
Within Groups	28629420	24	1192892			
Total	49570403	29				

The hypothesis rejected because F_0 is greater than $F_{critical}$ as shown in table 46. This means that dental examination causes disorders on muscle group for dentist 2.

Table 47. EMG recordings for Dentist 2 while Removable Prosthodontics treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	1339,9	2807,8	1562,5	287,66	425,99
Elbow/ Forearm	3713,6	3528,8	3343,4	2297,9	2083,2
Neck	237,98	207,41	121,90	109,65	50,79
Shoulder	1476,4	1813,7	1811,2	1897,7	1758,2
Upper back	3570,7	3528,2	2733,8	2411,4	2095,9
Lower back	921,15	799,34	375,00	239,75	221,45

Table 48. ANOVA results for Dentist 2, Removable Prosthodontics treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	34859559	5	6971912	19,27976	0,000000	2,620654
Within Groups	8678837	24	361618,2			
Total	43538397	29				

Table 47 shows that muscle strain for dentist 2 while applying prosthodontics treatment. According to table 48 suggested hypothesis rejected because F_0 value is greater than $F_{critical}$ value which means that removable prosthodontics has significant discomfort on muscle group for dentist 2.

Table 49. EMG recordings for Dentist 3 while Dental Filling Therapy

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	15,97	161,05	224,91	31,01	20,27
Elbow/ Forearm	63,76	83,42	123,14	75,41	18,24
Neck	36,63	6,67	33,57	48,68	56,50
Shoulder	79,98	25,44	42,55	60,55	50,46
Upper back	23,33	59,75	84,81	58,17	39,63
Lower back	17,06	40,05	7,19	14,92	19,14

Table 50. ANOVA results for Dentist 3, Dental Filling Therapy

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	15946,18	5	3189,237	1,574121	0,20529	2,620654
Within Groups	48625,02	24	2026,043			
Total	64571,21	29				

Muscle group data shown in table 49. H_0: mean musculoskeletal strain (in time) of the 6 body region does differ for applying dental filling therapy. The assumption is failed to reject because F_0 value is smaller than $F_{critical}$. This means that dental filling therapy has no significant disorder on six muscle group for dentist 3.

Table 51. EMG recordings for Dentist 3 while Tooth Cleaning treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	12,84	13,15	11,69	20,11	10,96
Elbow/ Forearm	13,35	18,77	38,62	63,74	24,01
Neck	149,03	136,96	53,39	48,94	121,65
Shoulder	72,06	44,52	25,62	231,10	4,73
Upper back	297,62	1246,9	302,08	240,69	77,47
Lower back	6,45	88,35	5,49	10,63	79,33

Table 52. ANOVA results for Dentist 3, Tooth Cleaning treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	629619,4	5	125923,9	3,314879	0,020415	2,620654
Within Groups	911699,3	24	37987,47			
Total	1541319	29				

The EMG data for dentist 3 collected on table 51. H_0 is: mean musculoskeletal strain [in time] of the six body region does not differ. The ANOVA result for muscle group

shows that again F_0 value is greater than $F_{critical}$ and hypothesis test is rejected. It means that tooth cleaning task has significant disorders on muscles for dentist 3 as seen in table 52.

Table 53. EMG recordings for Dentist 3 while Fixed Prosthodontics treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	58,96	101,26	27,91	18,10	37,85
Elbow/ Forearm	143,29	184,79	103,36	70,65	57,43
Neck	124,07	23,85	55,55	11,43	5,19
Shoulder	524,06	171,05	2109,6	2278,8	3264,8
Upper back	2493,6	1240,4	1194,2	441,37	584,84
Lower back	214,69	552,58	390,95	7,55	236,97

Table 54. ANOVA results for Dentist 3, Fixed Prosthodontics treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	12178792	5	2435758	6,161433	0,00083	2,620654
Within Groups	9487760	24	395323,3			
Total	21666551	29				

When we consider table 53, EMG data is shown based on fixed prosthodontics treatment when dentist 3 was applying the corresponding task. According to ANOVA result the hypothesis is rejected by reason of F_0 value is greater than $F_{critical}$ value. This means that there is a significant disorder on muscle while dentist was applying fixed prosthodontics as same the previous ones.

Table 55. EMG recordings for Dentist 3 while Tooth Extraction treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	9,40	15,13	18,06	21,83	38,88
Elbow/ Forearm	805,88	15,22	73,11	98,31	270,91

Neck	18,44	5,86	32,59	8,87	19,07
Shoulder	51,93	25,06	65,54	22,76	80,87
Upper back	711,96	5,48	24,73	39,89	120,42
Lower back	53,06	4,78	122,02	15,56	11,50

Table 56. ANOVA results for Dentist 3, Tooth Extraction treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	243736,5	5	48747,31	1,476098	0,234438	2,620654
Within Groups	792586,7	24	33024,45			
Total	1036323	29				

Group of muscle data shown in table 55. Mean musculoskeletal strain [in time] of the six body region differs while dentist was applying tooth extraction. The assumption is failed to reject because the F_0 value is smaller than $F_{critical}$ value. It means that tooth extraction treatment has no significant disorder on body muscles (Table 56).

Table 57. EMG recordings for Dentist 3 while Endodontic treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	28,43	43,98	16,99	7,13	14,26
Elbow/ Forearm	43,44	246,19	70,18	321,36	242,08
Neck	248,42	172,05	228,50	183,79	234,38
Shoulder	521,69	343,90	221,31	366,83	702,85
Upper back	77,38	586,46	504,57	442,93	523,99
Lower back	18,28	10,39	6,88	6,05	5,41

Table 58. ANOVA results for Dentist 3, Endodontic treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	860730,6	5	172146,1	11,30731	0,000011	2,620654
Within Groups	365383,8	24	15224,33			

Total	1226114	29

EMG data shown in table 57 for dentist 3 in 30 minutes. H_0: mean musculoskeletal strain [in time] of six body region does not differ. The result of ANOVA table as shown in table 58 shows that F_0 value is greater than $F_{critical}$. In this case as same as other conditions, hypothesis test is rejected and it shows that endodontic treatment has significant disorders on six body region for dentist 3.

Table 59. EMG recordings for Dentist 3 while Dental Examination treatment

Body Region	**Minutes**				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	1569,1	260,37	3285,5	3457,7	3442,7
Elbow/ Forearm	1429,8	700,69	3375,4	3546,8	3551,6
Neck	183,52	12,04	52,47	62,73	86,16
Shoulder	110,14	34,04	6,14	37,59	16,43
Upper back	1551,0	1705,1	801,33	1276,0	1999,3
Lower back	98,16	141,38	108,06	207,28	291,98

Table 60. ANOVA results for Dentist 3, Dental Examination treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	34398060	5	6879612	10,01707	0,000028	2,620654
Within Groups	16482932	24	686788,8			
Total	50880991	29				

The EMG data for dentist 3 collected on table 59. H_0: mean musculoskeletal strain [in time] of six body region. The ANOVA result for group of muscles shows that F_0 value is greater than $F_{critical}$ and hypothesis test is rejected. There is a significant disorder on muscles while applying dental examination treatment as shown in table 60.

Table 61. EMG recordings for Dentist 3 while Removable Prosthodontics treatment

Body Region	Minutes				
	2	**4**	**6**	**8**	**10**
Hand / Wrist	120,21	186,76	179,37	565,23	472,85
Elbow/ Forearm	12,79	7,53	5,90	7,26	15,32
Neck	46,52	14,19	15,88	23,25	18,07
Shoulder	20,86	18,99	33,72	71,41	32,93
Upper back	8,98	17,79	9,99	39,92	26,29
Lower back	13,79	12,83	37,02	50,07	69,18

Table 62. ANOVA results for Dentist 3, Removable Prosthodontics treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit.*
Between Groups	328382,4	5	65676,47	9,532707	0,000041	2,620654
Within Groups	165350,2	24	6889,593			
Total	493732,6	29				

Last dental task is performed by dentist 3 and based on data, mean musculoskeletal strain [in time] of six body region does not differ. The assumption is rejected because the F_0 value is greater than $F_{critical}$. It means that removable prosthodontics has significant disorder on muscle group for dentist 3 as seen in table 62.

4.4.2 Musculoskeletal strain on seven different dental tasks

In another hypothesis tests, EMG data shows the musculoskeletal strains on body regions for three dentists. Muscle strains of all participants were evaluated according to dental tasks separately.

Hypothesis H_0: (The median frequency (MDF) electrical activity in the muscle i does not differ on dental task is tested on three participant dentist.

Table 63. EMG recordings for Dental Filling Therapy

Body Region	Dentist	Minutes				
		2	4	6	8	10
Hand / Wrist	1	11,7	7,88	11,15	5,8	15,38
	2	49,4	35,41	50,33	61,16	55,98
	3	15,97	161,05	224,91	31,01	20,27
Elbow/ Forearm	1	27,45	19,28	16,17	14,49	3,98
	2	202,76	156,44	224,03	78,71	104,16
	3	63,76	83,42	123,14	75,41	18,24
Neck	1	4,91	3,18	4,22	4,16	4,38
	2	2678,7	2234,8	3269,2	1967	2991,9
	3	36,63	6,67	33,57	48,68	56,5
Shoulder	1	57,99	12,4	16,36	16,67	17,67
	2	1770,1	3708,3	3778	3761,2	3562,1
	3	79,98	25,44	42,55	60,55	50,46
Upper back	1	12,44	6,53	11,48	13,16	17,34
	2	3574,3	3579,8	3579,6	3570,6	3536,1
	3	23,33	59,75	84,81	58,17	39,63
Lower back	1	12,29	6,94	13,1	8,47	15,61
	2	2269,7	32,68	3480,4	1837,3	137,57
	3	17,06	40,05	7,19	14,92	19,14

Table 64. ANOVA results for Dentists, Dental Filling Therapy

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit*
Body Region	19526314	5	3905263	**2,280873**	2,37
Time	816686,42	4	204171,6	0,119247	2,53
Interaction	23703291	20	1185165	0,692197	1,75
Error	102730745	60	1712179	1	
Total	146777037	89			

The result from table 64 shows F_{BR} value is greater than $F_{critical}$. This means that only body region factor is significant on dental filling therapy for all participants.

Table 65. ANOVA results for Dentists, Tooth Cleaning treatment.

Body Region	Dentist	Minutes				
		2	4	6	8	10
Hand / Wrist	1	990,1	614,26	677,27	791,28	363,57
	2	405,17	3494,4	2408,5	2406,7	728,26
	3	12,84	13,15	11,69	20,11	10,96
Elbow/ Forearm	1	82,88	40,98	49,5	56,39	24,41
	2	495,6	385,63	342	824,9	282,19
	3	13,35	18,77	38,62	63,74	24,01
Neck	1	757,87	567,31	524,25	481,61	448,84
	2	2354,5	1559,4	1732,5	2453,7	1452,9
	3	149,03	136,96	53,39	48,94	121,65
Shoulder	1	102,02	175,27	387,34	161,58	298,78
	2	3352,9	3449,7	3572,5	3600,8	3598,4
	3	72,06	44,52	25,62	231,1	4,73
Upper back	1	85,49	37,62	24,39	11,45	40,05
	2	73,55	228,63	118,72	101	274,5
	3	297,62	1246,9	302,08	240,69	77,47
Lower back	1	56,26	193,79	138,84	2621,8	312,98
	2	36,99	15,53	99,33	16,27	30,18
	3	6,45	88,35	5,49	10,63	79,33

Table 66. EMG recordings for Tooth Cleaning treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit*
Body Region	15538960	5	3107792	1,815109	2,37
Time	1250628,4	4	312657,1	0,182608	2,53
Interaction	20103643	20	1005182	0,587078	1,75
Error	89383970	60	1489733	0,87008	
Total	126277201	89			

When we consider table 65, all EMG data were collected in one table with considering dentists and their body regions for one dental task. As a result of table 66, we can say that there is no significant factor for tooth cleaning treatment among variations. $F_{critical}$ values are bigger that F_{BR}, F_T, and $F_{intereaction}$.

Table 67. EMG recordings for Fixed Prosthodontics treatment

Body Region	Dentist	Minutes				
		2	4	6	8	10
Hand / Wrist	1	2951,10	2549,80	1214,10	1605,30	585,56
	2	1171,60	647,92	1181,90	2389,90	288,41
	3	58,96	101,26	27,91	18,10	37,85
Elbow/ Forearm	1	605,00	162,23	92,27	102,04	59,19
	2	1156,10	570,16	1200,60	667,11	115,20
	3	143,29	184,79	103,36	70,65	57,43
Neck	1	1696,70	3332,80	3319,00	2923,00	3181,80
	2	2195,50	1670,80	1727,50	751,40	1863,10
	3	124,07	23,85	55,55	11,43	5,19
Shoulder	1	94,12	79,79	53,17	58,70	52,90
	2	3140,10	3792,50	3202,70	904,50	873,50
	3	524,06	171,05	2109,60	2278,80	3264,80
Upper back	1	3675,20	8,67	7,85	11,82	11,21
	2	593,11	1468,30	560,97	485,95	421,48
	3	2493,60	1240,40	1194,20	441,37	584,84
Lower back	1	89,08	495,60	226,28	247,39	911,06
	2	2806,90	2639,80	1400,00	1676,40	2169,70
	3	214,69	552,58	390,95	7,55	236,97

Table 68. ANOVA results for Dentists, Fixed Prosthodontics treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit*
Body Region	12786799	5	2557360	1,493629	2,37
Time	3197689,5	4	799422,4	0,466903	2,53
Interaction	25741730	20	1287087	0,751724	1,75
Error	218975559	60	3649593	2,131548	
Total	260701777	89			

Table 67 shows EMG data for body regions for the entire participants in duration 10 minutes when they were applying fixed prosthodontics treatment. The ANOVA table as seen in table 68 shows that the $F_{critical}$ values were higher in all parts. In this case there is no significant factor for dentists when applying fixed prosthodontics treatment.

Table 69. EMG recordings for Tooth Extraction treatment

Body Region	Dentist	Minutes				
		2	4	6	8	10
Hand / Wrist	1	1572,60	1414,20	1679,90	685,43	887,63
	2	1882,20	2311,60	1332,90	761,63	11,77
	3	9,40	15,13	18,06	21,83	38,88
Elbow/ Forearm	1	597,37	484,43	428,24	320,21	390,52
	2	66,96	60,39	59,06	47,42	234,07
	3	805,88	15,22	73,11	98,31	270,91
Neck	1	405,36	242,15	83,89	60,91	57,27
	2	2229,60	16,60	3390,10	3084,90	3123,70
	3	2229,60	16,60	3390,10	3084,90	3123,70
Shoulder	1	6,84	5,70	9,22	12,34	6,10
	2	1627,10	2466,90	1678,90	2393,50	903,70
	3	51,93	25,06	65,54	22,76	80,87
Upper back	1	602,39	36,64	525,06	3427,30	3067,20
	2	2333,70	1944,40	735,23	886,49	2619,70
	3	711,96	5,48	24,73	39,89	120,42
Lower back	1	18,87	423,12	461,67	1119,20	306,60
	2	942,93	400,14	523,44	269,14	299,86
	3	53,06	4,78	122,02	15,56	11,50

Table 70. ANOVA results for Dentists, Tooth Extraction treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit*
Body Region	20304279	5	4060856	**2,371747**	2,37
Time	1585062,5	4	396265,6	0,231439	2,53
Interaction	37316474	20	1865824	1,089736	1,75
Error	169689629	60	2828160	1,65179	
Total	228895445	89			

In table 69 has EMG data which taken from dentists. ANOVA table as seen in table 70 shows result of significance of variation. F_{BR} is greater than $F_{critical}$ value. This means that body region factor is significant on tooth extraction treatment.

Table 71. EMG recordings for Endodontic treatment

Body Region	Dentist	Minutes				
		2	4	6	8	10
Hand / Wrist	1	19,9	109,21	74,12	223,29	236,22
	2	70,64	270,09	221,76	257,12	222,9
	3	28,43	43,98	16,99	7,13	14,26
Elbow/ Forearm	1	1297,2	1433,2	723,28	728,36	687,05
	2	229,89	276,98	256,69	269,9	246,61
	3	43,44	246,19	70,18	321,36	242,08
Neck	1	3200,9	3439,2	3256,3	2201,5	4,72
	2	3358,4	654,68	4,92	180,3	1615,8
	3	248,42	172,05	228,5	183,79	234,38
Shoulder	1	855,82	524,42	551,37	412,64	1634,4
	2	3347,9	3303,9	3650,9	3713,3	3621,1
	3	521,69	343,9	221,31	366,83	702,85
Upper back	1	3807,8	3470,7	3218	3327,1	3306,5
	2	931,92	608,25	1246,7	1199,5	1096,7
	3	77,38	586,46	504,57	442,93	523,99
Lower back	1	18,69	21,23	23,62	24,53	16,6
	2	2016,8	1924,9	1476	1548,7	1810,2
	3	18,28	10,39	6,88	6,05	5,41

Table 72. ANOVA results for Dentists, Endodontic treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit*
Body Region	29963331	5	5992666	**3,500023**	2,37
Time	802174,47	4	200543,6	0,117128	2,53
Interaction	35808534	20	1790427	1,045701	1,75
Error	201110397	60	3351840	1,957646	
Total	267684437	89			

In table 71 dentists' all body parts are considered for analyzing muscle strain while dentists were applying endodontic treatment. Based on table 72, only body region factor is significant on endodontic treatment. Because F_{BR} is greater than $F_{critical}$ value.

Table 73. EMG recordings for Dental Examination treatment

Body Region	Dentist	Minutes				
		2	4	6	8	10
Hand / Wrist	1	212,85	293,88	234,12	273,93	353,45
	2	174,33	209,23	223,00	3480,30	3240,10
	3	1569,10	260,37	3285,50	3457,70	3442,70
Elbow/ Forearm	1	1033,80	979,43	835,29	600,43	570,42
	2	1728,60	3823,60	3831,10	1705,40	1255,60
	3	1429,80	700,69	3375,40	3546,80	3551,60
Neck	1	653,06	569,04	332,47	107,07	103,27
	2	3389,80	2449,60	3337,80	3442,50	1304,60
	3	183,52	12,04	52,47	62,73	86,16
Shoulder	1	2730,90	3472,20	2182,80	1995,90	1877,80
	2	3510,50	3287,80	3515,20	3451,90	3589,40
	3	110,14	34,04	6,14	37,59	16,43
Upper back	1	392,56	284,67	274,10	526,63	19,03
	2	1642,00	2912,00	3631,00	2885,30	2628,20
	3	1551,00	1705,10	801,33	1276,00	1999,30
Lower back	1	192,00	124,92	148,09	153,53	257,31
	2	719,41	1266,70	2783,10	125,37	150,29
	3	98,16	141,38	108,06	207,28	291,98

Table 74. ANOVA results for Dentists, Dental Examination treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit*
Body Region	24678421	5	4935684	**2,882692**	2,37
Time	2268361,5	4	567090,4	0,33121	2,53
Interaction	42378931	20	2118947	1,237573	1,75
Error	404362458	60	6739374	3,936139	
Total	473688172	89			

Table 73 shows that EMG data that collected from EMG test for muscles when the dentists applying dental examination in 20 minutes duration. The ANOVA result for muscle regions when dentists applying dental examination prepared on table 74. Comparison between F_{BR} and $F_{critical}$ showed that F_{BR} is greater than $F_{critical}$. This means

that body regions factor has a significance while dentists were applying dental examination.

Table 75. EMG recordings for Removable Prosthodontics treatment

Body Region	Dentist	Minutes				
		2	4	6	8	10
Hand / Wrist	1	221,15	974,05	651,77	544,48	622,60
	2	1339,90	2807,80	1562,50	287,66	425,99
	3	120,21	186,76	179,37	565,23	472,85
Elbow/ Forearm	1	98,60	153,88	183,22	173,58	189,00
	2	3713,60	3528,80	3343,40	2297,90	2083,20
	3	12,79	7,53	5,90	7,26	15,32
Neck	1	3606,30	2699,10	728,54	2992,30	1804,10
	2	237,98	207,41	121,90	109,65	50,79
	3	46,52	14,19	15,88	23,25	18,07
Shoulder	1	1816,70	278,79	434,72	282,43	112,57
	2	1476,40	1813,70	1811,20	1897,70	1758,20
	3	20,86	18,99	33,72	71,41	32,93
Upper back	1	4,75	3692,50	3817,60	3813,40	3760,50
	2	3570,70	3528,20	2733,80	2411,40	2095,90
	3	8,98	17,79	9,99	39,92	26,29
Lower back	1	3219,90	127,87	681,33	2252,90	1479,40
	2	921,15	799,34	375,00	239,75	221,45
	3	13,79	12,83	37,02	50,07	69,18

Table 76. ANOVA results for Dentists, Removable Prosthodontics treatment

Source of Variation	*SS*	*df*	*MS*	*F*	*F crit*
Body Region	17555634	5	3511127	**2,050677**	2,37
Time	1284855,2	4	321213,8	0,187605	2,53
Interaction	26886304	20	1344315	0,785149	1,75
Error	220353538	60	3672559	2,144962	
Total	266080332	89			

Lastly, EMG data were collected based on specified muscles from all participants as seen in table 75. When we consider the result of these data, body region factor is

significant on removable prosthodontics. Time and interaction factors are not significant on removable prosthodontics.

Chapter 5

CONCLUSION

Musculoskeletal disorders among dentists revealed by this study. 67 dentists participated for questionnaire study besides three dentists included for taking EMG data. Discriminant analysis applied to obtain significant factors based on the questionnaire study. The Discriminant analysis applied to result of questionnaire survey and used twice based on survey questions. The disorder occurrence in the last 7 days and 12 months are considered as grouping variable.

This study did not focus on gender differences and its effects' comparisons. EMG data was obtained when three dentists applied seven tasks on patient. Based on the ANOVA results, one task had significant disorders on all of the body regions for three respondent.

When dentists were almost finishing their tasks, discomforts occurred on parts of their body regions. The pressure on some certain body regions of dentists are too much that even without the sEMG study it is predictable.

It was very difficult to work with dentists to obtain data for statistical analysis. In order to not violate the rights of patients, patient permission was required to study in working environment.

There are a few studies which show musculoskeletal disorders because of the lack of having correct position while treating. This study illustrates that dentists' efficiency is directly proportional with correct posture. Also routine exercise can decrease their pain. If dentists do not pay attention to their own future, early retirement is inevitable.

This study illustrates that training lessons to learn correct posture should be taken during dentistry education to avoid occurrence of musculoskeletal discomforts.

Significant factors found for body regions. The most significant factor is revealed physical demands of dental practice for knees, hip/thigh, wrist/hand, and shoulder regions based on discomfort occurrence in the 12 months. For elbow region, the significant factor is revealed as stress level. Taking break between patients has significance on ankles/feet. Significant factor is found as weekly exercise habit for upper back region. If analyze the latest body region, physical demand of hobbies is found as significant factor for lower back region.

According to discomfort occurrence in the last 7 days, the significant factor is found as age for wrist/hand, neck, elbow, and upper back regions. Considering shoulder, hip/thigh, ankles/feet and knees regions, significant factor is found as practice years. Gender is a significant factor of disorder occurrence in lower back region among dentists.

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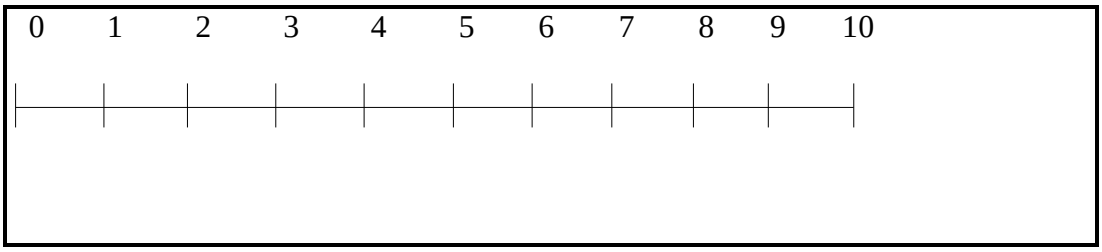
APPENDIX

Appendix A: Questionnaire Form

Gender	Female □ Male □
Age(y)	21-30 □ 31-40 □ 41-50 □ 51-60 □ >60 □
Height(cm)	151-160 □ 161-170 □ 171-180 □ 181-190 □ N/A □
Weight(kg)	41-50 □ 51-60 □ 61-70 □ 71-80 □ 81-90 □ 91-100 □ 101-110 □ N/A □
Years of practice	1-10 □ 11-20 □ 21-30 □ 31-40 □
Physical demands of dental practice	Monotonous/ Repetitive movements □ Awkward position □ Prolonged standing and sitting position □ Hand force demand □ Frequent use of vibrating tools □
Working time with patient(min)	1-10 □ 11-20 □ 21-30 □ 31-40 □ 41-50 □ >50 □ N/A □
Working hours per week	<10 □ 11-20 □ 21-30 □ 31-40 □ 41-50 □ >50 □
Practice type	General □ Specialty □
Area of specialization	General dentistry □ Endodontic □ Periodontics □

	Prosthodontics □ Oral Surgery □ Orthodontics □
Hand dominance	Right □ Left □
Number of dental assistants	0 □ 1 □ 2-5 □ 6-10 □ >10 □
Days worked per week	≤ 4 □ 5 □ 6 □ 7 □ N/A □
Family situation	Alone □ Relatives/Friends □
Vision	Direct □ Indirect □
Weekly exercise habit	None □ 1 □ 2 □ 3 □ 4 □ 5 □ 6 □ 7 □
Take break between patients	Yes □ No □
Smoking	Yes □ No □
Alcohol	Yes □ No □
Please indicate on the scale below the level of stress in your environment *(0= no stress, 10= unbearable stress)*	
0 1 2 3 4 5 6 7 8 9 10 	
Physical demand of hobbies, If yes; *(0= none, 10= very high)*	



The most performed typical work tasks weekly	
1. Tooth Cleaning	□
2. Dental Examination	□
3. Dental Filling Therapy	□
4. Orofacial Pain Therapy	□
5. Fixed Prosthodontics	□
6. Removable Prosthodontics	□
7. Oral Surgery	□
8. Endodontic	□
9. Tooth Extraction	□
10. Periodontal Treatment	□
11. Orthodontics	□
12. Pediatrics Treatment	□
13. Panoramic X-ray	□

Occurrence in the past 12 months									
Body regions	Wrist/ Hand	Shoul der	Neck	Upper back	Lower back	Knees	Hip/ Thigh	Ankle s/Feet	Elbow
Chronic complaints	□	□	□	□	□	□	□	□	□
Complaints with sickness absence	□	□	□	□	□	□	□	□	□
Medical care seeking	□	□	□	□	□	□	□	□	□

Symptoms preventing normal activities	□	□	□	□	□	□	□	□	□
Occurrence in the past 7 days									
Body regions	Wrist/ Hand	Shoulder	Neck	Upper back	Lower back	Knees	Hip/ Thigh	Ankles/Feet	Elbow
Chronic complaints	□	□	□	□	□	□	□	□	□
Complaints with sickness absence	□	□	□	□	□	□	□	□	□
Medical care seeking	□	□	□	□	□	□	□	□	□
Symptoms preventing normal activities	□	□	□	□	□	□	□	□	□