

T.C.

YEDITEPE UNIVERSITY

INSTITUTE OF HEALTH SCIENCES

DEPARTMENT OF SPORTS PHYSIOTHERAPY

**Applied Virtual Reality Techniques In Musculoskeletal
Assessment Of Cervical Ergonomic Disorders Among
Dentists**

MASTER THESIS

WESAM ALZEER, PT

ISTANBUL 2021

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SUPERVISOR

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This thesis has been deemed by the jury in accordance with the relevant articles of Yeditepe University Graduate Education and Examinations Regulation and has been approved by Administrative Board of Institute with decision dated and numbered

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DECLARATION

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree except where due acknowledgment has been made in the text.

28/01/2021

Wesam Alzeer



DEDICATION

I am dedicating this thesis to all the beloved people in my life. Firstly, to my parents, Taleb and Wadha Alzeer. Thank you for granting me this great opportunity to study this degree, and always believing in me, for the encouragement you always offered me, Secondly, to my brothers and sister, whose support made this thesis possible, and to all other family members, especially my uncle, Dr Abdulhamid Alzeer, who never stopped assisting me to complete my thesis. I am so privileged to have a great uncle like you. Finally, I want to dedicate this thesis to all my friends, and especially to my friend Heba Hamed.



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LIST OF SYMBOLS AND ABBREVIATIONS

BMI	Body Mass Index
BMI C	Body Mass Index Categories
BPI	Brief Pain Inventory
R	Correlation Coefficient
CP	Cumulative Percentage
°	Degree
DWP	Degree With Pain
DWOP	Degrees Without Pain
ES	Electrical Stimulation
ED	Exercise Duration
EH	Exercise Habits
ET	Exercise Type
Ex	Extension
Fx	Flexion
HC	Head Circumference
HD	Head Depth.
HP X	Head Posture x
HP Y	Head Posture y
HP Z	Head Posture z
HVLA	Hhigh-Velocity Low-Amplitude
INP	Idiopathic Neck Pain
Lt Rot	Left Rotation
Lt SF	Left side flexion
Lo	Lost
LED	Lower Extremity Disorders
MPQ	Mc Gill Pain Questionnaire
min.-max	Minimum And Maximum
MCID	Minimum Clinically Important Difference
MSDs	Musculoskeletal Disorders
NIOSH	National Institute Of Occupational Safety and Health
N	Neck

NDI	Neck Disability Index
NOPD	Number Of Predict Dependent
PI	Pain Intensity
%	Percentage
PA	Physical Activities
PPT	Pressure Pain Tests
QST	Quantitative Sensory Testing
ROM	Range Of Motion
RRF	Reflex Receptive Field
Rt Rot	Right Rotation
Rt SF	Right Side Flexion
RCTs	Rotator Cuff Tears
SF-MPQ	Short Form McGill Pain Questionnaire
Sp	Speed
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
St	Strength
TT	Thermo Tests
3D	Three-Dimensional
T	Time
T.NDI	Total Neck Disability Index
UE	Upper Extremities
VE	Virtual Environments
VR	Virtual Reality
WAD	Whiplash-Associated Disorders
WE	Work Experience
WMSDs	Work-Related Musculoskeletal Disorders

ABSTRACT

Wesam T. (2021). Applied virtual reality techniques in musculoskeletal assessment of cervical ergonomic disorders among dentists. Yeditepe University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, MSc thesis. Istanbul

The aim of this study was to examine the virtual reality applications in the clinical, physical and functional assessment of neck pain - musculoskeletal disorders (NP-MSDs) among dentists. Particularly, to investigate the use of a suggested VR system in quantifying the degree of deviation from neutral head position "head postural alignment", normal neck movements "range of movement", time and neck movements degree with pain and without pain among dentists. A sample of 40 dentists with neck pain (20F, 20M; 39.70 ± 9.53 years) from Yeditepe University Faculty of Health Sciences participated in this study. A single evaluation was given to the participants. A structured questionnaire was used to record the sociodemographic characteristics of the participants. The neck disability index was used to determine the functional levels of the neck. Head alignment, angular distance, time, speed, degree with pain and without pain of all cervical movements were measured by a virtual reality headset, while muscle strength of major neck movements was measured by a digital handheld dynamometer. The independent factors were age categories, gender, and exercise habits. The clinical parameters of degrees with pain, the physical parameters of neck range of motion and muscle strength, and the functional parameters in the neck disability index scale were all dependent variables in the study. There was a significant difference in BMI with all independent variables. There was no significant effect of age categories, gender, and exercise habits on clinical, physical and functional parameters of neck health among dentists, except there was a significant difference in strength favoring males and in the total neck disability index which was higher in the older age group. There were a positive correlation between work experience with pain intensity, body mass index categories and neck disability index categories, while negative with the exercise duration. Pain intensity and neck disability index categories were inextricably linked. And there was a negative correlation between body mass index categories with exercise

habits and exercise duration. The strongest independent predictive parameters calculated by virtual reality for neck movements, were the neck left side flexion: degrees with pain, the neck flexion time and head posture: X, which predicted the clinical, physical, postural, and functional health among dentists. In conclusion, virtual reality can predict and measure the head alignment, normal neck movements "range of movement", time and degree with pain and without pain, to assess various cervical musculoskeletal disorders.

Keywords: dentists, cervical pain, virtual reality, clinical, physical, postural, functional, assessment



ÖZET

Wesam A. (2021) Diş hekimlerinde servikal ergonomik bozuklukların kakelet te degerlendirmesinde sanal gerçeklik tekniklerinin uygulanması. Yeditepe Üniversitesi, Sağlık Bilimleri Enstitüsü, Fizyoterapi ve Rehabilitasyon Anabilim Dalı, Yüksek Lisans tezi, İstanbul.

Bu çalışmanın amacı, diş hekimlerindeki boyun ağrısı ve kas-iskelet sistemi rahatsızlıklarının klinik, fiziksel ve fonksiyonel değerlendirilmesinde sanal gerçeklik uygulamalarını incelemektir. Spesifik olarak, diş hekimlerinde başın nötr pozisyonundan sapma derecesini (baş duruşu), normal boyun hareketlerini (hareket aralığı), her hareketin süresini ve ağırlı ve ağrısız boyun ROM'unu ölçmek için önerilen bir VR sisteminin kullanımını araştırdık. Örneklem büyüklüğü açısından, bu çalışmaya Yeditepe Üniversitesi Sağlık Bilimleri Fakültesi'nde boyun ağrısı çeken 40 diş hekimi katılmıştır (20K, 20M; 39.70 ± 9.53 yıl). Katılımcılara tek bir değerlendirme yapılmıştır. Katılımcıların sosyodemografik özelliklerini kaydetmek için yapılandırılmış bir anket kullanıldı. Boynun fonksiyonel düzeylerini belirlemek için boyun disabilite indeksi kullanıldı. Tüm servikal hareketler açısından, baş dizilimi, açılma mesafe, hareketlerin süresi ve hızı, boynun ağırlı ve ağrısız ROM'u sanal gerçeklik gözlüğü ile ölçüldü. Büyük boyun hareketlerinin kas gücü dijital bir el dinamometresi ile ölçüldü. Bağımsız faktörler yaş kategorileri, cinsiyet, vücut kitle indeksi ve egzersiz alışkanlıklarıydı. Ağırlı boyun hareketinin toplam derecesi, boyun hareket açıklığı ve kas kuvvetinin fiziksel parametreleri ve Boyun Özürlülük sorgulama anketindeki fonksiyonel parametreler çalışmada bağımlı değişkenlerdir. Bağımsız değişkenler açısından VKİ'de anlamlı bir fark vardı. Diş hekimlerinde boyun sağlığının klinik, fiziksel ve fonksiyonel parametreleri üzerinde yaş kategorilerinin, cinsiyetin ve egzersiz alışkanlıklarının anlamlı bir etkisi yoktu. Yalnızca erkek katılımcılarda kuvvet lehine anlamlı bir farkı olmuş ve toplam boyun özürlülük sorgulama anketi yaşlı grupta daha yüksek çıkmıştır. İş deneyimi ile ağrı yoğunluğu, vücut kitle indeksi kategorileri ve boyun sakatlık indeksi kategorileri arasında pozitif bir ilişki varken, egzersiz süresi ile negatif bir ilişki vardı. Ağrı yoğunluğu ve boyun özürlülük sorgulama anketinin kategorileri birbirinden ayrılamazdı. Vücut kitle indeksi kategorileri ile egzersiz alışkanlıkları ve egzersiz süresi arasında negatif bir ilişki vardı. Boyun hareketleri için

sanal gereklik tarafından hesaplanan en gl baėımsız ngrc parametreler; aėrılı boyun sol yan fleksiyon dereceleri, boyun fleksiyon sresi ve baė postr x idi, ki bu diė hekimlerinin klinik, fiziksel, postural ve fonksiyonel saėlıėı hakkında bize bilgi verir. Sonu olarak, sanal gereklik, eėitli servikal kas-iskelet sistemi bozukluklarını deėerlendirmek iin baė hizasını, normal boyun hareketlerini (hareket aralıėını) , aėrılı ve aėrısız geen sreyi ve eklem hareket derecesini tahmin edebilir ve lebilir.

Anahtar Kelimeler: diė hekimleri, servikal aėrı, Sanal gereklik, klinik, fiziksel, postural, fonksiyonel, deėerlendirme



1. INTRODUCTION AND PURPOSE

Neck pain in the dental profession is a common term for an unpleasant sensory and emotional experience that can have a significant impact on the profession's quality of a dentist's life, between the first vertebra and the C7 vertebral prominence in the neck region¹. Many cases do not recover from the acute period and progress to chronic, resulting in persistent or recurrent pain that makes treatment more time-consuming to heal⁽²⁻³⁾. After low back pain, it is the second most common and expensive musculoskeletal complaint that is associated with injury and disability⁴. Chronic neck pain can be divided into traumatic neck pain that originates from whiplash-associated disorders (WAD) and non-specific non-traumatic neck pain (idiopathic neck pain)⁵. Both of them are associated with diminished muscle activity⁶, reduced range of motion (ROM)⁽⁷⁻⁸⁾, decreased isometric strength⁹, reduced movement accuracy, smoothness, stability and velocity⁽¹⁰⁻¹¹⁾. The various structures of idiopathic neck pain (INP) include facet joints, intervertebral disc, nerve root dura, ligaments and muscles¹². Strengthening exercises and maintaining good posture at work can help to improve function and reduce the spread of neck pain¹³.

Technical-wise, Dentistry, as a health care profession, required the dentist to make repetitive movements and hold his head, upper limbs and shoulders in an improper postural alignment for a long time. Keep of these postures can also become a habit over time, leading to deformities in both the musculoskeletal and soft tissue structures, in ergonomic health, such positions are considered as risk factors for cervical pain and musculoskeletal disorders (MSDs) among dentists¹⁴. Because of the positions that dentists hold while treating patients, it is thought that the back and neck are the areas most affected and that these two areas are particularly prone to a high risk of pain. Studies indicate that the prevalence of musculoskeletal pain affects between 63% and 93% of dentists around the world. The most prevalent types of pain have been shown in dentists' back and neck (36.3%-60.1%) and (19.5%-80%) respectively. It has also been proven that dentists, dental hygienists, and dental students have been shown to have a high rate of recurrent MSDs in the neck, back, shoulder, elbow, and hand. In addition,

the dental profession needs repetitive motion of the distal upper extremity and the awkward posture leads to tingling, discomfort and numbness, which may cause carpal tunnel syndrome, ulnar nerve compression, thoracic outlet syndrome, pronator syndrome, tendinitis, tenosynovitis, and rotator cuff tendinitis. All of these MSDs cause muscle imbalance, neuromuscular inhibition, muscle fatigue, and dysfunction¹⁵.

Virtual reality is defined as a world made by a computer in a three-dimensional (3D), 3D fashion, in which you move and live many adventures in it through the use of some accompanying technical devices, such as a dedicated headpiece or glasses, headphones and special gloves used to hold things in your imaginary world¹⁶. Consumer VR technologies have a lot of potential in clinical rehab for both providing and guidance in rehabilitation as exercise/training activities. In addition, assessing the kinematic and kinetic parameters such as distance, time, velocity and accuracy for neurological and musculoskeletal disorders¹⁷. Also, the intervention to improve motor performance and postural control⁽¹⁸⁻¹⁹⁾.

Virtual reality would have better reliability and validity compared to traditional assessment techniques for musculoskeletal disorders. And it is a powerful technique in the quantification and documentation of kinematic and kinetic parameters related to cervical pain and musculoskeletal disorders among dentists.

Despite the fact that dentists with cervical pain are taking an important space in physiotherapy research, many patients with various levels of pain still find it difficult to alleviate the harshness of the symptoms as well as limitations in movement of the neck and functional restrictions.

This study tries to conduct further and more thorough approaches and research in the assessment of cervical pain. The study will be professionally concerned with technical programming and assessment of the kinematic and kinetic of dentists' cervical pain. Therefore, the aim of this study was to examine the virtual reality applications in the clinical, physical and functional assessment of neck pain - musculoskeletal disorders NP-MSDs among dentists. Particularly, to investigate the use of a suggested VR system

in quantifying the degree of deviation from neutral head position “head postural alignment”, normal neck movements “range of movement“, time and degree with pain and without pain for neck movements among dentists.

Two hypotheses were identified in the study:

H_0 : VR is not a powerful technique in quantification, documentation and characterization of relevant kinematic and kinetic parameters in cervical assessment.

H_1 : VR is a powerful technique in quantification, documentation and characterization of relevant kinematic and kinetic parameters in cervical assessment.



2. GENERAL INFORMATION AND LITERATURE REVIEW

2.1 Cervical spine

2.1.1 Anatomy of the cervical spine

The cervical spine (neck region) consists of seven distinct vertebrae (C1-C7 vertebrae), which are located between the skull and the rib cage, all of which are localized on top of one another and work together to support and carry the head's weight. Intervertebral discs are separated between these vertebrae for the mobility of the head and neck. The cervical spine moves freely in all three planes, making it the most mobile part of the spine when compared to the other vertebrae. It's divided into two parts: the upper cervical spine and the lower cervical spine. The upper cervical spine has unique vertebrae, the first cervical vertebrae (C1) includes the occiput, atlas. And the second cervical vertebrae (C2) include the axis. The main movement of the atlanto-occipital joint CO-C1 is flexion-extension and extends from 15 to 20°, the lateral flexion is 10° and rotation is measly. While the atlanto-axial joint's C1-C2 main movement is rotation near 50°. The lower cervical spine consists of the third to the seventh cervical vertebrae (C3-C7) and it is known as the "cervicobrachial area" because the disorders in this part lead to pain in the neck, shoulder, elbow and wrist or cause pain in both upper extremities and may cause other signs and symptoms such as decreased range of motion, numbness and weakness²⁰.

2.1.2 Typical cervical spine vertebrae

The typical cervical vertebrae are known to be c3 to c6. All of these vertebrae have the same features. This is demonstrated in figure 2.1. Compared to other parts of the vertebral, the vertebral bodies of all typical cervical are comparatively narrower and much larger from side to side than they are in the anterior diameter to the posterior. Although the body is convex on the inferior side, and it is slightly concaved on the superior side. The vertebral foramen is broad in form and is somewhat triangular. The transverse processes have a very distinctive characteristic, namely the transverse foramina that may be tiny or missing in C7. The role of the transverse foramen is to

enable the movement of the vertebral artery, vein and plexus nerves. The superior facets are super-posteriorly oriented in the articular processes, whereas the inferior facets are infero-posteriorly oriented. They have short and bifid spinous processes ²¹.

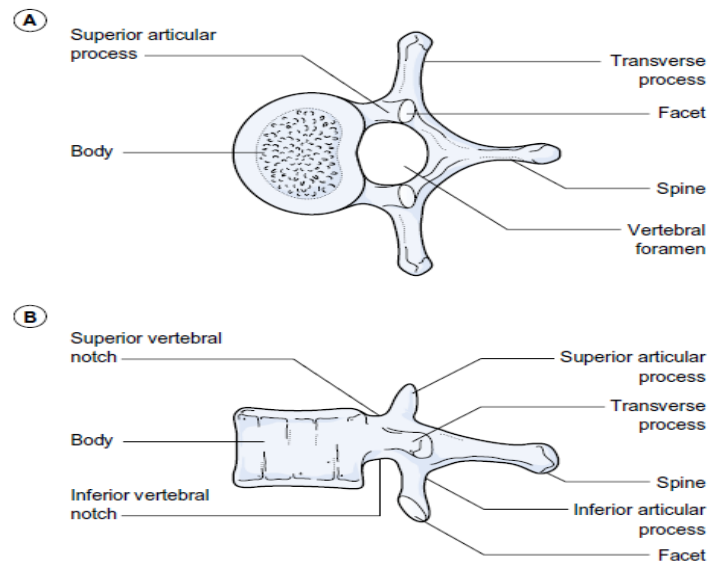


Figure 2.1. A typical cervical spine vertebra. (A) Superior aspect. (B) Left lateral aspect.²²

2.1.3 Atypical cervical spine vertebrae

C1 (Atlas), C2 (Axis) and C7 (Vertebral Prominence) are the atypical cervical vertebrae. The first cervical vertebrae is an atlas. It's ring-like. In this vertebra, there is no spinous process or a vertebral body. It is made up of an anterior and posterior arch. A tubercle and a lateral mass are composed of each arch. It articulates superiorly with the occipital condyles and inferiorly with the axis. And because C2 is the strongest bone in the vertebral column, it has a large and bifid spinous process and small transverse processes. In addition, it articulates inferiorly via c3 and superiorly surfaces with the atlas. Through rotation motion of the head, the skull lies on the atlas and rotates on the axis. The C7 (vertebra prominence) is different in that it has a unique large transverse process and the spinous process is not bifid and very long, so it can be felt in the neck quickly while the neck is in flexion. While the transverse foramina are small, for this reason, the vertebral arteries can't transmit²³.

2.1.4 Muscles of the cervical spine

Inside the cervical spine, there are two groups of muscles called the extrinsic and intrinsic groups. The extrinsic has been split into superficial. The superficial muscles are divided into anterior, posterior, and lateral (Table 2.1), and their role is primarily to generate or control limb movement. The superficial anterior group controls cervical flexion. The posterior group is responsible for extension, rotation, and lateral flexion. Lateral flexion and extension are controlled by the lateral group²⁴.

Table 2.1: The three groups of superficial cervical muscles and their actions²⁵

Group	Muscle	Action
Anterior	Longus capitis	Flexion
	Rectus capitis anterior	Flexion
	Longissimus capitis	Extension, rotation, lateral flexion
	Oblique capitis superior	Extension, lateral flexion
Posterior	Rectus capitis posterior	Extension, rotation
	Semispinalis capitis	Extension, rotation
	Splenius capitis	Extension, rotation, lateral flexion
	Trapezius	Extension, lateral flexion
Lateral	Rectus capitis lateralis	Lateral flexion
	Sternocleidomastoid	Rotation, extension, flexion

And the deep muscles are the intrinsic muscles (Figure 2.2), which are difficult to palpate independently. Their action is to produce movement of the vertebral column and sustain its posture²⁵.

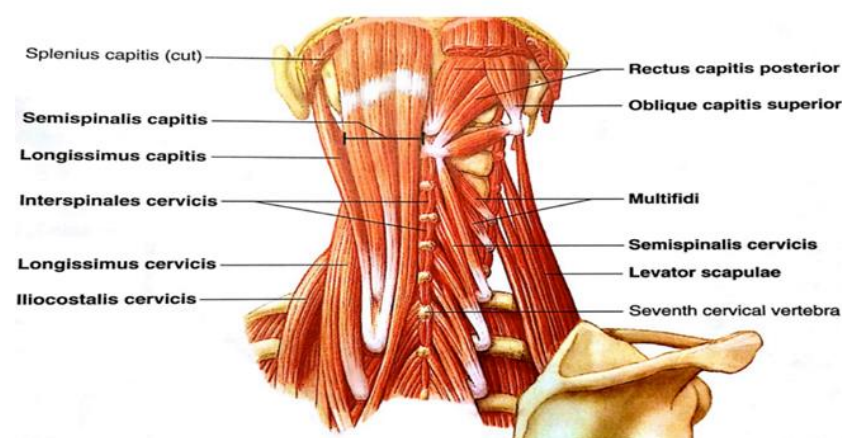


Figure 2.2. Deep muscles of the neck²⁵

2.1.5 The ligaments of the cervical spine

The ligaments of the cervical spine are divided into two groups based on their location. The suboccipital region is the first, and the lower cervical spine ligaments is the second.

2.1.5.1 Suboccipital ligaments

The superficial ligament plane includes the posterior longitudinal ligament and the median occipito-axial ligament, also the intermediate ligament plane consists of the cruciate ligaments consisting of the transverse, the transverse-axial ligaments, and the transverso-occipital; the capsular ligaments of the occipito-axial joint laterally and the atlanto-axial joint inferiorly, and the deep ligaments plane have the apical and alar ligaments of the odontoid process, the transverse ligament (a strong ligament that runs horizontally between the atlas lateral masses), the transverso-occipital ligament, and the transverso-axial ligament (Figure 2.3)²⁶.

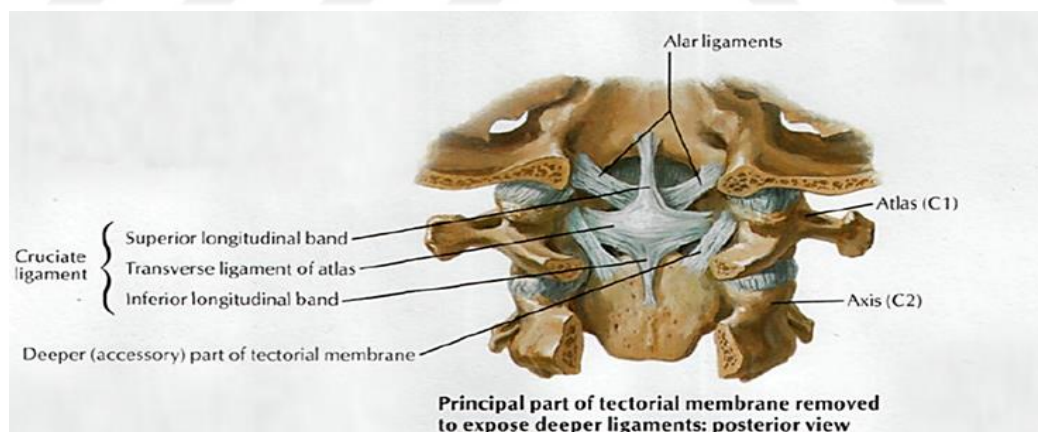


Figure 2.3. Deep cervical spine ligaments posterior view²⁶

2.1.5.2 Lower cervical spine ligaments

The anterior longitudinal ligament is located anterior to the vertebral bodies, while the posterior longitudinal ligament is located posterior to the vertebral bodies. On each

side, a joint capsule binds the unco-vertebral joints. On both sides, the ligamentum flavum connects the laminae. The spinous processes are linked by the interspinous ligament. The supraspinous ligament, also known as the posterior cervical ligament, provides attachment to the trapezius and splenius muscles in the suboccipital region. The transverse processes are connected by the inter-transverse ligament²⁷.

2.2 Dentists ergonomic

Dentistry as a health care profession is a branch of medicine that focuses on the diagnosis, prevention, and treatment of diseases of the mouth, face, jaws, and other conditions that are linked to the teeth and mouth cavity tissues. The repair, extraction, and insertion of artificial teeth, in particular, require a high level of manual precision²⁸. The work environment of the dental industry has many limitations that lead to the development of many MSDs, especially of the neck and upper limbs, which have become common among dentists and workers in other occupations at a high degree. All parts of the body create a strong requirement for advancement in ergonomics principles²⁹.

The term ergonomics is a branch of science that can be loosely described as the analysis of job characteristics in finer detail. It is the process of designing or improving workplaces, products, and systems to be fitted for the employees instead of the work design forcing the worker to work more than their body's capabilities³⁰. The ergonomics interaction with dental workers includes a variety of new tools and elements such as workstations, tasks and tools, all of which must be adapted to fit the dentists' jobs. The main goal of ergonomic is to ensure maximum productivity in environments with minimizing the risk prevalence of discomfort and fatigue in this industry³¹. In past because of a lack of awareness and little attention in the evolution of ergonomics design workplaces, the number of MSDs increased among dental practitioners. Despite technological improvement day after day and an awareness increase among dental workers, injuries and illness continue to be a major source of concern for dental health care providers³².

2.2.1 Nature of the work

The major cause of the high prevalence of MSDs among dental professionals is the nature of the work. It plays an essential role in the development of musculoskeletal disorders, the nature of dental work, it is a limited and restricted field³³. In comparison with other occupations, the nature of the dental professional's work reports a higher incidence of work-related musculoskeletal disorders (WMSDs) than others and a poorer work environment. The dentist adopts inflexible work postures. This results in prolonged standing or static posture without breaks, which is susceptible to MSDs, particularly in the neck, back and shoulders. Also, unsupported sitting with an unnatural body position. In order to finish each patient's treatment as quickly as possible, their backs are bent or twisted. Also, holding the trunk and neck twisted for a long period of time with repetitive use of the upper extremities (hands in excessive tightening and firmness or arm abduction and elevated) in heavy forces is also prone to injury. An extended interval of static muscle activity during tooth filling, extraction, or scaling normally imposes high visual demands and requires excessive force of the small muscles. In dentistry, the dominant hand is used to hold tools to clean the teeth while the other hand holds the mirror. Tools such as suction is used to keep the mouth dry and the scalar is used to remove tartar and plaque. Also, the mirror is used to reflect images that the dentists cannot see directly⁽³³⁻³⁴⁻³⁵⁾. Furthermore, certain tasks involve exposure to working with high-frequency vibration tools, extrinsic stress such as working in cold environments, improper ergonomic dental equipment and noise, which contribute to increasing the load³⁷. So that affect negatively on the quality of life and reduced productivity, which leads to the early development of MSDs or may abandon the professional career³⁸.

2.2.2 Musculoskeletal disorders among dentists

In the dental profession, there are numerous MSDs; consequently, this literature will focus on the majority of the MSDs associated with prolonged static posture (PSP)³⁹.

Tension neck syndrome is characterized by pain, tightness, stiffness and spasms in the neck muscle, usually, the pain referring between the shoulder blades or in the occiput, and tingling or numbness in one arm or hand on occasion. Forward head posture may occur prior to the onset of this syndrome, causing muscle imbalances, trigger points, degeneration or herniation of the cervical disc. This syndrome can be exacerbated by operating with the arm in a raised position. Which frequently occurs in the trapezius muscle on the same side of the dentist who is holding the mirror³⁹.

Non-specific lower back pain that sometimes radiates to the hip, buttock and both or one leg. It's possible that the cause is instability due to postural muscle weakness, muscle strains, hypomobile spinal joints, disc degeneration or herniation³⁹.

Rotator cuff tears (RCTs) are a common injury among diverse professions, especially in dentists. This injury is increasing with age and is characterized by weakness and pain in the shoulder that is aggravated by physical activities (PA) and body mechanics that aren't right. Working posture where the shoulders are rounded with overuse and applied weight can lead to the impingement of the rotator cuff³⁹.

2.2.3 Risk factors

Technology has increased with the development of dental tools and techniques, as well as productivity. Thus, the risk factors for work-related musculoskeletal disorders (WMSDs) that exist across the work environments of dental professionals will increase. Researchers directed focus on the work organization which influences on the WMSDs, the work organization or work system evaluated by various aspects: scheduling, job design, management style and interpersonal. In addition, it deeply focuses on determining the risk factors because it is quite a complex and multi-faceted trouble that leads to real field impairment in the lives of dentists. After establishing the risk factors, can put a proper approach to improving and modifying their work conditions and prevention can be taken⁴⁰.

In 1997, the United States National Institute of Occupational Safety and Health (NIOSH) published over six thousand scientific articles about the link between MSDs

and work factors. However, the etiological mechanisms of the relationship between epidemiologic evidence for MSD's of the neck, upper extremity, and low back and workplace factors still require much discussion and are poorly understood. Studies have indicated that physical load, work-linked psychosocial factors, and individual factors have been identified as the main causes of risk factors. These categories which may contribute to the development of work-related MSD's⁴¹. Furthermore, cognitive factors are also a category of risk factors that assist in the formation of WMSDs⁴². The four major categories of risk factors for the development of WMSDs are depicted in Figure 2.4.

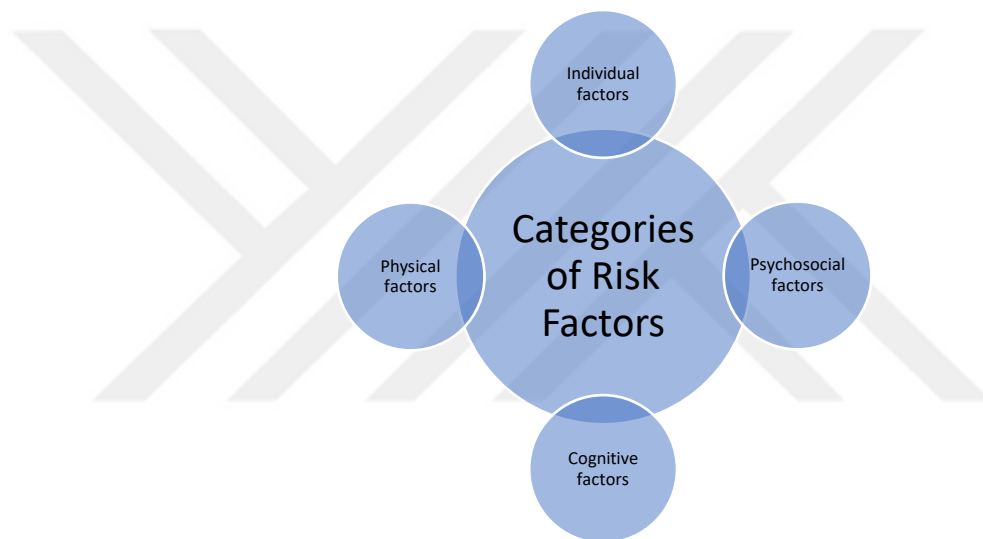


Figure 2.4. Categories of Risk Factors⁴²

2.2.3.1 Physical factors

Physical risk factors are characteristics of the work environment that put workers at a high risk of being prone to the development of WMSDs. The findings of the review showed that there is strong evidence to indicate a significant causal relationship between workstation arrangement (ex. height of bed, height of chair and distance from the visual display), duration and frequency of awkward posture, force, vibration, temperature, light, noise and dental instruments with increasing the load of MSD's among dentists. The physical load of dentistry was found to be more strongly associated with the prevalence of musculoskeletal disorders, particularly in the upper extremities (UE), than

the lower extremity disorders (LED). Moreover, evidence reported a causal link between repetitive movements and contributing of MSD's of the neck and shoulder. Continuous repetition of arm or hand movements and forceful exertion affects negatively on the neck and shoulder muscles and this leads to tingling, discomfort and numbness in the upper extremities or radiating pain to one or both of the upper extremities from the neck, and therefore generates loads on the neck and shoulder regions. Also, there is strong evidence showing prolonged static posture or awkward working postures are related to an increased risk of MSD's in the neck and shoulder region, which leads to the development of tension-neck syndrome. In addition, a causal relationship between low back pain, whole-body vibration and hand-arm vibration syndrome with work in poor ergonomic⁴³⁻⁴¹.

2.2.3.2 Psychosocial factors

Psychosocial factors have often been described as influences that impact a person psychologically and have an effect on their general health status. There are several domains that may affect workers' performance responses, such as job negative stress, anxiety, lack of control, high workload, tight deadlines, need to deal with difficult people, troubles with the dental staff and low job satisfaction⁴⁴. The ability to handle workplace stress has been influenced by a person's personality and psychological state. Furthermore, this stressor will have a contrary outcome on the work environment. In the epidemiology literature, there is evidence of a link between psychosocial factors in the occupational environment and WMSDs of the upper extremity and back⁴¹. Moreover, many studies back up the importance of psychosocial factors in ergonomics and the work environment. Psychosocial factors are just as important as physical load because it causes psychosocial stress which can develop into musculoskeletal tension and disorders⁴⁵⁻⁴⁶. There are many proofs in establishing the relative influence of physical and psychosocial factors. One concern is that psychosocial factors are often measured at an individual level, but the physical factors are usually measured at a group level. It is hard to find tool measures for different aspects of the psychosocial work environment, whereas measuring the physical environment is more attainable⁴¹. The findings on

psychosocial factors in dentistry have been inconclusive, putting either a poor or a satisfactory psychosocial work environment ⁴⁷⁻⁴⁰.

2.2.3.3 Individual factors

Individual risk factors are related to dentists' personality and genetic makeup, as well as the dentists' medical history, which indicates the individual's significantly prone to developing workload and the incidence of WMSDs. Individual factors, such as body mass index (BMI), age, experience, gender, fitness level, marital status, obesity, and previous health condition. One of these variables that have been repeatedly reviewed by studies is age. In several studies, it has been found that there is a direct relationship between increasing age and neck and back disorders. On the other hand, other studies did not find any link between them, and one countered that back problems are more common in younger people⁴¹. Several studies of musculoskeletal disorders and occupational ergonomics have found that when women are exposed to the same task factors as men, they are at an increased risk⁴⁸. On the contrary, other studies reported there were no differences between males and females when performing the same stress. So, they do not believe gender is a risk factor⁴⁹. In dentistry, statistically, females are more vulnerable to having pain in their fingers whereas males are more likely to experience pain in their lower back²⁹. Minimal evidence indicates that individual factors are more effective when combined with physical work-related factors in the contribution to MSD's. Consequently, disorders may occur in the absence of any work environment exposures or events. It has been shown that individuals with a recent history of injury have been shown to have a higher risk of developing fatigue⁵⁰.

2.2.3.4 Cognitive factors

Cognitive factors are indicated characteristics of the tasks that place a load on people's cognitive abilities and performance in order to achieve their cognitive goals. Memory, mapping, carrying out actions, attention, reasoning, and making decisions are all cognitive factors. It can also have a significant impact on human information processing systems. Definitely, mental stress and cognitive demands are unquestionably

linked to increased muscle tension and cognitive workload, which can lead to a high prevalence of musculoskeletal disorders in the long run, especially in the upper extremities. The findings of previous studies show that different dental procedures, such as cleaning teeth, correcting bite issues, performing surgeries and extractions, necessitate different levels of cognitive and physical effort, as well as physical⁵¹.

2.2.4 Positioning

2.2.4.1 Working Posture

Working postures are influenced by the surrounding environment and the organization of the dentistry workstation. In Europe, at the beginning of the 16th century, both the dentists and the patients were standing during treatment. In the first sixty years of the 20th century, the practice of dentistry in the United States stayed basically the same (treatment of the teeth in a standing position). Following this time, several advances in science and technology were made, as well as the rapid development of the term ergonomics⁵². In recent years, the majority of dentists have been working in a sitting position to the side or behind the patient, and their postures needed to be corrected. The patient is in a supine position. Also, there is a chair-side assistant who assists the dentist on the other side of the patient. The postural dynamics were significantly affected by the requirements of the dental profession's design. Seat height, seat depth, the distance between the dentist's eyes and the patient's mouth (the normal is 30 cm to 40 cm), the number of hours worked during the day (no more than 7 hours), working posture and task lighting⁵³. Working postures that are significantly harmful to the ideal state of musculoskeletal balance cause an increase in pain and fatigue throughout the workday, especially in the back, neck, and shoulders. Repetition of incorrect postures with inflexible work postures results in the static activity of the muscles, which leads to poor working postures⁵⁴. Static posture loading can lead to a compression of the blood vessels (nutrition), preventing it from reaching the muscle, ligaments, and isometric muscular contractions with acid lactic accumulation, as well as vicious static postures⁵⁵. Poor postures of the dentist are not uncommon else do a great change of posture included the head being bent forward. Several studies have found a

link between neck pain and forward head posture, especially among dentists with more than 15 years of experience. FHP of the head and neck creates muscle imbalances with shortening of the posterior cervical and suboccipital muscles, tightness of the anterior chest muscles, lengthening and weakness of the anterior neck flexors and supra-and infra-hyoid muscles, weakness of the upper back and scapular retractor muscles, contributing to a rounded shoulder posture. Because the head is in front of the gravitational line, a variety of factors contribute to FHP, including gravity, an exaggerated bend in body alignment, and abnormal postures during occupational jobs⁵⁶. The cervical lordosis will be decreased in the long run with repeated neck flexor movements. FHP works as a compensatory mechanism linked to an increased cervical curve through standing⁵⁷. The amount of head tilt and neck tilt angle were significantly attached to gaze angle. At 10°–15°, the neck is in a neutral position, facing forward and slightly downward⁵⁸. The amount of stress to the cervical spine from a forward tilt was found to be 27 pounds at 15°, 40 pounds at 30°, 49 pounds at 45°, and 60 pounds at 60°⁵⁹. Also, most of the dentist's work is done with the arms elevated or abducted more than 30°, causing damage to the supraspinatus muscle and tendon. In addition, trapezius myalgia-chronic pain and trigger points in the upper trapezius muscle can also result from prolonged arm abduction. Lordosis postures with a forward-leaned pelvis, back bent forward and twisted are the main causes of the increase in discomfort, also producing a distorted and unnatural body posture when preserved for long periods of time. The musculature may be strained, resulting in physical fatigue⁽⁶⁰⁻⁶¹⁾. This allows the prevalence of abnormal tensions in joints and ligaments, particularly in the sacroiliac joint, peripheral nerves, zygapophyseal joints of the lumbar also cervical vertebrae, connective tissues, vascular system and muscles that maintain these joints, which may lead to an abnormal posture. These anatomical components may also be damaged by an awkward posture, which is most likely due to the nature of the tasks³⁸. There is an association: the relationship between working posture and pain indicates that dental working postures are gradually deteriorating over time, as the posture of dentists at the start of their careers is better than that of a dentist who works long hours and spends more time in clinics⁶². Another study indicated that when dentists are seated or working in a slumped posture with low back pain, the muscle activity in spinal extensors will increase⁶³. Dentists should practice sitting postures while adhering to

these guidelines in order to improve their posture. First, symmetrical postures of the body, second, ensure that all horizontal axes are parallel, third, Legs should be slightly apart (at 30 to 45 degrees) and the head could bend between 20 and 25 degrees, about the shank must be perpendicular to the ground, also, the upper limb should be vertical on the seat – forward motions must be performed without the spine curving, both arms and forearms should be horizontal and nearly to the body, the thigh /knee should be at 115°, The soles should be in full contact with the ground (Figure 2.5). Normal posture and awareness of ergonomics principles could not be achieved without workplace equipment that allows for maximum adjustability in order to optimize dentistry tasks ⁵⁵.

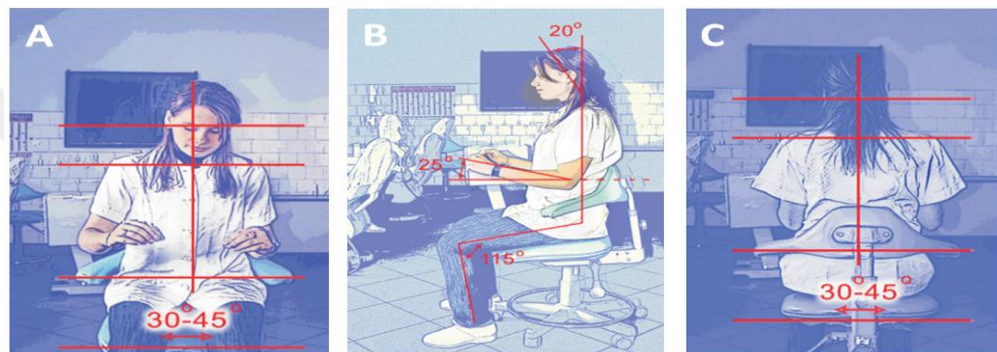


Figure 2.5. Dentist Ideal Posture (a) Symmetrical postures (b) Ergonomics Evaluation of static working postures (c) Back support ⁵⁵

2.2.5 Assessment protocols in Ergonomics

Assessment protocols are the previous step for ergonomic intervention protocols. With a brief meeting with the worker, many methods and ways are used to assess the workplace to determine the musculoskeletal stress factors that cause several harmful effects. Assessment of the ergonomic risk factors by questions regarding awkward work postures, hours worked, fatiguing work movements, poor tool styling in the workplace, environmental and organizational conditions. The worker has answered the questions related to the task after the observer has made the assessment. The tasks which were used for most including; weight handling, the force has been used, consuming time, occurring vibration, exhausting stress and desired visual that was used and analyzed within the assessments. A short note of the numbered area in the task is formed or

ticked if any hazards are seen, for example, pain, numbness, stiffness and ache. This was originally designed to determine the location of pain, whether the pain is localized or radiating, as well as musculoskeletal risk factors for a specific body region⁶⁴.

There are many diverse scales and tools that have been proposed through studies to assess cervical pain. Three main scales measure were reported in the literature to evaluate the intensity of pain and dimensions linked to the quality of pain at the neck area, for example, the character and perception of pain, the first Mc gill pain questionnaire (MPQ), second is the short Form McGill Pain Questionnaire (SF-MPQ), the third is Brief Pain Inventory (BPI), each scale uses different procedures for determining pain intensity, additionally the various quality of measurement⁶⁴. A comparison of these scales can be found in table 2.2.

MPQ: was developed to supply a quantitative statistical process for measuring clinical pain ⁶⁵. It ensures that measurements are reliable, valid, and proportional. Add in the fact that the MPQ's have been validated in numerous multilingual versions, which is a significant advantage ⁶⁶.

SF-MPQ: is statistically qualitative and can be used in cases when the primary focus of the examination is on the intensity of pain. It also provides reliable and valid measurements in situations where the standard MPQ takes too long to administer. The SF-MPQ is a useful tool. It is sensitive enough to confirm variances that result from treatment at a statistical level when compared with a standard form that has been obtained⁶⁷.

BPI: This is a self-administered questionnaire that can assess the intensity of pain and the interference of pain on functioning in a patient's life. It can also be described as the sensory dimension and the reactive dimension. This survey includes questions about pain relief, pain quality, and pain causes according to patient perception. The BPI is a very strong tool that provides reliability and validity through cultures and languages. It has been adopted in several countries for the assessment of clinical pain, the

effectiveness of pain treatment studies, and epidemiological studies. It was developed for cancer patients to use as a pain measure in arthritis and back pain cases⁶⁸.

Table 2.2. Multidimensional Pain Scales⁶⁴

	Measurement	Quality of measurement
MPQ	Pain intensity-pain descriptors	Reliable/valid
SF-MPQ	Pain intensity-pain descriptors	Reliable/valid/sensitive in changes
BPI	Pain intensity in different time-impact on mood/physical activity/sleep	Reliable/valid

Besides, there are several diagnostic experimental methods for pain are electrical stimulation (ES), pressure pain tests (PPT), EMG recording, reflex receptive field (RRF) and thermo tests (TT). Some of these methods evaluate pain thresholds but the others evaluate pain tolerance. Also the quantitative sensory testing (QST)⁽⁶⁹⁻⁷⁰⁾.

2.2.6 Therapeutic interventions

Pain is a powerful, uncomfortable feeling in the body that forces the patients to seek treatment⁷¹. Neck disorders are a common occurrence among dentists, and they may cause them to miss work, causing patients' appointments to pile up, in addition to increasing subsequent costs. Because there are various forms of cervical disorders that rely on the affected level, many dentists with chronic neck pain depend on conservative treatments such as manual therapy, which are also commonly used to alleviate pain and disability symptoms. Ergonomic changes that occur at the clinic and exercise therapy are useful for increasing mobility and flexibility as well as reducing pain and stiffness⁷². Furthermore, these numerous methods are very effective for non-specific neck pain⁷³. And forms of ergonomics concerning self-management plans, working posture, position, and exercises can be given. The prescription of therapeutic exercise contains stretching, strengthening exercises for specific muscles, and active and passive relaxation movements that aim to decrease the stress of daily living⁷².

The most important factor in preventing the occurrence of the injury can be achieved by ergonomics, suitable ergonomic workplace design, by establishing a setting that minimizes awkward body positioning. Employee and employer training is critical for assessing ergonomically inefficient workstations and making the necessary adjustments in order to improve employee health. Taking short breaks, standing up and stretching the muscles between activities can help reduce inactivity and muscle fatigue in the workplace⁷².

In the osteopathy, chiropractic, or physical therapist profession the term "manual therapy" can be slightly varied, relying on which medical professional's field of practice is used, but in physiotherapy, we can define it as utilizing skillful passive movement techniques through the hands to treat ailments of several aetiologies, decrease swelling or inflammation, and myofascial limitation to progress muscle length, increase range of motion, and facilitate movement to achieve better function. Many professions use manipulative therapies, for instance, chiropractors, physiotherapists, osteopaths, and other manual therapists. Several researchers utilize term manipulation to depict the high-velocity low-amplitude (HVLA) thrust technique, The HVLA mechanism works by applying force to a joint, pushing it to exceed its passive range of movement. Occasionally, an audible pop can be heard⁷⁴. In contrast, the mobilization is a non-thrust form of manipulation that uses force low-grade passive movement with different amplitudes⁷⁵. Both manipulation and mobilization are common forms of manual therapy for the cervical spine. There are many systematic reviews that confirm the efficacy of the treatment of chronic neck pain by manual therapy. They're used mainly for treating musculoskeletal problems, including spine, neck and shoulder disorders to decrease pain and improve the cervical range of motion⁷⁶.

Traction therapy for the neck is one of the oldest ways of treatment for the neck used in order to relax the muscles, separate joint surfaces, stretch spinal vertebrae and the soft tissues by pulling the head force along the axis of the spine or separating the vertebrae to expand and prevent compression. Several chiropractors today still utilize traction in their treatments. It alleviates any nerve root compression in the cervical spine that causes symptoms such as pain and paresthesia in one or both sides of the upper

extremity. There is much research did about the effectiveness of cervical traction on spinal structures in the treatment of herniated nucleus pulposus with disc protrusion, degenerative disc or joint disease, cervical facet joint dysfunction, and muscle stiffness or hypomobility, and the results showed that more than half of these cases felt decreased pain and resolution in the treatment of chronic neck pain to a high degree⁷⁷.

2.3 Virtual reality Applications in health management

2.3.1 What is Virtual Reality? “Definition and components”

Virtual reality (VR) is defined as "a describing objects in a simulation experience that can be similar to or completely different from the real-world events". When viewing the environment through virtual reality, we witness an interactive display and engage between persons wearing the VR headset and objects that are available inside of the virtual environments (VE). Interaction is a core aspect in all VR apps differentiating them from other media⁷⁸.

A VR system has three hardware components: an input device, a display, and a computer. The user communicates with the virtual environment by the input device. To use this technology, we'll need a VR headset. This headset is worn over the user's head and has a screen that covers their eyes. The virtual environment is shown on the monitor and offers visual feedback to the user. The display and the input system are attached to the computer. The computer is responsible for operating the virtual reality applications as well as any other programs required by the VR device. The user can shift his head across the simulated world for a complete 360-degree view. Also, the tracking device monitors head motions. The bundles can be used as hand controllers. In my study, as I refer to VR headsets, I recommend a VR headset with no other equipment next to the headset⁷⁹.

2.3.2 The importance of VR in Rehabilitation

The importance of VR is really common in the technological world. The most significant advantage of VR is that useful tools provide complex environments and a wide field of view that contribute to a simulated reality that is more interactive and every aspect of this system is still remaining under control. The other advantage is that it encourages participants to try and perfect movements or tasks in a simulated environment with minimum side effects for longer. In the real world, this could put them at high risk. (For example, people who have had a stroke and are wearing VR can perform a task such as cutting the fruits without risk). Also, VR technologies provide a methodology for achieving applications to test, assess, treat and rehabilitate patients with different conditions. Stimuli given by the VR like recognizing voices, visual displays, graphics, wireless tracking, 3D audio, memory storage, computing speed and tactile will attract people to the point at which they believe that the scenario is “actual”⁸⁰. When it comes to difficulties in cognitive performance in patients with various circumstances of impairments and handicaps such as attention, working memory, and executive function, the findings show that VR technologies have the potential to be extremely beneficial in terms of providing training and improving these conditions. VR produces enjoyable and interesting interventions for motor rehabilitation. As such, it has been observed that traditional rehabilitation interventions do not offer optimal options in rehabilitation and assessment and are less enjoyable than VR app interventions⁸¹. Physical patterns as well as Behavioral issues are important factors in the rehabilitation of people with neurodegenerative diseases, so they're crucial for virtual reality interventions. VR enables these patients to respond with action-based responses, reducing behavioral issues and problems problems⁸²⁻⁸³.

2.3.3 Virtual Reality in rehabilitation assessment

Many recent studies have been interested in or focused on VR tools in rehabilitation as a form of assessment rather than a method of exercise/training activities. Virtual reality (VR) is one of the most promising options for enhancing evaluation with accurate results. It has been used for projects linked to assessing motor

control dysfunction, balance, and upper limb motor impairments in patients with different conditions⁸⁴. And focus on cognitive tasks such as attention processes, spatial abilities, executive functions and memory in patients with brain injury. And the cognitive impairments are a consequence of traumatic brain injury, cerebral tumors, stroke, neurodegenerative diseases such as Parkinson's disease, and several other brain diseases⁸⁰. Also, it provides an accurate and informative analysis, diagnostic norms, assessment data and insights on various measurements and metrics of kinematic and kinetic parameters to measure the musculoskeletal disorders in different joints of the human body and to determine the level of impairment associated with upper and lower extremities, for example, to monitor the limitation in range of motion, accuracy, speed and evaluating postural control in an easy and entertaining gaming scenario, in addition to assessing the efficacy of therapeutic treatments by VR technologies before and after the rehabilitation process starts. Stimuli offered options systematically and timed exactly for the finding to have high internal validity and reliability. This advantage is of high significance for the development of rehabilitation assessments in which repeatability and standardization are critical⁸⁵.

2.3.4 Virtual Reality in rehabilitation management

Virtual reality applications can be extended to assist in physiotherapeutic management and rehabilitation of cognitive and functional impairments or limitations with different conditions of ergonomic, neurological disorder and musculoskeletal disorders. After traumatic brain injuries, Alzheimer's disease, Parkinson's disease and stroke several patients suffer from diminished physical and/or cognitive abilities⁸⁰. Physical deficits include difficulties with movement and control of physical body parts such as the head, limbs, hands and fingers. On the other hand, cognitive impairments are linked to knowledge processing such as problems in vision, hearing, decision and remembering names⁸⁶. So many VR/neuropsychological applications have been designed as games to rehab these impairments seen in a variety of our clinical conditions and teach patients how to manage simple everyday tasks that could serve to provide support for adapting in real life more easily and promote independence in less time, such as crossing the street, recognizing common objects, meal preparation, market

shopping, navigation in a wheelchair, as well as public transportation ⁸⁰. These games are actually more effective in rehabilitation and assistance to address both attention and physical capabilities for a diversity of causes. In addition, attention skills are the required basis for future educational practices. Some VR applications can also be used to distract pain and enhance motor performance. Many considerations must be understood in order to engage effectively and to accomplish new skills in a virtual task. First, understanding the VR environment's interaction process, and comprehending the task's directions, finally sustaining continuous concentration to fulfill the task for the length of the operation. Rehabilitation for people who have experienced a stroke has been proven to be effective at all phases of rehabilitation, sub-acute, chronic stages and inpatient/outpatient, was the perfect approach to determine the advantages of VR training. Also, the use of VR interventions has increased for upper-extremity exercises in patients after a stroke to increase the range of motions, improve the speed of movement and restore the strength of their fingers. It has also been used to treat neglect, gait and standing balance to regain impaired functions and abilities⁸⁷⁻⁸⁸

3. MATERIALIALS AND METHODS

3.1 Study Design

This research is a descriptive research design, which was conducted in the physiotherapy laboratory of Yeditepe University.

3.1.1 Sample Size

A sample size of 40 participants is appropriate to get a power value of 0.8, according to Gpower analysis.

3.2 Ethics Approval Statement

This study was conducted in Istanbul between July 10th to August 10th, 2021. This study was submitted to the Bezmialem Vakıf University Clinical Research Ethical Committee for approval, and the Ethical Committee approved it (App.1).

3.3 Participants

This study included 40 dentists, 20 male and 20 female, the participants were divided into two age categories, with the first ranging from 29-36 years old and the second from 37-60 years old⁸⁹. The sample was chosen from dentists with clinical experience were chosen from the university campus, whether they are masters, Ph.D. students, or supervisors. A single evaluation was given to the participants. All participants voluntarily agreed to participate in this study and signed the informed consent form, after the nature of the procedure was explained to them in detail (App.2).

Table 3.1. Inclusion and Exclusion Criteria.

Inclusion criteria	1. Age group from 29 to 60 years. 2. All the participants with neck pain, with or without referral to the upper limb, longer than 4 weeks. 3. Etiology of mechanical neck pain due to dentists work.
Exclusion criteria	1. Suffering from visual or vestibular disorders. 2. chronic intake of drugs which may alter pain or performance . 3. after whiplash injury .

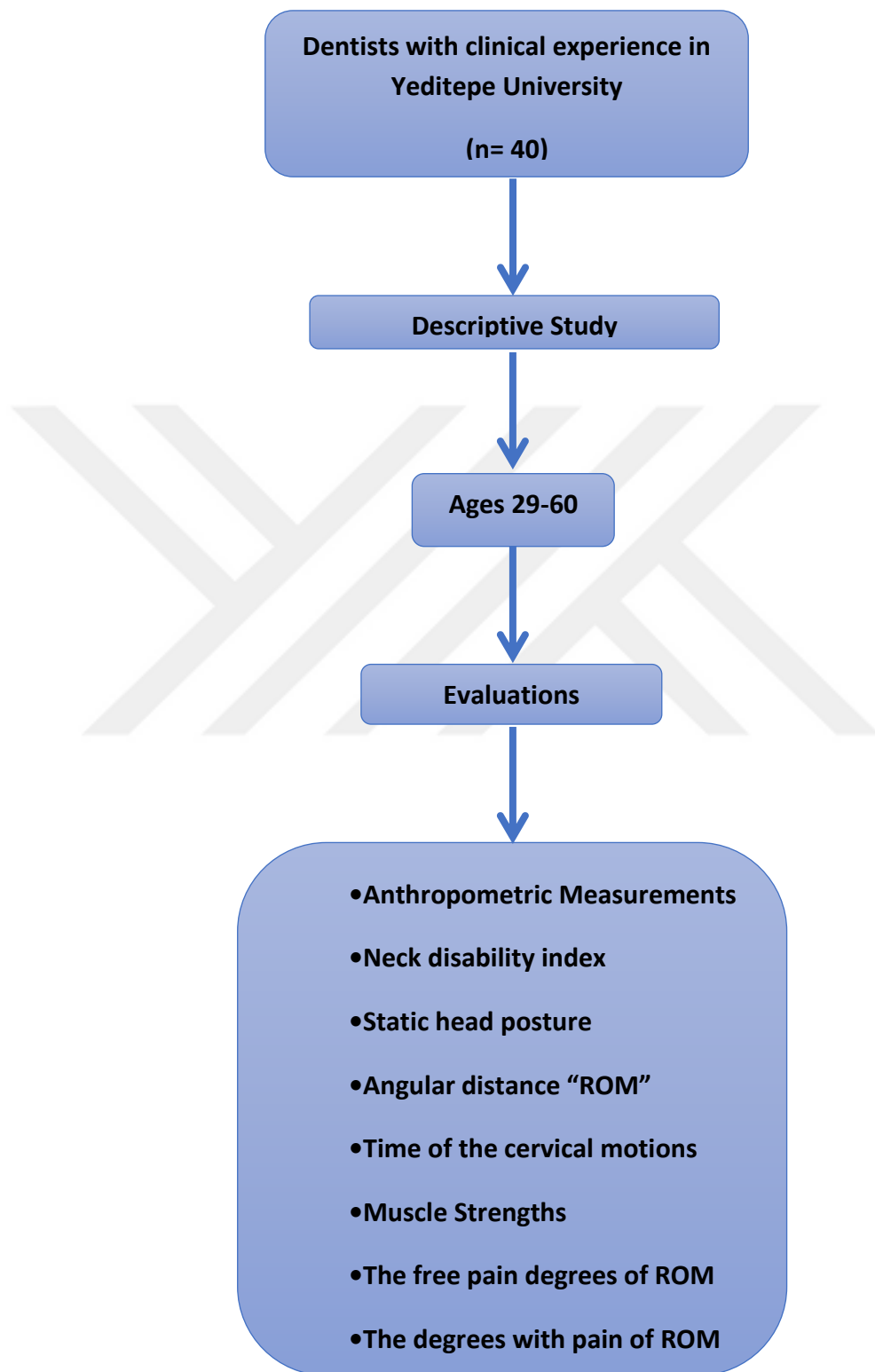


Figure 3.1. Flow Chart of Study

3.4 Assessment Methods

The evaluation procedure was followed by all participants in the same order. Each participant was given their own time separately. First, they started with a structured questionnaire and then, Neck Disability Index (NDI), followed by neck strength by Microfit Dynamometer. Lastly, a VR application was put on the participant's head, used to assess the static head posture, angular distance "ROM", time, and degree with pain and without pain of the neck.

3.4.1 Demographic Features

This contained information about demographic features, such as name, age, weight, height, body mass index but after taking measurements of height and weight, head length, head circumference, head depth, diseases or previous surgeries, medications, smoking behaviors, drinking habits, exercise habit categories⁹⁰, exercise type, duration of exercise, and years of experience.

3.4.2 Neck disability index

The Neck Disability Index (App.6) is a ten-item self-reported questionnaire describing daily life, pain, and concentration. Each item is rated on a score from 0–5, with 0 indicating no disability and 5 indicating extreme disability. To be clinically meaningful, there must be a minimum clinically important difference (MCID) of 5 points, at least, from a total of 50 (Table 3.2). Many studies have confirmed that the NDI has a high degree of validity and reliability. The NDI has also been used as an outcome measure in a number of studies involving the treatment of neck pain and patients with whiplash injury⁹¹⁻⁹².

Table 3.2. scoring of the neck disability index via (Vernon H)⁹³

Total score	0-4 points	5-14 points	15-24 points	25-34 points	35-50 points
classification	No disability	Mild disability	Moderate disability	Severe disability	Complete disability

3.4.3 Muscle Strength

Muscle strength of the neck was taken using a Microfit Dynamometer. The participants were seated comfortably on a stool with their feet in full contact with the floor, avoiding bracing the trunk against a chair. There are no back or armrests, and from the neutral head position, the participant is instructed to push his head against the dynamometer with maximum force for three seconds. During any of the six head movements, the therapist's hand is placed on the dynamometer to resist movement in the following all neck movements. (microFET2™ Hoggan Health Industries, Inc., West Jordan, Utah). Forward flexion (with resistance applied to the forehead with the therapist's hand), extension (with resistance applied to the backward of the occiput by the therapist's hand), right and left side flexion (with resistance applied above the ear with the ipsilateral hand for both sides) and right and left pure rotation (with resistance applied with the ipsilateral hand along the jaw near the chin)⁹⁴.

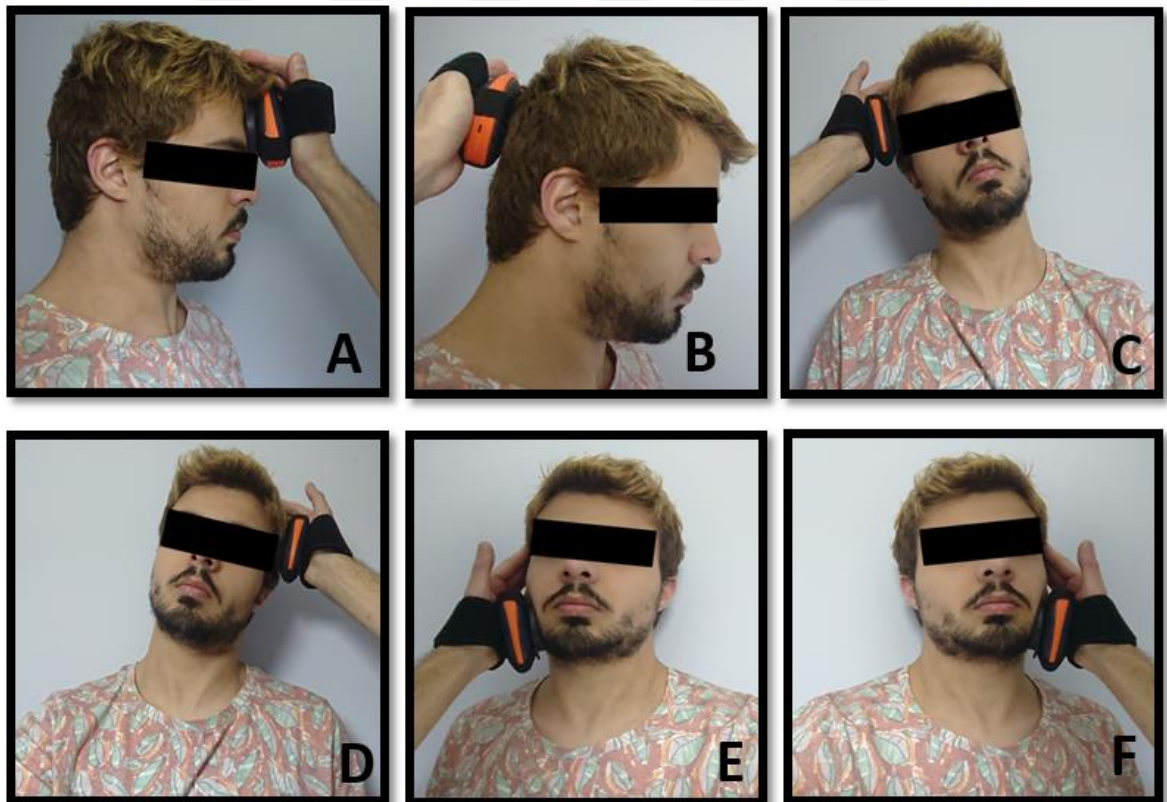


Figure 3.2. Strength testing by hand-held dynamometer. (A) forward flexion (B) extension (C) Right side flexion (D) Left side flexion (E) Right rotation (F) Left rotation

3.4.4 Virtual reality application

Special software programming and settings of the virtual reality headset for kinematic and kinetic assessment of head alignment and movements were developed by the specialized center for virtual reality in Jordan, "Clever Mind POB program foundation." In my study, I used a VR headset with no other equipment next to the headset. The participants will sit and their back supported and hips and knees flexed to 90°, the hands placed on the knees and feet resting on the ground. Then, wear the VR headset. To measure head alignment, angular distance, time, and degree with pain and without pain for all cervical movements.

Automatically, when the participant makes any movement of the six head movements, the results of angular distance, time, and the free pain degrees will be measured directly. There is no need to measure them separately.

3.4.4.1 Static Head posture

After the participant sit down and put on the VR glasses, the VR will detect how many degrees the head position has displaced from the neutral position ($X = 0$, $Y = 0$, $Z = 0$). The x , y and z describe the head alignment, and in the table (3.3), they explain the 3D axis (X , Y , Z). Also in fig 3.3 the participant's head is in $X=5.027058$ $Y=2.466827$ $Z=2.93206$, which explains the degree of deviation from the neutral position.

Table 3.3 Describe the 3D axis for head alignment¹²²

3D axis	Variables
X+	The head in a right bending
X-	The head in a left bending
Y+	The head rotate to right rotation
Y-	The head rotate to left rotation
Z+	The head in extension
Z-	The head in flexion



Figure 3.3. Head alignment how the degree of deviation from the neutral position.

3.4.4.2 Angular distance “ROM”

Cervical range of motion assessment is achieved through virtual reality. After detecting the static head posture, Participants will be asked to flex their necks as far as possible toward their chins and anterior chests. Then elevate the head to the neutral and extend the neck to the most tolerable range. Following that, he/she performs maximal neck side-bending in both directions along the coronal plane. Lastly, each participant is required to return the neck to an upright position for the examination of the maximum angle of neck rotation by "turning the chin toward the right and then left shoulders" without shrugging the shoulders. All of the tests will be repeated three times, and the averaged values of neck movement in each direction will be taken for analysis (Figure 3.4).⁹⁵



Figure3.4. Using virtual reality to measure six cervical ranges

3.4.4.3 Time

A stopwatch inside the virtual reality headset will be used to measure the total time, from the beginning of the movement to the end of the movement, for each of the cervical movements.

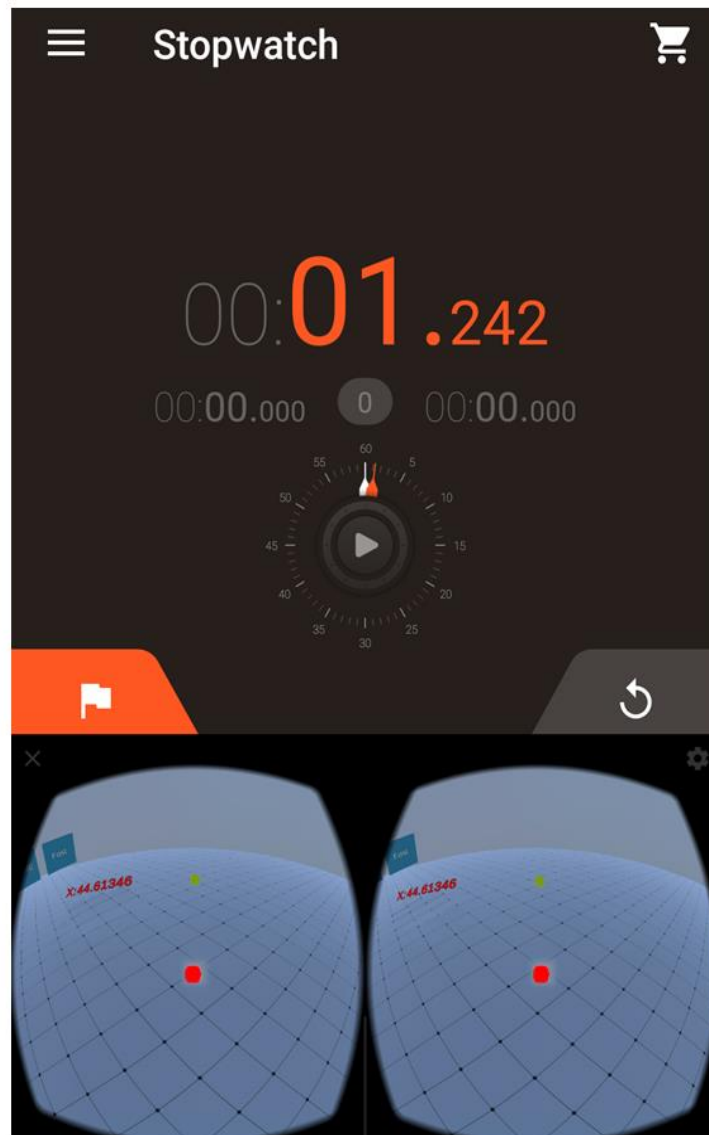


Figure3.5. Displaying the time spent during neck extensor

3.4.4.4 The free pain

During the six motions of the cervical, the free pain degrees of ROM will be measured in each cervical motion, and the tolerable with pain ROM will be documented.

3.5 Statistical Methods

SPSS (Statistical Package for Social Sciences) was used to evaluate the study's data and create the tables, consisting of the computation of descriptive statistics and exposing the frequency and percentage (%) were used for categorical data, mean $\pm$ Standard Deviation (mean $\pm$ SD), and the minimum and maximum (min.-max.) for the continuous variables. To determine the normality of numerical variables the Kolmogorov-Smirnov test was used. As well as the fact that the data backs up parametric assumptions, and the Tukey post hoc test was applied for parametric variables.

To study the comparison between gender and age categories on the physical parameters (neck ROM and strength), we used the independent sample t-test, the same test used for the comparison of the total score for NDI on gender and age categories. The ANOVA For comparison between of exercise habits on the physical parameters (neck ROM and strength), also to study the comparison of the total score for NDI on exercise habits and BMI. Also, a one-sample t-test was utilized to study the differences between normal degrees of ROM with the degrees available between genders. To study the correlation analysis between exercise habit, exercise duration, BMI categories, categories of the NDI scale, pain intensity and work experience, we performed the Spearman correlation test. The regression test was used to detect the strong predictions between virtual reality variables. Independent variables were age categories, gender and exercise habits and the dependent variables were the clinical (pain), physical (neck movements ROM and strength) and functional (NDI items and score). A statistically significant p-value was defined as one that was set to $p \leq 0,05$.

4. RESULTS

Table 4.1 Frequencies and ratio distribution for identification variables of study sample

Factors / variables	Categories	Male		Female		Total	
		N	%	N	%	N	%
Age Categories	Young Adult 29-36	5	25	15	75	20	50
	Old Adult 37-60	15	75	5	25	20	50
BMI- Categories	Low weight less than 18	0	0	2	10	2	5
	18.5 – 24.9 Normal weight	4	20	9	45	13	32.5
	25 – 29.9 Over weight	6	30	7	35	13	32.5
	30 – 34.9 Obesity Grade 1	5	25	0	0	5	12.5
	35 – 39.9 Obesity Grade 2	4	20	1	5	5	12.5
	≥ 42 Obesity Grade 3	1	5	1	5	2	5
Dominant Side	Right	19	95	20	100	39	97.5
	Left	1	5	0	0	1	2.5
Smoking Habit	Never	8	40	12	60	20	50
	Quit	3	15	3	15	6	15
	Yes	9	45	5	25	14	35
Alcohol Habit	Never	6	30	5	25	11	27.5
	Only Special days	6	30	7	35	13	32.5
	Several times a month	5	25	7	35	12	30
	Few times a week	2	10	1	5	3	7.5
	Regularly everyday	1	5	0	0	1	2.5
Medication	Yes	9	45	3	15	12	30
	No	11	55	17	85	28	70
Surgery	Yes	9	45	5	25	14	35
	No	11	55	15	75	26	65
Disease	No	17	85	18	90	35	87.5
	Rheumatismal	1	5	0	0	1	2.5
	Orthopedic	2	10	0	0	2	5
	Different type	0	0	2	10	2	5

N: Number, %: percent.

Forty respondents participated in the analysis. The gender of the respondents was (20,50%) males and (20, 50%) females. The data was stratified according to the gender of the participants. The age distribution of the respondents showed that (5, 25%) of the male participants were in the young group (29–36) years old, while (15, 75%) of the females belonged to the same group. All female participants used their right side (20, 100%), and only one male is using his left side (1, 5%). Using medication among the enrolled sample was as following; (9, 45%) out of male participants using medication and only (3, 15%) of female participants using medication. More details about the study sample and their characteristics are in table 4.1.

Table 4.2 Frequencies and ratio distribution of exercise habits among study sample

Factors / variables	Categories	Male		Female		Total	
		N	%	N	%	N	%
Exercise Habit	Never	9	45	3	15	12	30
	Less than 3 days	9	45	11	55	20	50
	3 days or more	2	10	6	30	8	20
Exercise Type	Never	9	45	3	15	12	30
	Fitness	0	0	6	30	6	15
	Pilates	1	5	0	0	1	2.5
	Swimming	0	0	3	15	3	7.5
	Strength	1	5	0	0	1	2.5
	Running	0	0	1	5	1	2.5
	Walking	8	40	7	35	15	37.5
	Basketball	1	5	0	0	1	2.5
Exercise Duration	Never	9	45	3	15	12	30
	15 min per day	0	0	1	5	1	2.5
	30 min per day	2	10	1	5	3	7.5
	45 min per day	1	5	0	0	1	2.5
	1 hour per day	5	25	5	25	10	25
	1-2 hours per day	0	0	1	5	1	2.5
	1 hour per week	2	10	7	35	9	22.5
	2 hours per week	1	5	1	5	2	5
	3 days per week	0	0	1	5	1	2.5

N: Number, %: percent.

Regarding exercise, the male participants who never did any exercise and those who did exercise less than three days a week were (9, 45%) and (2, 10%) who did exercise more than three days a week. Females differ in this percentage; (3, 15%) never exercise, (11, 55%) exercise less than three days per week, and (6, 30%) exercise three or more days per week. The most common exercise was walking in males and females (8, 40%) and (7, 35%), respectively. Both males and females (5, 25%) did their exercise for more than an hour a day.

Table 4.3 Descriptive statistics of qualitative functional data for Neck disability index

Functional variables	Answers of variables	Total		
		N	%	CP
Pain Intensity	0	16	40	40
	1	16	40	80
	2	6	15	95
	3	2	5	100
Personal Care	0	35	87.5	87.5
	1	4	10	97.5
	3	1	2.5	100
Lifting	0	21	52.5	52.5
	1	7	17.5	70
	2	2	5	75
	3	3	7.5	82.5
	4	7	17.5	100
Reading	0	11	27.5	27.5
	1	23	57.5	85
	2	5	12.5	97.5
	3	1	2.5	100
Headaches	0	20	50	50
	1	9	22.5	72.5
	2	5	12.5	85
	3	6	15	100
Concentration	0	28	70	70
	1	7	17.5	87.5
	2	3	7.5	95
	3	2	5	100
Work	0	31	77.5	77.5
	1	7	17.5	95
	2	2	5	100
Driving	0	27	67.5	67.5
	1	13	32.5	100
Sleeping	0	19	47.5	47.5
	1	11	27.5	75
	2	5	12.5	87.5
	3	4	10	97.5
	4	1	2.5	100
Reaction	0	23	57.5	57.5
	1	8	20	77.5
	2	4	10	87.5
	3	5	12.5	100
Disability Level	No Disability	17	42.5	42.5
	Mild Disability	18	45	87.5
	Moderate disability	5	12.5	100

CP: Cumulative percentage, N: Number, %: percent.

As the above table demonstrated, the NDI scale showed that 40% of the participants had no pain at the moment. More than 80% of the participants could take care of themselves naturally without causing additional pain. The findings indicate that (42.5%) of

participants were very close to having no disability, and (45.0%) had a mild disability. And 12.5% had a moderate disability. Table 4.3 shows more details about the NDI scale in gender.

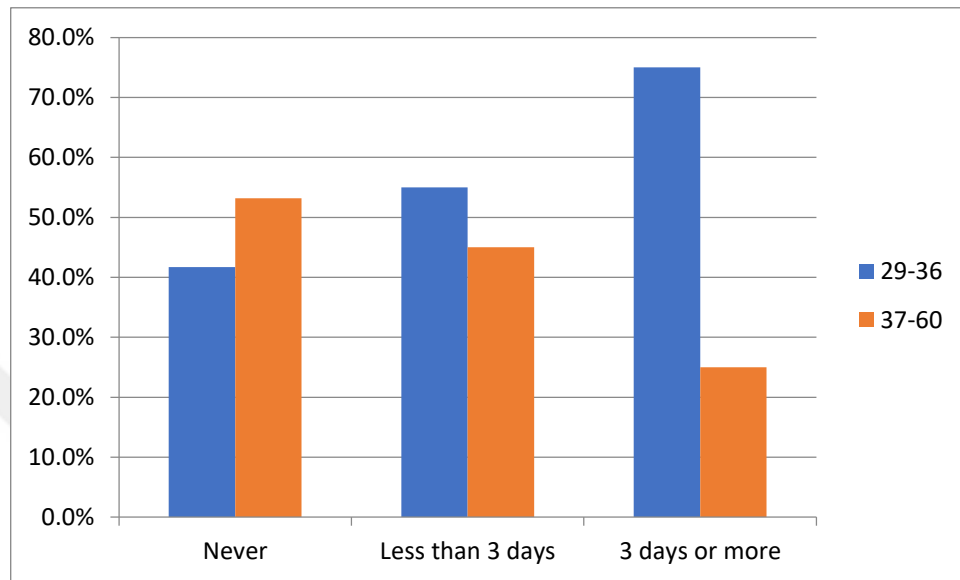


Figure 4.1. Percentage of exercise habits stratified by age categories.

As figure 1 demonstrated, around 75% of the participants between 29–36 years old do their exercises 3 days or more a week. This percentage decreases to 25% in participants who are 37–60 years old. The participants who were between 29–36 years old and did their exercises less than 3 days a week were 55% and around 45% of the 37-60 years old participants. (Figure 1)

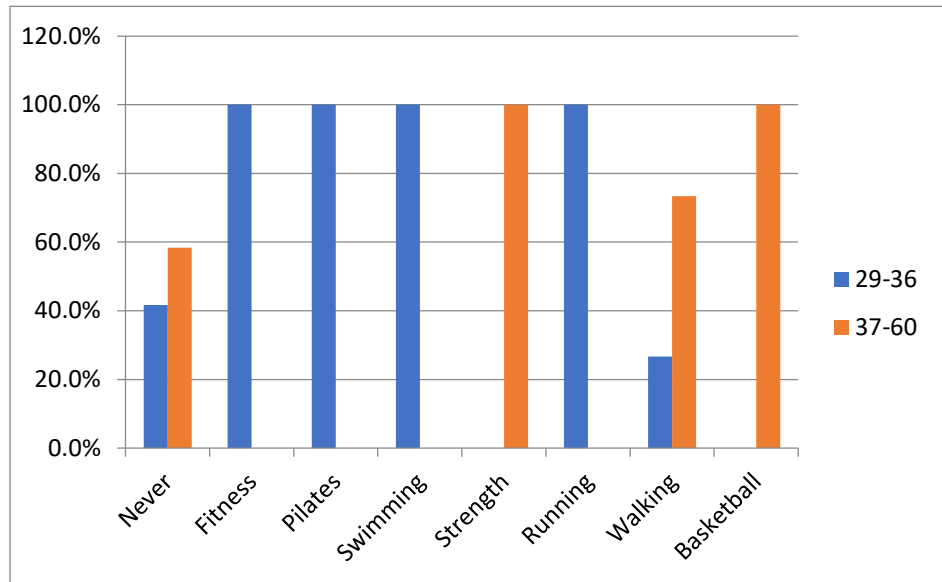


Figure 4.2. Percentage of exercise type stratified by age categories.

As figure 2 demonstrated, no one from 37–60 years old did any fitness, Pilates, swimming and running. Around 40% of people aged 29–36 years old never do any exercise and around 60% of those aged 37–60 years old never do exercise. The participants who were between 29–36 years old found the walking to be around 25% and around 70% in the 37-60 years old participants. (Figure 2)

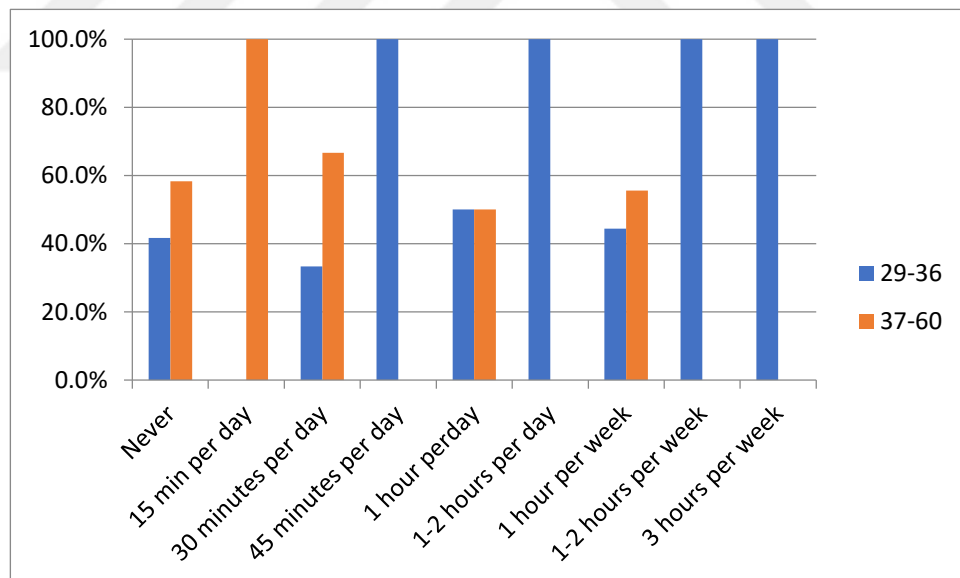


Figure 4.3. Percentage of exercise duration stratified by age categories.

As figure 3 demonstrated the exercise duration of the participants, half of the participants (20, 50%) who are between 29–36 do their exercise for 1 hour a day. Around 40% of those aged 29–36 years old do exercise for 1 hour a week, and more than 55% of those aged 37–60 years old do exercise for the same duration. (Figure 3)

Table 4.4 Descriptive and inferential statistics of anthropometric measurements stratified by age categories.

Anthropometric variables	Young Adult 29-36	Old Adult 37-60	Total	t	p
	Mean± SD	Mean± SD	Mean± SD		
Age	-	-	39.70±9.53	-	-
Weight	75.76±32.36	89.13±17.53	82.44±26.56	-1.62	0.11
Height	167.05±8.39	174.75±7.83	170.90±8.91	-3.00	0.00*
Body Mass Index (BMI)	26.68±9.45	29.28±6.04	27.98±7.94	-1.03	0.30
Head length	27.96±1.39	25.90±5.55	26.93±4.13	1.61	0.11
Head Circumference	56.44±2.29	57.05±1.90	56.75±2.10	-0.91	0.36
Head depth	22.51±2.11	22.41±1.91	22.46±1.99	0.16	0.87

SD: standard deviation. # Independent t test was applied. * Significant difference at $p < 0.05$.

Based on the respondents' age and anthropometric variables, the young adult respondents had a significantly lower mean height compared to older adults (167.05±8.39) (174.75±7.83) ($p < 0.05$), respectively. The young adult respondents had an insignificantly lower mean of BMI compared to older adults (26.68±9.45) (29.28±6.04) ($p < 0.05$), respectively. The mean of head circumference for young adults was insignificantly lower compared to old adults (56.44±2.29) (57.05±1.90) ($p < 0.05$), respectively. More details about the anthropometric variables are available in table 4.4.

Table 4.5 Descriptive and inferential statistics of range of movement and strengths in neck movements stratified by age categories.

Variables of physical parameters	Young Adult 29-36	Old Adult 37-60	Total	t	p
	Mean± SD	Mean± SD	Mean ± SD		
Neck Fx ROM	44.29±13.42	38.83±8.68	41.56±11.50	1.52	0.13
Neck Ex ROM	47.90±8.32	45.18±10.09	46.54±9.23	0.93	0.35
Neck Rt SF ROM	29.85±7.81	29.53±7.99	29.69±7.80	0.13	0.89
Neck Lt SF ROM	30.90±6.81	30.83±7.11	30.86 ± 6.87	0.03	0.97
Neck Rt Rot ROM	61.80±6.50	54.48±10.01	58.134 ± 9.12	2.74	0.00*
Neck Lt Rot ROM	64.88±9.76	58.55±9.56	61.71 ± 10.06	2.07	0.04*
Neck Fx St	13.58±7.19	14.38±3.66	13.98 ± 5.64	-0.44	0.66
Neck Ex St	11.43±5.86	13.93±5.57	12.68 ± 5.78	-1.38	0.17
Neck Rt SF St	11.35±5.50	12.20±3.82	11.78 ± 4.69	-0.56	0.57
Neck Lt SF St	16.15±6.36	16.45±5.60	16.30 ± 5.92	-0.15	0.87
Neck Rt Rot St	12.75±6.60	12.55±5.68	12.65 ± 6.08	0.10	0.91
Neck Lt Rot St	13.45±4.91	13.09±5.03	13.27 ± 4.91	0.23	0.81

SD: standard deviation. # Independent t test was applied. * Significant difference at $p < 0.05$. Fx: flexion. Ex: extension. Rt SF: right side flexion. Lt SF: left side flexion. Rt Rot: right rotation. Lt Rot: left rotation. ROM: range of motion. St: strength

Depends on the respondents' age and physical parameters. The young adult respondents had a significantly higher mean of neck right rotation ROM compared to older adults (61.80 ± 6.50) (54.48 ± 10.01) ($p < 0.05$), respectively. The young adult respondents had a significantly higher mean of neck left rotation ROM compared to older adults (64.88 ± 9.76) (58.55 ± 9.56) ($p < 0.05$), respectively. The mean of neck right side flexion strength for young adults was insignificantly lower compared to older adults (11.35 ± 5.50) (12.20 ± 3.82) ($p < 0.05$), respectively. More details about the physical parameters are available in table 4.5.

Table 4.6 Descriptive and inferential statistics in neck movement pain by age categories.

Variables	Young Adult 29-36	Old Adult 37-60	Total	t	p
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD		
Neck Fx DWP	0.57 $\pm$ 1.24	0.80 $\pm$ 1.74	0.68 $\pm$ 1.49	-0.49	0.62
Neck Ex DWP	0.30 $\pm$ 1.34	0.45 $\pm$ 1.23	0.38 $\pm$ 1.28	-0.36	0.71
Neck Rt SF DWP	1.84 $\pm$ 1.89	1.48 $\pm$ 1.40	1.66 $\pm$ 1.65	0.68	0.49
Neck Lt SF DWP	0.58 $\pm$ 1.33	0.58 $\pm$ 1.27	0.58 $\pm$ 1.28	0.00	0.99
Neck Rt Rot DWP	1.88 $\pm$ 2.76	1.93 $\pm$ 2.26	1.90 $\pm$ 2.49	-0.06	0.95
Neck Lt Rot DWP	1.03 $\pm$ 1.53	0.33 $\pm$ 1.24	0.68 $\pm$ 1.42	1.59	0.11

SD: standard deviation. # Independent t test was applied. * Significant difference at $p < 0.05$.
Fx: flexion. Ex: extension. Rt SF: right side flexion. Lt SF: left side flexion. Rt Rot: right rotation. Lt Rot: left rotation. DWP: degrees with pain

Depends on the age group and pain in 6 movements. The young adult (29–36) respondents had an insignificantly higher mean of neck left rotation degrees with pain compared to older adults (1.03 ± 1.53) (0.33 ± 1.24) ($p > 0.05$), respectively. The young adult respondents had an insignificantly lower mean of neck extension degrees with pain compared to older adult respondents (0.30 ± 1.34) (0.45 ± 1.23) ($p > 0.05$), respectively. The young adult respondents had significantly higher mean neck right side flexion degrees with pain compared to older adults (1.84 ± 1.89) (1.48 ± 1.40) ($p > 0.05$), respectively. The highest degree of pain was in Neck Right Rotation degrees with pain, the total (1.90 ± 2.49) and younger adults had a lower mean than older adults in their pain (1.88 ± 2.76) (1.93 ± 2.26), respectively. More details about the pain and age are available in table 4.6.

Table 4.7 Descriptive and inferential statistics of anthropometric measurements stratified by gender

Anthropometric variables	Male	Female	Total	t	p
	Mean± SD	Mean± SD	Mean± SD		
Age	44.40 ± 10.01	35 ± 6.29	39.70 ± 9.53	3.56	0.00*
Weight	95.37 ± 26.76	69.52 ± 19.51	82.44 ± 26.56	3.49	0.00*
Height	176.25 ± 5.39	165.55 ± 8.58	170.90 ± 8.91	4.72	0.00*
Body Mass Index	30.71 ± 8.61	25.25 ± 6.28	27.98 ± 7.94	2.29	0.02*
Head length	26.088 ± 5.62	27.77 ± 1.34	26.93 ± 4.13	-1.30	0.20
Head Circumference	57.23 ± 1.85	56.27 ± 2.27	56.75 ± 2.10	1.47	0.15
Head depth	22.63 ± 1.72	22.29 ± 2.25	22.46 ± 1.99	.55	0.58

SD: standard deviation. # Independent t test was applied. * Significant difference at p <0.05.

Based on the respondents' gender and anthropometric variables, the male respondents had a significantly higher mean weight compared to females (95.37 ± 26.76) (69.52 ± 19.51) (p <0.05), respectively. The male respondents had a significantly higher mean height compared to females (176.25 ± 5.39) (165.55 ± 8.58) (p <0.05), respectively. The mean age for females was significantly lower compared to males (35.00 ± 6.29) (44.40 ± 10.01) (p <0.05), respectively. More details about the anthropometric variables are available in table 4.7.

Table 4.8 Descriptive and inferential statistics of range of movement and strengths in neck movements stratified by gender.

Variables of physical parameters	Male	Female	Total	t	p
	Mean± SD	Mean± SD	Mean ± SD		
Neck Fx ROM	38.83 ± 8.12	44.29 ± 13.77	41.56±11.50	-1.529	0.13
Neck Ex ROM	45.13 ± 11.05	47.95 ± 6.98	46.54±9.23	-.967	0.34
Neck Rt SF ROM	29.88 ± 8.32	29.50 ± 7.46	29.69±7.80	-.150	0.88
Neck Lt SF ROM	31.18 ± 6.80	30.55 ± 7.10	30.86 ± 6.87	.284	0.77
Neck Rt Rot ROM	56.20 ± 9.29	60.08 ± 8.74	58.14 ± 9.12	-1.358	0.18
Neck Lt Rot ROM	59.20 ± 7.73	64.23 ± 11.60	61.71 ± 10.06	-1.612	0.11
Neck Fx St	16.95 ± 5.76	11.00 ± 3.69	13.98 ± 5.64	3.892	0.00*
Neck Ex St	16.23 ± 6.03	9.13 ± 2.41	12.68 ± 5.78	4.891	0.00*
Neck Rt SF St	14.20 ± 4.66	9.35 ± 3.32	11.78 ± 4.69	3.787	0.00*
Neck Lt SF St	19.50 ± 6.28	13.10 ± 3.29	16.30 ± 5.92	4.035	0.00*
Neck Rt Rot St	15.53 ± 7.29	9.78 ± 2.31	12.65 ± 6.08	3.364	0.00*
Neck Lt Rot St	15.11 ± 5.55	11.43 ± 3.41	13.27 ± 4.91	2.532	0.01*

SD: standard deviation. # Independent t test was applied. * Significant difference at p <0.05. Fx: flexion. Ex: extension. Rt SF: right side flexion. Lt SF: left side flexion. Rt Rot: right rotation. Lt Rot: left rotation. ROM: range of motion. St: strength

Depends on the respondents' gender and physical parameters. The male respondents had significantly higher mean neck flexion strength compared to females (16.95 ± 5.76) (11.00 ± 3.69) ($p < 0.05$), respectively. The males' respondents had a significantly higher mean of neck right rotation strength compared to females (15.53 ± 7.29) (9.78 ± 2.31) ($p < 0.05$), respectively. The mean of neck left rotation strength for females was significantly lower compared to males (15.11 ± 5.55) (11.43 ± 3.41) ($p < 0.05$), respectively. More details about the physical parameters are available in table 4.8.

Table 4.9 Descriptive and inferential statistics in neck movement pain by gender

Variables	Male	Female	Total	T	P
	Mean± SD	Mean± SD	Mean± SD		
Neck Fx DWP	0.75±1.74	0.62±1.24	0.68±1.49	0.28	0.77
Neck Ex DWP	0.20±0.62	0.55±1.70	0.38±1.28	-0.86	0.39
Neck Rt SF DWP	1.50±1.32	1.81±1.95	1.66±1.65	-0.58	0.55
Neck Lt SF DWP	0.50±1.24	0.65±1.36	0.58±1.28	-0.36	0.71
Neck Rt Rot DWP	1.90±2.51	1.90±2.54	1.90±2.49	0.00	0.99
Neck Lt Rot DWP	0.20±0.70	1.15±1.78	0.68±1.42	-2.22	0.03*

SD: standard deviation. # Independent t test was applied. * Significant difference at $p < 0.05$.
Fx: flexion. Ex: extension. Rt SF: right side flexion. Lt SF: left side flexion.
Rt Rot: right rotation. Lt Rot: left rotation. DWP: degrees with pain

Depends on the gender and pain in 6 movements. The male respondents had a significantly lower mean of neck left rotation degrees with pain compared to females (0.20 ± 0.70) (1.15 ± 1.78) ($p < 0.05$), respectively. The males respondents had significantly lower mean of Neck Extension degrees with pain compared females respondents (0.20 ± 0.62) (0.55 ± 1.70) ($p > 0.05$), respectively. The males respondents had significantly lower mean of Neck Left side flexion degrees with pain compared females (0.50 ± 1.24) (0.65 ± 1.36) ($p > 0.05$), respectively. The highest degree of pain was in Neck Right Rotation degrees with pain, the total (1.90 ± 2.49) and males and females participants showed similarity in their pain (1.90 ± 2.51) (1.90 ± 2.54), respectively. More details about the pain and gender available in table 4.9.

Table 4.10 Statistical results of one sample t test for range of motions stratified by gender

Variables of physical parameters	Normal ROM	Male				Female			
		Mean±SD	t	MD	p	Mean±SD	t	MD	p
N Fx ROM	50	38.83±8.12	-6.15	-11.18	.00	44.29±13.77	-1.86	-5.71	.08
N Ex ROM	60	45.13±11.05	-6.02	-14.88	.00	47.95±6.98	-7.72	-12.05	.00
N Rt SF ROM	45	29.88±8.32	-8.13	-15.13	.00	29.50±7.46	-9.29	-15.50	.00
N Lt SF ROM	45	31.18±6.80	-9.09	-13.83	.00	30.55±7.10	-9.10	-14.45	.00
N Rt Rot ROM	80	56.20±9.29	-11.46	-23.80	.00	60.08±8.74	-10.19	-19.93	.00
N Lt Rot ROM	80	59.20±7.73	-12.03	-20.80	.00	64.23±11.60	-6.08	-15.78	.00

MD: Mean Difference, M: mean, SD: Standard Deviation, ROM: Range of Motion, N: neck, Fx: flexion, Ex: extension, Rt: right, Lt: left, Rot: rotation, SF: side flexion

Depends on the respondents' gender and physical parameters. The mean neck flexion ROM for males (38.83±8.12) was lower than the population's 'normal' neck flexion ROM score of 50 ($p < 0.05$). The mean neck flexion ROM (44.29±13.77) for females was lower than the population's 'normal' neck flexion ROM score of 50 ($p > 0.05$). The mean neck extension ROM for males (45.13±11.05) was lower than the population 'normal' neck extension ROM score of 60 ($p < 0.05$). The mean neck extension ROM (47.95±6.98) for females was lower than the population 'normal' neck extension ROM score of 60 ($p < 0.05$). More details about the physical parameters in gender group are available in table 4.10.

Table 4.11 Descriptive and inferential statistics of anthropometric measurements stratified by exercise habits.

Anthropometric variables	Never	< 3 days	3 days or >	Total	F	P
	Mean± SD	Mean± SD	Mean± SD	Mean± SD		
Age	41.17±9.82	40.70±10.03	35±7.01	39.70±9.53	1.24	.30
Weight	104.69±33.61	74.35±16.79	69.30±12.57	82.44±26.56	8.46	.00*
Height	174.75±7.05	170.85±9.30	165.25±8.21	170.90±8.91	3.01	.06
Body Mass Index	34.11±10.58	25.37±4.97	25.31±4.00	27.98±7.94	6.58	.00*
Head length	26.79±1.27	26.73±5.76	27.64±1.18	26.93±4.13	.14	.86
Head-circumference	57.18±2.09	56.56±2.15	56.55±2.19	56.75±2.10	.36	.69
Head depth	22.69±2.15	22.31±1.90	22.46±2.18	22.46±1.99	.13	.87

SD: standard deviation. # Independent t test was applied. * Significant difference at $p < 0.05$.

Based on the respondents' habits of exercise and anthropometric variables, the participants who did exercise 3 days or more had a significantly lower mean weight

compared to those who never did any exercise (69.30 ± 12.57) (104.69 ± 33.61) ($p < 0.05$), respectively. The participants who do exercise 3 days or more had a significantly lower mean BMI compared to those who never do any exercise (25.31 ± 4.00) (34.11 ± 10.58) ($p < 0.05$), respectively. The mean of Head Circumference for never do exercise was insignificantly higher compared to who do exercise less than 3 days (57.18 ± 2.09) (56.56 ± 2.15) ($p > 0.05$), respectively. More details about the anthropometric variables and exercise habits are available in table 4.11.

Table 4.12 Descriptive and inferential statistics of range of movement and strengths in neck movements stratified by exercise habits

Variables of physical parameters	Never	Less than 3 days	3 days or more	Total	F	p
	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD	Mean $\pm$ SD		
Neck Fx ROM	38.17 $\pm$ 7.66	43.27 $\pm$ 13.88	42.38 $\pm$ 9.62	41.56 $\pm$ 11.50	.75	0.47
Neck Ex ROM	45.96 $\pm$ 12.13	47.23 $\pm$ 8.24	45.69 $\pm$ 7.54	46.54 $\pm$ 9.23	.11	0.89
Neck Rt SF ROM	29 $\pm$ 8.89	29.85 $\pm$ 8.15	30.31 $\pm$ 5.75	29.69 $\pm$ 7.80	.07	0.93
Neck Lt SF ROM	29.42 $\pm$ 7.58	31.70 $\pm$ 7.36	30.94 $\pm$ 4.51	30.86 $\pm$ 6.87	.40	0.67
Neck Rt Rot ROM	56.21 $\pm$ 10.32	58.03 $\pm$ 8.45	61.31 $\pm$ 9.18	58.14 $\pm$ 9.12	.75	0.48
Neck Lt Rot ROM	60.21 $\pm$ 9.05	62.45 $\pm$ 9.03	62.13 $\pm$ 14.43	61.71 $\pm$ 10.06	.19	0.83
Neck Fx St	16.42 $\pm$ 6.30	12.80 $\pm$ 4.86	13.25 $\pm$ 6.01	13.98 $\pm$ 5.64	1.68	0.20
Neck Ex St	15.88 $\pm$ 6.74	11.63 $\pm$ 5.06	10.50 $\pm$ 4.41	12.68 $\pm$ 5.78	3.01	0.06
Neck Rt SF St	13.79 $\pm$ 5.33	10.78 $\pm$ 4.46	11.25 $\pm$ 3.73	11.78 $\pm$ 4.69	1.67	0.20
Neck Lt SF St	19.08 $\pm$ 6.81	15 $\pm$ 4.78	15.38 $\pm$ 6.42	16.30 $\pm$ 5.92	2.01	0.14
Neck Rt Rot St	15.58 $\pm$ 6.40	10.55 $\pm$ 4.65	13.50 $\pm$ 7.39	12.65 $\pm$ 6.08	2.94	0.06
Neck Lt Rot St	13.79 $\pm$ 5.31	12.89 $\pm$ 4.83	13.44 $\pm$ 5.07	13.27 $\pm$ 4.91	.13	0.88

SD: standard deviation. # Independent t test was applied. * Significant difference at $p < 0.05$. Fx: flexion. Ex: extension. Rt SF: right side flexion. Lt SF: left side flexion. Rt Rot: right rotation. Lt Rot: left rotation. ROM: range of motion. St: strength

Depends on the respondents' exercise and physical parameters, the participants who never did exercise had an insignificantly lower mean of neck flexion ROM compared to those who did exercise less than 3 days and 3 days or more (38.17 ± 7.66) (43.27 ± 13.88) (42.38 ± 9.62) ($p > 0.05$), respectively. The participants who never do exercise had insignificantly lower mean of Neck Left Rotation ROM compared to who do exercise less than 3 days and 3 days or more (60.21 ± 9.05) (62.45 ± 9.03) (62.13 ± 14.43) ($p > 0.05$), respectively. The participants who never do exercise had an insignificantly higher mean of neck right rotation strength compared to those who do exercise less than 3 days and 3 days or more (15.58 ± 6.40) (10.55 ± 4.65) (13.50 ± 7.39) ($p > 0.05$), respectively. More details about the physical parameters are available in table 4.12.

Table 4.13 Descriptive and inferential statistics in neck movement pain by exercise habits

Variables	Never	Less than 3 days	3 days or more	Total	F	p
	Mean± SD	Mean± SD	Mean± SD	Mean± SD		
Neck Fx DWP	1.00±1.65	0.76±1.65	-	0.68±1.49	1.15	0.32
Neck Ex DWP	0.33±0.77	0.55±1.70	-	0.38±1.28	.53	0.59
Neck Rt SF DWP	1.41±1.37	1.41±1.57	2.62±2.01	1.66±1.65	1.80	0.17
Neck Lt SF DWP	0.62±0.82	0.40±1.27	0.93±1.86	0.58±1.28	.50	0.61
Neck Rt Rot DWP	1.91±2.76	2.42±2.51	0.56±1.59	1.90±2.49	1.65	0.20
Neck Lt Rot DWP	0.54±1.58	0.20±0.69	2.06±1.74	0.68±1.42	6.40	0.00*

SD: standard deviation. # Independent t test was applied. * Significant difference at $p < 0.05$. Fx: flexion. Ex: extension. Rt SF: right side flexion. Lt SF: left side flexion. Rt Rot: right rotation. Lt Rot: left rotation. DWP: degrees with pain

Depends on the exercise habits and pain in the 6 movements. The participants who never did exercise had a significantly lower mean of neck left rotation degrees with pain compared to those who did exercise for 3 days or more (0.54 ± 1.58) (2.06 ± 1.74) ($p < 0.05$), respectively. The participants who never do exercise had an insignificantly lower mean of neck right side flexion degrees with pain compared to those who do exercise 3 days or more (1.41 ± 1.37) (2.62 ± 2.01) ($p > 0.05$), respectively. The participants who had never did exercise had a significantly higher mean of neck right rotation degrees with pain compared to those who did exercise 3 days or more (1.91 ± 2.76) (0.56 ± 1.59) ($p > 0.05$), respectively. The highest degree of pain was in Neck Right Rotation degrees with pain, the total (1.90 ± 2.49) and those who did their exercise less than 3 days had a higher mean than those who never did any exercise in their pain (2.42 ± 2.51) (1.91 ± 2.76), respectively. More details about the pain and age are available in table 4.13.

Table 4.14 Inferential statistical results for the total score of neck disability index by gender, age categories, BMI categories and exercise habit

Characteristics	Categories	Median (Min-Max)	Mean ± SD	t / f	p value
Gender					
Female		14 (0-38)	14.00± 11.01	0.21	0.83
Male		11 (2-34)	13.30 ±9.80		
Age categories					
Young Adult 29-36		8 (0-26)	10.30± 8.39	-2.15	0.03*
Old Adult 37-60		17 (0-38)	17.00± 11.11		
BMI categories					
Low weight less than 18		18 (2-8)	5.00 ±4.24	0.64	0.66
18.5 – 24.9 Normal weight		14 (2-22)	12.00± 7.78		
25 – 29.9 Over weight		10 (0-30)	13.38 ±10.43		
30 – 34.9 Obesity Grade 1		20 (8-32)	18.80 ±9.95		
35 – 39.9 Obesity Grade 2		12 (4-38)	15.60 ±13.66		
≥ 42 Obesity Grade 3		17 (0-34)	17.00 ±24.04		
Exercise habit					
Never		11 (0-38)	16.50 ±13.26	1.97	0.15
Less than 3 days		10 (0-20)	10.50 ± 7.07		
3 days or more		22 (2-30)	17.25± 11.00		

SD: standard deviation. # Independent t test and ANOVA test were applied. * Significant difference at $p < 0.05$.

Referring to the NDI scale, the males' respondents had an insignificantly lower mean compared to females (13.30 $\pm$ 9.80) (14.00 $\pm$ 11.01) ($p > 0.05$), respectively. The young adult participants (29-36) years old had a lower mean compared to the old participants (10.30 $\pm$ 8.39) (17.00 $\pm$ 11.11) ($p = 0.03$) respectively. More details about the NDI scale are available in table 4.14.

Table 4.15 The spearman correlation between exercise habit, exercise duration, BMI categories, pain intensity, work experience and categories of NDI scale

		EH	ED	BMI C	NDI C	PI	WE
EH	r	1					
	p	.					
ED	r	.806**	1				
	p	.000	.				
BMI C	r	-.446**	-.476**	1			
	p	.004	.002	.			
NDI C	r	-.033	-.213	.215	1		
	p	.842	.186	.182	.		
PI	r	.126	-.007	.300	.642**	1	
	p	.440	.964	.060	.000		
WE	r	-.359*	-.459**	.406**	.431**	.332*	1
	p	.023	.003	.009	.006	.037	

EH: exercise habits. ED: exercise duration. BMI C: body mass index categories.
NDI C: neck disability index categories. PI: pain intensity. WE: work experience

The above table showed the spearman correlation between several categorical variables, the table showed that there is a significant weak negative association between the exercise duration and BMI ($r = -0.47$, $p < 0.05$). There is weak and insignificant association between the NDI with exercise duration and BMI ($r = -0.21$, $p > 0.05$) and ($r = 0.21$, $p > 0.05$), respectively. Also there is significant weak negative association between the exercise habit and BMI ($r = -0.44$, $p < 0.05$). In addition there is a significant weak positive association between working years with the BMI, NDI and pain intensity ($r = 0.406$, $p < 0.05$). ($r = 0.431$, $p < 0.05$). ($r = 0.332$, $p < 0.05$). Finally there is a significant strong positive association between pain intensity and NDI ($r = .642$, $p < 0.05$).

Statistical results of Regression

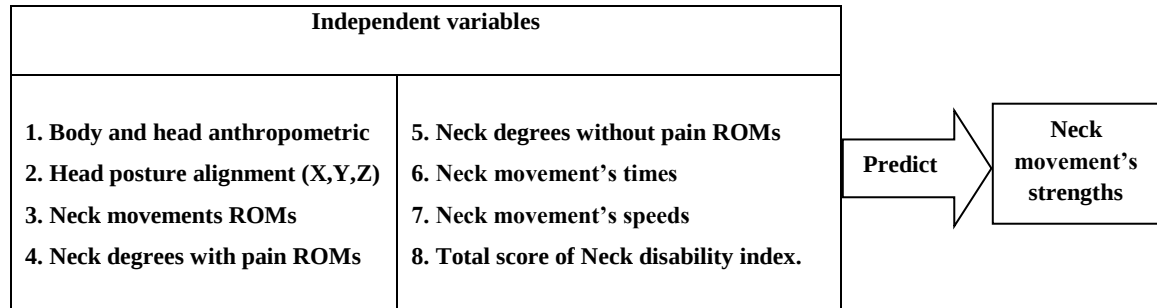


Figure 4.4 Illustrates predictive factors of neck movement's strengths

Table 4.16. Clarifies results of multivariate linear regression in terms of predictive factors of neck movement's strengths

Dependent variables	Independent predictive variables	R	R ²	F value	F sig	B	T	t sig
Fx St	N St: Rt Rot	.735	.541	44.75	.000	5.34	3.74	.001
	Height	.773	.597	27.44	.000	-20.98	-1.81	.079
Ex St	N St: Lt SF	.816	.665	75.52	.000	-.321	-.202	.841
	N St: Lt Rot	.870	.757	57.62	.000	-2.21	-1.51	.139
	Weight	.902	.814	52.53	.000	-5.32	-3.33	.002
Rt SF St	N St: Ex	.781	.611	59.61	.000	3.74	3.28	.002
	N St: Rt Rot	.825	.680	39.32	.000	2.84	2.59	.013
	N Rt Rot: DWP	.867	.752	36.33	.000	1.57	1.48	.147
	N Fx: time	.884	.782	31.39	.000	-1.79	-.986	.331
	Sp Fx	.899	.807	28.52	.000	-7.51	-2.34	.025
	Weight	.914	.835	27.77	.000	-9.52	-3.03	.005
LT SF St	N St: Ex	.816	.665	75.52	.000	5.73	4.29	.000
	N St: Rt Rot	.856	.732	50.63	.000	4.61	3.65	.001
Rt Rot St	N St: Lt SF	.767	.588	54.29	.000	-.192	-.103	.918
	N St: Fx	.835	.697	42.61	.000	-2.15	-1.27	.213
	N Lt SF: DWP	.861	.742	34.51	.000	-3.43	-2.06	.047
	Age	.880	.775	30.12	.000	1.15	.45	.657
	Sp Fx	.896	.803	27.68	.000	5.14	1.69	.100
Lt Rot St	N St: Ex	.788	.621	62.291	.000	4.785	4.05	.000
	N Rt Rot: ROM	.843	.711	45.541	.000	-4.734	-1.58	.122

Fx: flexion. Ex: extension. SF: side flexion. Rot: rotation. Rt: right. Lt: Left. St: strength. Sp: speed. N: neck. DWP: degrees with pain

The results indicated that neck strength: right rotation was a significant predictive factor where $F=44.75$, $P=.000$, $R^2=.541$. We inferred from t value and its linked p-value between the predictive and dependent variables. Neck strength: right rotation was positively correlated with neck flexion strength where $t=3.74$, $P=.001$. Also, the results indicated that weight was a significant predictive factor where $F=52.53$, $P=.000$, $R^2=.814$. Weight was negatively correlated with neck extension strength where $t=-3.33$, $P=.002$.

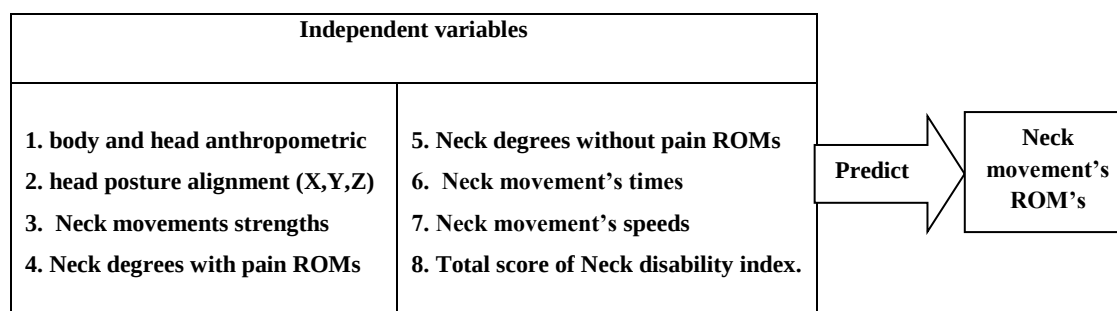


Figure 4.5 Illustrates predictive factors of neck movement's ROMs

Table 4.17 Clarifies results of multivariate linear regression in terms of predictive factors of neck movements ROMs

Dependent variables	Independent predictive variables	R	R ²	F value	F sig	B	T	t sig
Fx ROM	Sp Rt Rot	.609	.371	22.41	.000	22.48	5.25	.000
	N Ex: DWP	.711	.505	18.89	.000	23.79	6.41	.000
	HC	.761	.580	16.55	.000	109.72	3.21	.003
	HP Y	.797	.636	15.29	.000	102.45	3.16	.003
	T.NDI	.824	.679	14.41	.000	108.85	3.51	.001
	HP X	.846	.716	13.89	.000	104.09	3.51	.001
	N Lt Rot: DWP	.869	.756	14.16	.000	100.52	3.59	.001
Ex ROM	N Lt Rot: DWOP	.509	.259	13.29	.001	17.84	2.24	.031
RT SF ROM	N Lt SF Rom	.827	.684	82.34	.000	.702	.215	.831
	N Fx: T	.877	.769	61.58	.000	-6.06	-1.79	.081
	BMI	.904	.817	53.47	.000	-12.45	-3.37	.002
LT SF ROM	N Rt SF: DWOP	.832	.692	85.57	.000	11.87	5.54	.000
	BMI	.860	.740	52.59	.000	16.34	6.19	.000
	N St: Rt SF	.883	.780	42.67	.000	15.41	6.21	.000
RT Rot ROM	N Lt Rot: DWOP	.636	.404	25.79	.000	22.75	3.22	.003
	N Rt SF ROM	.710	.504	18.79	.000	15.14	2.13	.040
	Age	.780	.608	18.58	.000	36.42	3.87	.000
LT Rot ROM	N Rt Rot: ROM	.633	.400	25.36	.000	21.14	2.59	.013
	N Lt SF: DWP	.723	.523	23.30	.000	21.95	2.97	.005
	Sp Ex	.764	.583	16.81	.000	17.19	2.36	.024
	N Rt Rot: DWOP	.793	.629	14.85	.000	17.78	2.55	.015
	N Ex: DWP	.820	.672	13.96	.000	20.07	2.97	.005

Fx: flexion. Ex: extension. SF: side flexion. Rot: rotation. Rt: right. Lt: Left. St: strength. Sp: speed. N: neck. DWP: degrees with pain. DWOP: degrees without pain. BMI: body mass index. HC: head circumference. HP X: head posture x. HP Y: head posture y.

The results indicated that Head posture: Y was a significant predictive factor where $F=15.29$, $P=.000$, $R^2=.636$. We inferred from t value and its linked p-value between the predictive and dependent variables. Head posture: Y was positively correlated with neck flexion ROM where $t=3.16$, $P=.003$. Also, the results indicated that neck Left rotation: Degrees without pain was a significant predictive factor where $F=13.29$, $P=.001$, $R^2=.259$. Neck Left rotation: Degrees without pain was positively correlated with neck extension ROM where $t=2.24$, $P=.031$.

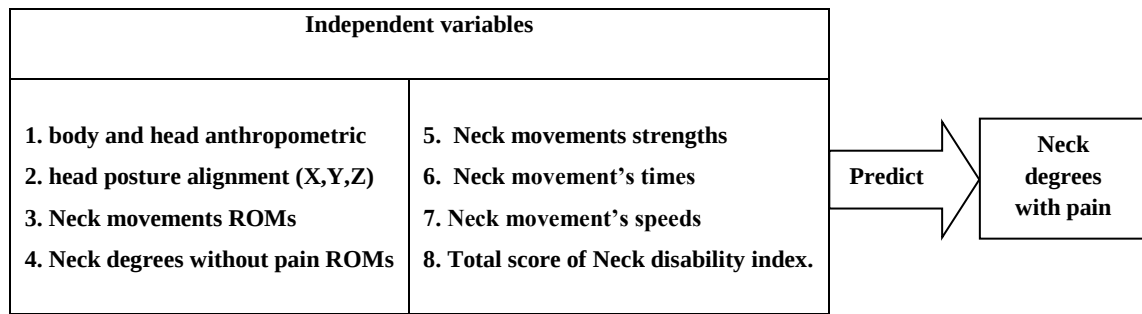


Figure 4.6 Illustrates predictive factors of neck degrees with pain ROMs

Table 4.18. Clarifies results of multivariate linear regression in terms of predictive factors of neck degrees with pain ROMs

Dependent variables	Independent predictive variables	R	R ²	F value	F sig	B	T	t sig
N Fx DWP	N Rt Rot: DWOP	.571	.326	18.38	.000	.396	1.91	.064
	HP X	.654	.428	13.82	.000	.677	3.04	.004
N Ext DWP	Sp Fx	.587	.345	19.98	.000	-1.25	-3.13	.003
	N Lt Rot ROM	.677	.458	15.63	.000	1.25	1.29	.205
N Rt SF DWP	N Lt SF: DWOP	.357	.127	5.54	.024	4.15	3.82	.000
	N Fx: T	.466	.217	5.13	.011	2.56	1.98	.055
N Lt SF DWP	N Rt Rot: DWOP	.561	.314	17.41	.000	.333	1.85	.072
	N Lt Rot ROM	.656	.430	13.98	.000	3.02	3.04	.004
	Age	.709	.502	12.09	.000	5.68	3.79	.001
N Rt Rot DWP	Sp Lt Rot	.466	.217	10.52	.002	-1.13	-1.13	.264
	N Lt SF: T	.607	.369	10.81	.000	-7.45	-3.23	.003
	N Ex ROM	.673	.453	9.95	.000	-5.34	-2.27	.029

Fx: flexion. Ex: extension. SF: side flexion. Rot: rotation. Rt: right. Lt: Left. St: strength. Sp: speed. N: neck. DWOP: degrees without pain. T: time. HC: head circumference. HP X: head posture x. ROM: range of motion

The results indicated that head posture: X was a significant predictive factor where $F=13.82$, $P=.000$, $R^2=.428$. We inferred from t value and its linked p-value between the predictive and dependent variables. Head posture: X was positively correlated with neck flexion degrees with pain where $t=3.04$, $P=.004$. Also, the results indicated that speed Flexion was a significant predictive factor where $F=19.98$, $P=.000$, $R^2=.345$. Speed Flexion was negatively correlated with neck extension degrees with pain where $t=-3.13$, $P=.003$.

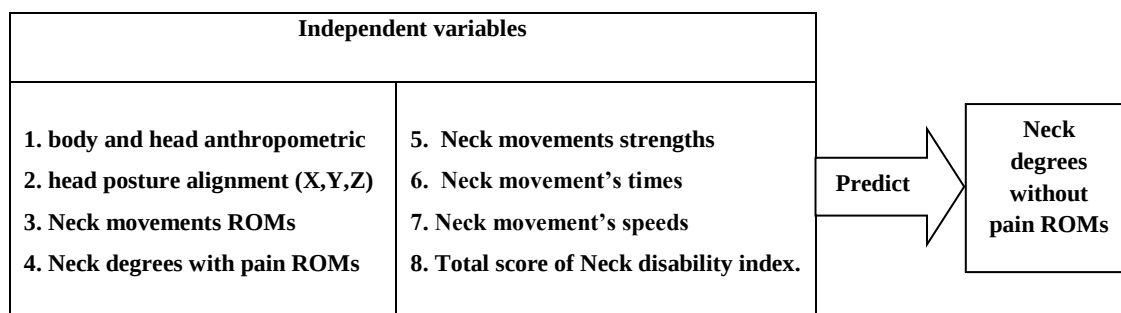


Figure 4.7 Illustrates predictive factors of Neck degrees without pain ROMs

Table 4.19. Clarifies results of multivariate linear regression in terms of predictive factors of Neck degrees without pain ROMs

Dependent variables	Independent predictive variables	R	R ²	F value	F sig	B	T	t sig
N Fx DWOP	Sp Rt Rot	.611	.373	22.59	.000	21.06	4.750	.000
	N Ex: DWP	.699	.489	17.67	.000	22.32	5.469	.000
	HC	.752	.565	15.61	.000	112.68	3.128	.003
	T.NDI	.782	.612	13.82	.000	119.78	3.45	.001
	HP: Y	.812	.660	13.20	.000	113.04	3.42	.002
	N Lt Rot: DWP	.840	.705	13.16	.000	109.39	3.49	.001
N Ex DWOP	N Lt Rot: DWOP	.531	.282	14.93	.000	15.96	2.02	.051
N Rt SF DWOP	N Lt SF ROM	.832	.692	85.57	.000	-3.505	-1.00	.322
	BMI	.864	.746	54.45	.000	-11.04	-2.64	.012
	N Fx: T	.887	.786	44.16	.000	-15.85	-3.67	.001
N Lt SF DWOP	N Rt: DWOP	.799	.639	67.18	.000	11.29	4.67	.000
	BMI	.837	.701	43.30	.000	16.62	5.64	.000
	N St: Fx	.866	.750	35.99	.000	14.16	4.91	.000
N Rt Rot DWOP	N Fx: DWP	.571	.326	18.38	.000	23.72	.519	.607
	N Lt SF: DWP	.713	.509	19.17	.000	-22.35	-.540	.593
N Lt Rot DWOP	Lo N Rt Rot ROM	.636	.404	25.79	.000	79.77	20.51	.000
	N Lt SF: DWP	.719	.517	19.81	.000	81.61	22.64	.000
	Sp Ex	.764	.584	16.85	.000	72.49	14.26	.000
	N Rt Rot : DWOP	.795	.631	14.98	.000	71.45	14.64	.000

Fx: flexion. Ex: extension. SF: side flexion. Rot: rotation. Rt: right. Lt: Left. St: strength. Sp: speed. N: neck. DWOP: degrees without pain. T: time. HC: head circumference. HP Y: head posture y. BMI: body mass index. DWP: degrees with pain. ROM: range of motion. Lo: lost

The results indicated that head posture: Y was a significant predictive factor where $F=13.20$, $P=.000$, $R^2=.660$. We inferred from t value and its linked p-value between the predictive and dependent variables. Head posture: Y was positively correlated with neck flexion degrees without pain where $t=3.42$, $P=.002$. Also, the results indicated that neck Left rotation: Degrees without pain was a significant predictive factor where $F=14.93$, $P=.000$, $R^2=.282$. Neck Left rotation: Degrees without pain was positively correlated with neck extension degrees without pain where $t=2.02$, $P=.051$.

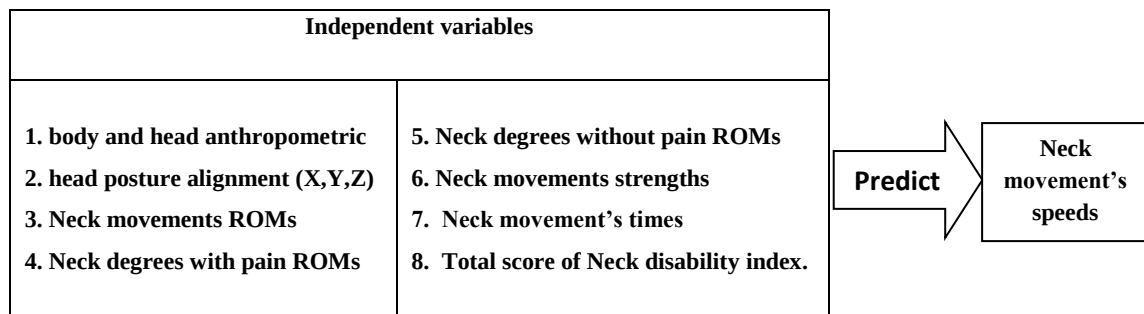


Figure 4.8 Illustrates predictive factors of neck movement's speed

Table 4.20. Clarifies results of multivariate linear regression in terms of predictive factors of neck movements speeds

Dependent variables	Independent predictive variables	R	R ²	F value	F sig	B	T	t sig
Fx Sp	Sp Rt Rot	.659	.434	29.12	.000	.084	1.05	.300
	N Ex: DWP	.800	.639	32.80	.000	.116	1.78	.083
	HP: Y	.826	.683	25.83	.000	.084	1.33	.192
Ex Sp	Sp Lt Rot	.723	.522	41.52	.000	.166	2.83	.007
	N Fx: T	.761	.579	25.41	.000	.437	3.26	.002
	N St: Fx	.792	.628	20.25	.000	.600	4.06	.000
Rt SF Sp	Sp Lt SF	.807	.651	70.88	.000	.021	.544	.589
	BMI	.849	.721	47.79	.000	-0.91	-1.784	.083
Lt SF Sp	Sp Rt SF	.807	.651	70.88	.000	.108	3.47	.001
	Sp Rt Rot	.882	.778	64.66	.000	.041	1.41	.168
	HC	.898	.806	49.81	.000	.572	2.45	.019
Rt Rot Sp	Sp Lt Rot	.895	.800	152.19	.000	.094	1.89	.066
	N Fx: DWOP	.920	.846	101.72	.000	-.037	-.620	.539
	N Lt SF: DWP	.940	.884	91.28	.000	-.117	-2.05	.048
	Sp Lt SF	.952	.906	83.86	.000	-.163	-2.97	.005
	HP: Z	.960	.921	79.37	.000	-.159	-3.13	.004
Lt Rot Sp	Sp Rt Rot	.895	.800	152.19	.000	.048	.851	.400
	Sp Ex	.918	.843	99.09	.000	-.028	-.49	.623
	N Rt Rot: DWP	.932	.869	79.26	.000	-.019	-.36	.720
	N Rt SF: T	.942	.888	69.39	.000	.181	1.91	.064
	N Lt SF: T	.952	.905	65.15	.000	-.097	-.68	.499
	N Ex: DWP	.960	.921	63.98	.000	-.173	-1.29	.208
	N Lt SF: DWP	.966	.934	64.21	.000	-.104	-.81	.426

Fx: flexion. Ex: extension. SF: side flexion. Rot: rotation. Rt: right. Lt: Left. St: strength. Sp: speed. N: neck. DWOP: degrees without pain. T: time. HC: head circumference. HP Y: head posture y. BMI: body mass index.

The results indicated that head posture: Y was a significant predictive factor where $F=25.83$, $P=.000$, $R^2=.683$. We inferred from t value and its linked p-value between the predictive and dependent variables. head posture: Y was positively correlated with neck flexion speed where $t=1.33$, $P= 1.92$. Also, the results indicated that speed left rotation was a significant predictive factor where $F=41.52$, $P=.000$, $R^2=.522$. Speed left rotation was positively correlated with neck extension speed where $t=2.83$, $P= .007$.

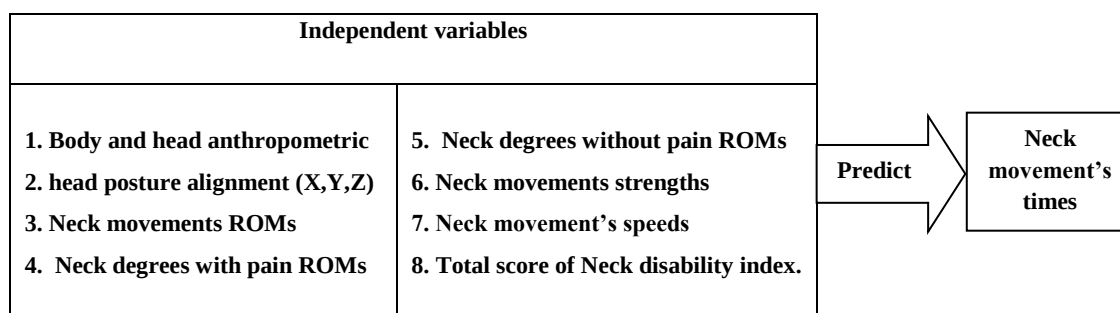


Figure 4.9 Illustrates predictive factors of neck movement's times

Table 4.21. Clarifies results of multivariate linear regression in terms of predictive factors of neck movement's times

Dependent variables	Independent predictive variables	R	R ²	F value	F sig	B	T	t sig
Fx T	Sp Fx	0.680	0.463	32.716	.000	2229.49	18.84	.000
	N Ex: T	0.738	0.544	22.079	.000	1592.57	5.87	.000
Ex T	N Lt SF: T	0.730	0.533	43.310	.000	550.31	2.961	.005
	Age	0.783	0.613	29.270	.000	1007.51	4.230	.000
	Sp Lt Rot	0.825	0.680	25.544	.000	1952.83	4.802	.000
	N Rt Rot: DWOP	0.848	0.719	22.404	.000	1892.16	4.882	.000
Rt SF T	N Rt Rot: T	0.918	0.843	203.71	.000	203.99	1.754	.088
	N Lt SF: T	0.939	0.882	138.80	.000	-139.56	-.990	.329
	Sp Ex	0.954	0.909	120.15	.000	-841.92	-3.376	.002
	N Lt Rot: T	0.962	0.926	110.1	.000	-1062.48	-4.419	.000
Lt SF T	N Rt SF: T	0.904	0.816	168.92	.000	514.64	5.50	.000
	Sp Ex	0.939	0.882	138.19	.000	1069.50	7.42	.000
	N Rt SF: DWP	0.947	0.897	105.07	.000	1198.13	8.16	.000
	N Rt Rot ROM	0.956	0.913	92.31	.000	1604.43	7.62	.000
	N Lt Rot: DWOP	0.966	0.933	94.23	.000	1460.28	7.53	.000
	HD	0.973	0.947	98.46	.000	410.92	1.050	.301
	N Fx: T	0.978	0.956	99.17	.000	331.68	.911	.369
Rt Rot T	N Lt Rot: T	0.977	0.955	812.97	.000	-15.47	-.229	.820
	HP: X	0.982	0.965	506.35	.000	-52.42	-.848	.402
	N Lt SF: T	0.987	0.974	455.22	.000	-222.56	-3.142	.003
	N Lt SF: DWP	0.989	0.978	381.82	.000	-194.58	-2.851	.007
Lt Rot T	N Rt Rot: T	0.977	0.955	812.97	.000	92.89	1.455	.154
	HP: X	0.982	0.964	496.69	.000	112.75	1.931	.061
	N Lt SF: DWP	0.985	0.969	381.34	.000	87.74	1.582	.122
	HC	0.987	0.974	327.73	.000	1597.21	2.596	.014

Fx: flexion. Ex: extension. SF: side flexion. Rot: rotation. Rt: right. Lt: Left. Sp: speed. N: neck. DWOP: degrees without pain. T: time. HC: head circumference. HP X: head posture x. DWP: degrees with pain. Lo: lost. HD: head depth.

The results indicated that neck speed flexion was a significant predictive factor where $F=32.716$, $P=.000$, $R^2=.463$. We inferred from t value and its linked p-value between the predictive and dependent variables. Speed flexion was positively correlated with neck flexion time where $t=18.84$, $P=.000$. Also, the results indicated that neck Left side flexion: time was a significant predictive factor where $F=43.31$, $P=.000$, $R^2=.533$. Neck Left side flexion: time was positively correlated with neck extension time where $t=2.961$, $P=.005$.

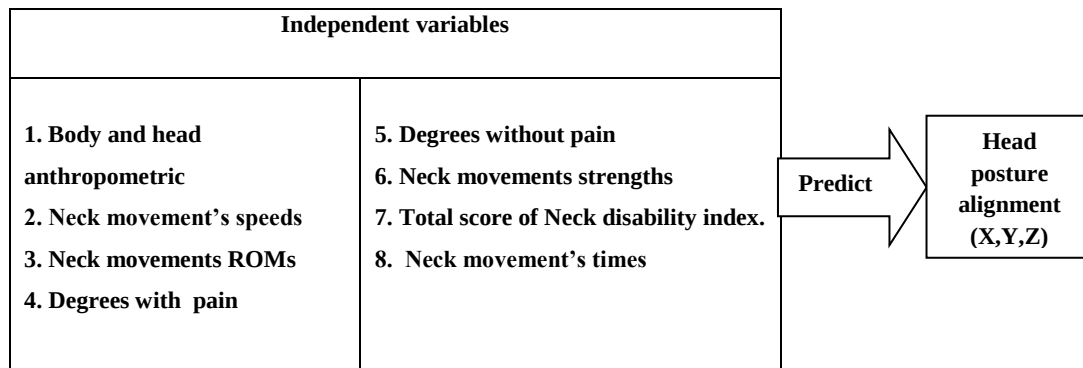


Figure 4.10 Illustrates predictive factors of head posture alignment (X,Y,Z)

Table 4.22. Clarifies results of multivariate linear regression in terms of predictive factors of head posture alignment (X,Y,Z)

Dependent variables	Independent predictive variables	R	R ²	F value	F sig	B	T	t sig
HP: X	HP: Z	.430	.185	8.62	.006	2.18	3.97	.000
	N Fx: DWP	.563	.317	8.59	.001	2.81	5.00	.000
HP: Y	Age	.324	.105	4.47	.041	4.80	1.88	.068
HP: Z	HP : X	.430	.185	8.62	.006	.706	1.36	.183
	N Ex: T	.547	.299	7.90	.001	4.09	2.79	.008

HP X: head posture x. HP Y: head posture y. HP Z: head posture z. N: neck. Fx: flexion.

DWP:degrees with pain. Ex: extension.

The results indicated that head posture: Z was a significant predictive factor where $F=8.62$, $P=.006$, $R^2=.185$. We inferred from t value and its linked p-value between the predictive and dependent variables. Head posture: Z was positively correlated with Head posture: X where $t=3.97$, $P=.000$. Also, the results indicated that Age was a significant predictive factor where $F=4.47$, $P=.041$, $R^2=.105$. Age was positively correlated with a Head posture: Y where $t=1.88$, $P=.068$. Finally, the results indicated that head posture: X was a significant predictive factor where $F=8.62$, $P=.006$, $R^2=.185$. Head posture: X was positively correlated with Head posture: Z where $t=1.36$, $P=.183$.

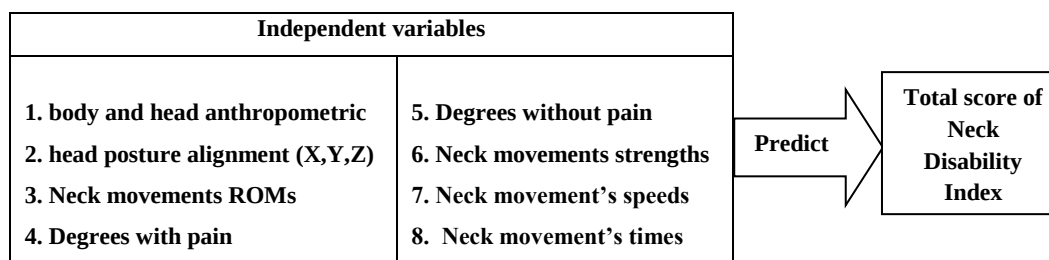


Figure 4.11 Illustrates predictive factors of neck movement's speed

Table 4.23. Clarifies results of multivariate linear regression in terms of predictive factors of neck movements speeds

Dependent variables	Independent predictive variables	R	R ²	F value	F sig	B	T	t sig
Total NDI	N Lt Rot: DWOP	.532	.282	14.96	.000	47.05	5.38	.000
	Age	.610	.372	10.96	.000	24.40	1.89	.066
	N Lt Rot: DWP	.676	.457	10.09	.000	15.59	1.23	.228
	N Lt Fx : DWP	.719	.517	9.37	.000	3.85	.288	.775

T.NDI: total neck disability index. N: neck. Lt: left. Rot: rotation. DWOP: degrees without pain. DWP: degrees with pain. Fx: flexion

The results indicated that neck Left rotation: degrees with pain was a significant predictive factor where $F=10.09$, $P=.000$, $R^2=.457$. We inferred from t value and its linked p-value between the predictive and dependent variables. Neck Left rotation: degrees with pain was positively correlated with Total NDI where $t=1.23$, $P=.228$

Table 4.24. The results of multiple regressions in predicting virtual reality variables

Independent predictive variables	NOPD	Dependent predicted variables	R² (from -to)
N Lt SF: DWP	9	Lt Rot ROM, N Rt Rot DWOP, N Lt Rot DWOP, Rt Rot T, Lt Rot T, T.NDI, Rt Rot St, Rt Rot Sp, Lt Rot Sp	(0.509 -0.978)
N Fx: T	6	RT SF St, Rt SF ROM, N Rt SF DWP, N Rt SF DWOP, Ex Sp, LT SF T	(0.217 -0.956)
Age	6	Rt Rot St, Rt Rot ROM, N Lt SF DWP, Ex T, HP: Y, T. NDI	(0.105 -0.775)
BMI	5	RT SF ROM, LT SF ROM, N Rt SF DWOP, N Lt SF DWOP, Rt SF Sp	(0.701 -0.817)
Sp Ex	5	LT Rot ROM, N Lt Rot DWOP, Lt Rot Sp, Rt SF T, Lt SF T	(0.583 -0.909)
N Ex: Dwp	5	Fx ROM, Lt Rot ROM, N Fx DWOP, Fx Sp, Lt Rot Sp	(0.489 -0.921)
Sp Rt Rot	5	Fx ROM, N Fx DWOP, Fx Sp, Lt SF Sp, Lt Rot Sp	(0.371 -0.800)
N Lt SF: T	5	N RT Rot DWP, Lt Rot Sp, Ex T, Rt SF T, Rt Rot T	(0.369 -0.974)
N Rt Rot : DWOP	5	Lt Rot ROM, N Fx DWP, N Lt SF DWP, N Lt Rot DWOP, Ex T	(0.314 -0.719)
N Lt Rot: DWOP	5	Ex ROM, RT Rot ROM, N Ex DWOP, Lt SF T, T.NDI	(0.259 -0.933)
HP: X	5	Fx ROM, N Fx DWP, Rt Rot T, Lt Rot T, HP: Z	(0.185 -0.965)
HC	4	Fx ROM, N Fx DWOP, LT SF Sp, LT Rot T	(0.565 -0.974)
Sp Fx	4	Rt SF St, Rt Rot St, N Ex DWP, Fx T	(0.345 -0.807)
Sp Lt Rot	4	N Rt Rot DWP, Ex Sp, Rt Rot Sp, Ex T	(0.217 -0.800)
N Lt SF: DWP	3	RT Rot St, RT Rot Sp, Lt Rot Sp	(0.742 -0.934)
HP: Y	3	Fx ROM, N Fx DWOP, Fx speed	(0.636 -0.683)
N St: Fx	3	N Lt SF DWOP, Rt Rot St, Ex Sp	(0.628 -0.750)
N St: Ex	3	RT SF St, LT SF St, LT Rot St	(0.611 -0.665)
N St: Rt Rot	3	Fx St, RT SF St, LT SF St	(0.541 -0.732)
N Lt Rot : DWP	3	Fx ROM, N Fx DWOP, T.NDI	(0.457 -0.756)
N Lt Rot: T	2	Rt SF T, RT Rot T	(0.926 -0.955)
N Rt Rot: T	2	Rt SF T, LT Rot T	(0.843 -0.955)
N Rt SF T	2	Lt Rot Sp, Lt SF T	(0.816 -0.888)
Weight	2	Ex St, Rt SF St	(0.814 -0.835)
N Rt Rot: DWP	2	Rt SF St, Lt Rot Sp	(0.752 -0.869)
N Rt SF: DWOP	2	Lt SF ROM, N Lt SF DWOP	(0.692 -0.639)
Sp Lt SF	2	Rt SF Sp, RT Rot Sp	(0.651 -0.906)
T.NDI	2	Fx ROM, N Fx DWOP	(0.612 -0.679)
N St: Lt SF	2	Ex St, RT rot St	(0.588 -0.665)
N Rt Rot: ROM	2	Lt Rot St, Lt Rot ROM	(0.400 -0.711)
N Fx: DWP	2	N Rt Rot DWOP, HP: X	(0.317 -0.326)
N Ex: T	2	Fx T, HP: Z	(0.299 -0.544)
HP: Z	2	HP: X, Rt Rot Sp	(0.185 -0.921)
HD	1	Lt SF T	0.947
N Rt SF : DWP	1	Lt SF T	0.897
N Fx: DWOP	1	Rt Rot Sp	0.846
N St: Rt SF	1	Lt SF ROM	0.780
N St: Lt Rot	1	Ex St	0.757
Sp Rt SF	1	Lt SF Sp	0.651
Height	1	Fx St	0.597

Lo N Rt Rot ROM	1	N Lt Rot DWOP	0.404
N Lt SF: DWOP	1	N Rt SF DWP	0.127

NOPD: Number of Predict dependent. N: neck. FX: flexion. EX: extension. SF: side flexion. Rot: rotation. Rt: right. Lt: left. ROM: range of motion. St: strength. Sp: speed. HP X: head posture x. HP Y: head posture y. HP Z: head posture z. HD: head depth. HC: head circumference. T.NDI: total neck disability index. Lo: lost

This is the most important table because it shows 41 parameters for the indicators of virtual reality that predict clinical, physical, postural, and functional health. Based on the respondents, the degrees with the pain of neck left side flexion were predicted with (left rotation ROM, neck right rotation degrees without pain, neck left rotation degrees without pain, right rotation time, left rotation time, right rotation strength, right rotation speed, left rotation speed, and total NDI), the prediction power of R square was between (50-97%). Also, the neck flexion time predicted with six dependent variables (RT side flexion strength, RT side flexion ROM, Neck right side flexion degrees with pain, Neck right side flexion degrees without pain, Extension speed, LT side flexion time), the prediction power of R square was from (21-95 %). In addition, the age predicted with six dependent variables (RT rotation strength, RT rotation ROM, Neck left side flexion degrees with pain, Extension time, Head posture: Y, Total NDI), the prediction power of R square was between (10-77%).

4.1 Results summary

Forty people took part in the study. The respondents were 20 males and 20 females. The respondents' age distribution revealed that half were between the ages of 29–36, and the other half were between the ages of 37–60. out of 40 participants 9 males and 3 females never did any exercises, 9 males and 11 females did exercises less than 3 days per week, and 2 males and 6 females did exercise 3 days or more per week.

The BMI was higher for males than females ($p < 0.05$), also the BMI of participants aged 29 to 36 years was lower than that of participants aged 37 to 60 years ($p > 0.05$), the BMI decreased with regular training ($p < 0.05$).

There was found to be a significant difference in terms of weight, height, and BMI between the genders. females has more range than males except the neck left side flexion and right side flexion, males' are stronger than females ($p < 0.05$), the females had a higher mean NDI score than the males ($p > 0.05$), females showed higher degree of pain compared to males in all movements except the flexion motion, highest motion that had a load with a high mean difference was far from normal, the right rotation for both males and females.

The young adults aged 29–36 had a higher mean neck range of motion compared to respondents aged 37–60, and there was a significant difference only in the ROM right and left rotation, the strengths for the old groups had stronger than the young, the old adult had a higher mean NDI scores than the young adult ($p < 0.05$), most of motions had more pain in the older than younger.

The NDI's mean scores of disability level, more than 40% of the participants of both genders had no disability, 40% of the participants had a minimal disability and less than 15 % had a moderate disability.

The dentists who did exercises less than three times or more the range of motion for all neck muscles was more than dentists who never did any exercise, but the strength

test was greater in the dentists who never did any exercises more than who did exercises, the dentists who never did any exercises had more pain than those who did exercises less than 3 days per week.

Positive association between exercise habit and exercise duration was found. A negative correlation was found between the total score of NDI and exercises, and a positive correlation was found between the NDI and BMI. Also, there is a positive association between working years with the BMI, NDI and pain intensity. There is a significant strong positive association between pain intensity and NDI

The powerful Independent predictive variables among the clinical, physical, postural, and functional variables were the neck left side flexion: degrees with pain, neck flexion time, age, neck speed extension, neck extension degrees with pain, neck speed right rotation, neck left side flexion time, body mass index, neck right rotation degrees without pain and neck left rotation degrees without pain

5. DISCUSSION

Dentists' work, comprising extensive physical load, psychosocial factors, individual factors and cognitive factors, has been linked to being a risk factor for several musculoskeletal disorders, , and this concern has been backed up by numerous other studies such as Alexopoulos et al and Rabiei el al ⁽⁹⁶⁻⁹⁷⁾. There has been very little research about the assessment of the neck by VR glasses, but this current research study concentrate on these parameters. Thus, we aimed to examine the virtual reality applications in the clinical, physical, postural and functional assessment of neck pain - musculoskeletal disorders NP-MSDs among dentists. Particularly, to investigate the use of a suggested VR system in quantifying the degree of deviation from neutral head position “head postural alignment”, normal neck movements “range of movement“, time and degree with pain and without pain for neck movements among dentists. The study's findings point to poor work habits and a poor role in work administration as a result of a lack of ergonomic and assessment the development of neck pain via VR application.

Almost all of the reviewed MSDs literature among dentists agreed that the neck was involved, and in our study through the questionnaire and results, we got to the same finding. As a Rabiei el al result ⁹⁷, we can deduce that there is no serious effort to enhance the ergonomic of dentistry professionals and deficiency in equipment that needs to be improved in order to avoid putting extra forces on muscle.

In our study, there was a significant difference in terms of weight, height, and BMI between males and females. In addition, over 62 percent of the participants had a BMI that was higher than normal, also the BMI was for males' more than females, another study published by Šustová et al.,⁹⁸ reported the same result.

Regarding the age groups, the age was separated into two categories (young adult 29-36 years) and (old adult 37-60 years),and appeared that there was no significant difference between BMI and age, similar to Ohlendorf et al.,⁹⁹ that was aimed to investigate the prevalence of MSDs in dental assistants in Germany, by an online

questionnaire analyzed for 406 participants. However, based on science knowledge, the BMI and weight were in the older adults higher compared to young adults, as confirmed in the present study. Due to the changes that occur in body composition, that is a gradual increase in fat mass and deterioration in the mass and bone, Body fat redistribution occurs as well, with visceral abdominal fat increasing¹⁰⁰.

When compared to respondents aged 37-60, the young adults aged 29-36 had a higher mean neck range of motion, and there was a significant difference only in the right and left rotation, (This could be due to the dentists often uses the rotation motion more during their work, therefore with the years of work the rotation range will decrease), another study by Smm et al., in Chinese dentists to determine the prevalence of painful MSDs and evaluate neck mobility, showed the same result with increasing age, the range of flexion, extension, and right rotation decrease¹⁰¹. But when compared the strengths between the two groups, we notice that the old groups were stronger than the young, as a result the participants in the old groups were 15 males and 5 females but in young groups 5 males and 15 females, as we are all aware, the physical strength of men is higher than women, for this, the old age groups seem stronger than the younger age groups. another study was performed by Medina et al.,¹⁰² "descriptive study and purpose to determine the test-retest reliability for measuring muscular strength of the neck flexor and extensor muscles in a healthy population, of 94 participants" reported that decreasing neck strength with age.

According to results of range of motion between gender groups, there was no significant difference between gender and the ROM, but the females had more range than males, (this be due the flexibility in the women body more than men), In another study done in Chinese dentists by Smm et al.,¹⁰¹ reported that men showed a smaller cervical range of left lateral flexion and rotation than women. About the neck strength, our results showed that males' are stronger than females ($p < 0.05$), this could be due to the fact that men's tolerance thresholds are higher than women's ¹⁰³, Furthermore, according to a study conducted by Abduljabbar et al.,¹⁰⁴ the objective of his study was to find out the prevalence and distribution of musculoskeletal symptoms among dentists in Saudi Arabia, 140 dentists, and their findings are similar to our results.

Also we notes that the range of motion and strength of neck left side flexion more than neck right side flexion, and neck left rotation more than neck right rotation, because the dentists frequently rotate their necks to left, with side bending to the right for better visibility, resulting in strengthening the muscles on one side while the opposing side's muscles are weakened, leading to the inability to turn the neck to the right with the side bending on the left.¹⁰⁵

Based on our results finding, the highest motion that had a load with a high mean difference far from normal, was the right rotation for both males and females, also the second motion that is more affected is left rotation. Another study was carried out by Fayeze. et al.,¹⁰⁶ When compared to flexion and side bending positions, dentists reported that the neck flexion position combined with rotation produced the most pain.

According to our results of the NDI's mean scores of disability level, more than 40% of the participants of both genders had no disability, 40% of the participant had a minimal disability and less than 15 % had a moderate pain-related disability. Other research conducted by Nadri et al.,¹⁰⁷ among 80 dentists 44.6 % of whom were female and 55.4 % were male, aimed to identify the pain intensity and neck disability index among dentists, displayed that 53.5% and 44.2% of dentists had mild and moderate neck disability index, respectively, we can interpret the difference in the disability level results between studies to variation between age experience, regular exercises and hours of work per day. Besides, to his study¹⁰⁷ there was insignificant in the NDI's overall score by gender, our research yielded the same result, the females had a higher total score of the neck disability than the males. But also in the same study¹⁰⁷, the BMI and the exercise were significant with total score of the NDI, on the contrary of our results. And in the other study by Alexopoulos et al.,⁹⁶ and Anshul et al.,¹⁰⁸ found that the NDI scores are higher in the older age group, and this result is similar to our study finding ($p < 0.05$).

Also when compared dentists who never did any exercises with dentists who did exercises less than three days or more per week, the results showed, the dentists who did

exercise the range of motion for all neck muscles was more than dentists who never did any exercise, other study done by Letafatkar et al., aimed to investigate the effect of therapeutic exercise on pain, disability and posture in female dentists suffering from chronic neck pain, and confirm on our finding that exercises like head rotation and cervical extensor strengthening can change the alignment of the scapula and cervical spine, which can lead to increase the neck ROM¹⁰⁹. The results of the strength test was more in the dentists who never did any exercises more than who did exercises, here we may explain or say that our reason due to low numbers of participants and awareness, the awareness in females more than males, most men are categorized into the never did any exercise group, and as we know the physical body for males more than females, for that the strength seem high in the dentists who never did any exercises, Another reason could be that the exercises were not designed specifically for the neck, other study performed by Terblanche et al.,¹¹⁰ reported that strengthening exercise improves the neck muscle and quality of life, and after 8 weeks of exercise, there was a significant improvement in neck ($p < 0.05$).

Describing the pain during movements, our results the females showed higher degree of pain compared to males, and there was a significant difference via degrees with pain in neck left rotation, other study done by Rafie et al.,¹¹¹ to investigate the factors that contribute to MSD among dentists, reported that females experienced more frequent and widespread neck pain than males, and ($p > 0.05$), another study by Alexopoulos et al.,⁹⁶ reported similar that females had more pain, however, another research for Saxena et al.,¹¹² confirmed that males had more pain in the neck than females, This can be attributed to their heavier bodyweight, shorter stature, as well as variations in muscle mass and composition¹¹³.

Furthermore, Alexopoulos et al.,⁹⁶ explained a relation between neck pain and age group among 430 dentists, and their findings revealed that older participants experienced more pain than younger participants, however, according to another study conducted by Saxena et al.,¹¹² as dentists get older, their pain decreases. The pain in the older age group is greater than the pain in the younger age group, according to our research. While it differs according to the total number of patients served and the number of working hours per day¹¹⁴.

According to our results there was no significant association between regular exercises and pain in the neck motion excepts neck left rotation, the dentists who never did any exercises had more pain than who did exercises less than 3 days per week, but who did exercises more than 3 days per week had more pain than who never did any exercises, we think if our participants' number was more this comparison will be different because only 8 participants from 40 did exercises more than 3 days per week, also just one participant who did strength exercises. Another study for Rising et al.,⁶² examined the occurrence of MS pain in dental, n=271, reported that there was no significant link between pain intensity, frequency, duration with the regular physical activity, other study performed by Feng et al.,¹¹⁵ aimed to examine and identify the risk factors associated with the dental profession, n=272, the finding showed that there was a significant association between regular exercise and minimize the neck pain.

The relationships between the variables in the study appeared to be as follows, in addition, there was an inverse relationship between exercise habits and exercise duration with BMI ($p < 0.05$), according to Ahmed et al.,¹¹⁶ physical exercise has an inverse relationship with obesity and overweight, other study for Nadri.,¹⁰⁷ reported that there was a significant negative correlation with BMI and physical exercise. In addition, there was a positive relationship between pain intensity and work experience. Many studies had the same findings as ours, such as Rana et al., and Kaya et al.,¹¹⁷⁻¹¹⁸.

Regression statistics results enable the researcher to study and identify the strong parameters for predicting clinical, physical, postural, and functional abnormalities in each neck movement. The numbers of independent predictive variables that entered the prediction model were 53 variables [(flexion, extension, RT\ LT rotation and bending for available range, range with pain, range without pain, lost range, time, speed, and strength), (head posture X,Y,Z), (total score of neck disability index), (anthropometric measurements: age, body mass index, head circumference, head depth, head length, height, weight)], 11 independent variables did not predict any dependent variable comparing with 42 variables that predicted one or more variables. As shown in table 4.24, the independent variables were categorized into three levels of predictability: strong, moderate, and weak. The strongest dependent variables were predicted through

nine, six or five independent variables, while the moderate dependent variables were predicted through four or three independent variables. The weak dependent variables were only predicted through two or one independent variables. The most powerful Independent predictive variables among the clinical, physical, postural, and functional variables were the neck left side flexion: degrees with pain, neck flexion time and age. At the same time, these variables were the most predictive factors for neck musculoskeletal disorders among dentists. Another study done by Falla et al. reported that the most common movements of dentists leading to the development of imbalances in the neck muscles were forward flexion, lateral flexion and rotation¹²¹. In another study in 2013, Anshul et al. found in their research that neck pain was caused by prolonged work with the neck flexed¹⁰⁸. And both of them, virtual reality showed the same results. And the first strong independent variable was neck left side flexion: degrees with pain and this predictive one of the indicators calculated by the virtual reality and was able to predict with nine parameters (left rotation ROM, neck right rotation degrees without pain, neck left rotation degrees without pain, right rotation time, left rotation time, right rotation strength, right rotation speed, left rotation speed, and total NDI). This intimates the high credibility of this indicator on the physical and functional prediction. In addition, neck flexion time was the second strong independent predictive, measured through virtual reality, predicted with six dependent variables (right side flexion strength, right side flexion ROM, neck right side flexion degrees with pain, neck right side flexion degrees without pain, extension speed, left side flexion time) we can summaries the prolonged neck flexion independent variable can predict the disorders associated with physical and clinical health. And therefore fits with our hypothesis. Age was not one of the parameters or variables of virtual reality, but it had a strong predictive effect with virtual reality variables (right rotation strength, right rotation ROM, neck left side flexion degrees with pain, extension time, head posture: Y, total NDI), and this demonstrates that the age factor affects the clinical, physical, and functional condition. Also, the neck speed extension was an strong independent predicted with five dependent variables (LT rotation ROM, neck Lt rotation degree without pain, Lt rotation speed, Rt side flexion time, Lt side flexion time), the speed of raising the head from the flexion position during the dentist's work will affect negatively on the neck health. One of the strong independent variables that was important to measure

the head static alignment was head postural alignment at X axis, calculated using virtual reality, predicted with five dependent variables (flexion ROM, neck flexion degrees with pain, right rotation time, left rotation time, head posture : Z). Also, there were many strong Independent predictive variables calculated by VR, predicting with five parameters leading to neck musculoskeletal disorders such as neck right and left rotation degrees without pain and neck lift side flexion time, due to dentists work frequently rotating their necks to the side with side bending to another side, resulting in strengthening the muscles on one side while the opposing side's muscles are weakened¹⁰⁵.

The 42 parameters of virtual reality for neck movements enabled us to predict clinical status, physical, postural, and functional health among dentists.

Our study had some limitations; increasing the number of participants and the variety of exercises could improve statistical power.



6. CONCLUSION

In conclusion, the virtual reality can predict and measure the head alignment, normal neck movements “range of movement“, time and degree with pain and without pain, and could be used to assess cervical musculoskeletal disorders. Results approve the hypothesis that virtual reality is a powerful technique in quantification, documentation, and characterization of relevant kinematic and kinetic parameters of cervical assessment.

According to results of our study we recommend, the use of virtual reality in clinical, physical, postural and functional assessment of ergonomic disorders among dentists and related other professions.

7. REFERENCES

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APPENDIXES

Appendix 1. Ethical Approval.

Evrak Tarih ve Sayısı: 09.07.2021-23360



T.C.
BEZMİALEM VAKIF ÜNİVERSİTESİ REKTÖRLÜĞÜ
Girişimsel Olmayan Araştırmalar Etik Kurulu

Sayı : E-54022451-050.05.04-23360
Konu : Etik Kurul Kararı - Şule DEMİRBAŞ

09.07.2021

Sayın Şule DEMİRBAŞ|

2021/278 numaralı "Diş hekimlerinde servikal ergonomik bozuklukların kasiskelet sistemi değerlendirmesinde sanal gerçeklik tekniklerinin uygulanması" başlıklı başvurunuz Üniversitemiz Etik Kurullar Birimi' nin 08.07.2021 tarihli, 15 sayılı Girişimsel Olmayan Araştırmalar Etik Kurul toplantısında değerlendirilmiş olup, mevcudun oybirliğiyle onaylanmasına karar verilmiştir.

Gereğini ve bilgilerinizi arz/rica ederim.

Prof.Dr. İsmail MERAL
Başkan

Bu belge, güvenli elektronik imza ile imzalanmıştır.

Doğrulama Kodu :BSE447U2Z2 Pin Kodu :44352 Belge Takip Adresi : <https://turkiye.gov.tr/ebd?eK=5394&eD=BSE447U2Z2&eS=23360>
Bezmialem Vakıf Üniversitesi Adnan Menderes Bulvarı (Vatan Caddesi) Fatih /
İstanbul Bilgi için: Zübeyde ÖZDEMİR
Telefon No:0 (212) 523 22 88 Faks No:0 (212) 533 23 26 Unvan: Memur
e-Posta:info@bezmialem.edu.tr İnternet Adresi:www.bezmialem.edu.tr



Appendix 2. Consent to Participate in a Research Form (English)



Consent to Participate in a Research

Title of Study: Applied virtual reality techniques in musculoskeletal assessment of cervical ergonomic disorders among dentists

Investigator: Name: Wesam Taleb Alzeer **Dept** physiotherapy **phone** 05525031469

Introduction

- You are being asked to be in a research study of measurement the kinematic and kinetic assessment of cervical ergonomic disorders.
- We ask that you read this form and ask any questions that you may have before agreeing to be in the study.

Purpose of Study

- Was to examine the virtual reality applications in the clinical, physical and functional assessment of neck pain - musculoskeletal disorders (NP-MSDs) among dentists.
- Particularly, to investigate the use of a suggested VR system in quantifying the degree of deviation from neutral head position "head postural alignment", normal neck movements "range of movement", time and neck movements degree with pain and without pain among dentists.

Description of the Study Procedures

- This research is targeting dentists with neck pain aged between 29-60 years, data will be collected from 40 participant between 1 Apr 2021 and 1 June 2021.
- You will take one group in this study (dentists with cervical pain) according to your criteria.
- Weight and height will be noted.
- We will start with measuring head alignment, range of motion of all cervical movements, time for each movements and the free pain degrees using a virtual reality.
- Neck strength will be assessed using the Micro fit Dynamometer.
- Head length, head circumference and head depth will be noted by Tape measure.
- Then start with questionnaires such as Neck Disability Index (NDI) used to measure neck-specific disability.
- A questionnaire that you will fill out by yourself.
- The procedure time will be approximately 20 / 35 minutes.

Risks/Discomforts of Being in this Study

- There are no reasonable foreseeable (or expected) risks. There may be unknown risks.
- Due to the nature of the approach that works on muscles a slight discomfort might occur.

Confidentiality

- This study is anonymous. We will not be collecting or retaining any information about your identity.
- The records of this study will be kept strictly confidential. Research records will be kept in a locked file, and all electronic information will be coded and secured using a password protected file. We will not include any information in any report we may publish that would make it possible to identify you.

Right to Refuse or Withdraw

- The decision to participate in this study is entirely up to you. You may refuse to take part in the study at any time without affecting your relationship with the investigators of this study or the institution. You have the right not to answer any single question, as well as to withdraw completely from the interview at any point during the process; additionally, you have the right to request that the interviewer not use any of your interview material.

Right to Ask Questions and Report Concerns

- You have the right to ask questions about this research study and to have those questions answered by me before, during or after the research. If you have any further questions about the study, at any time feel free to contact me (Wessam Alzeer) at wisam.zir@gmail.com .or by telephone at 05525031469 If you like, a summary of the results of the study will be sent to you. If you have any problems or concerns that occur as a result of your participation, you can report them to the investigator at the number above.

Consent

- Your signature below indicates that you have decided to volunteer as a research participant for this study, and that you have read and understood the information provided above. You will be given a signed and dated copy of this form to keep, along with any other printed materials deemed necessary by the study investigators

Subjets name _____

Signature _____

Investigators name _____

Signature _____

Appendix 3. Consent to Participate in a Research Form (Turkish)



Araştırmaya Katılma Onayı

Çalışmanın adı: Dis hekimlerinde servikal ergonomik bozuklukların kakelet te deęerlendirmesinde sanal gereklik tekniklerinin uygulanmas.

Araştırmacı İsim: Wesam Taleb Alzeer
05388215279

Bölümü: fizyoterapi

Tele:

Giriş:

- Sizden, servikal bölgede görülen ergonomik bozuklukların kinetik ve kinematik deęerlendirmesini içeren bir araştırmaya katılmanız istenecek.
- Çalışmayı kabul etmeden önce bu formu okumanızı ve sorularınızı sormanızı rica ediyoruz.

Çalışmanın amacı:

- ile diř hekimleri arasında servikal ağrıya baęlı kas-iskelet sistemi rahatsızlıklarının klinik kinematik ve kinetik deęerlendirilmesinde sanal gereklik uygulamalarının incelenmesi amaçlanmıştır.
- Sonuç olarak, bu araştırma Yüksek lisans tezi için kullanılacak ve harici yayınlarda kullanılabilecektir.

Çalışma Prosedürlerinin Tanımı

- Bu araştırma 29-60 yař arası ve boyun ağrısı olan diř hekimlerini hedef almaktadır. Bu çalışmadaki iki gruptan birine (atlet ya da atlet deęil) kriterlerinize göre katılacaksınız.
- 1 Nisan - 1 Haziran 2021 tarihleri arasında 40 gönüllü katılımcıdan veriler toplanacaktır.
- Bu çalışmanın kriterlere göre bir grup (servikal ağrılı diř hekimleri) alacaksınız.
- Aęırlık ve boy bilgileriniz alınacaktır.
- Sanal gereklik kullanarak baş hizasını, tüm servikal hareketlerin eklem-hareket açıklığını, her hareketin süresini ve ağrısız hareket edebilme derecelerini ölçerek başlayacağız.
- Boyun kuvveti Micro fit Dinamometre kullanılarak deęerlendirilecektir.
- Baş uzunluęu, baş çevresi ve baş derinlięi mezura ile not edilecektir.
- Ardından, boyundaki engellilięi ölçebilmek için Boyun Engellilik İndeksi (NDI)

- Kendi başınıza dolduracağınız bir anket.
- Uygulama süresi yaklaşık 20 ila 35 dakika arası olacaktır.

Bu Çalışmada Olmanın Riskleri / Rahatsızlıklar:

- Öngörülebilir (veya beklenen) herhangi bir makul risk yoktur. Bilinmeyen riskler olabilir.
- Kaslar üzerinde çalışan yaklaşımın doğası gereği hafif bir rahatsızlık oluşabilir.

Gizlilik:

- Bu çalışma anonimdir. Kimliğiniz hakkında herhangi bir bilgi toplamayacağız veya saklamayacağız.
- Bu çalışmanın kayıtları kesinlikle gizli tutulacaktır. Araştırma kayıtları kilitli bir dosyada saklanacak ve tüm elektronik bilgiler şifre korumalı bir dosya kullanılarak kodlanacak ve güvence altına alınacaktır. Yayınlayabileceğimiz hiçbir raporu, sizi tanımayı mümkün kılacak hiçbir bilgiyi eklemeyeceğiz.

Reddetme veya Geri Çekme Hakkı:

- Bu çalışmaya katılma kararı tamamen size kalmış. Bu araştırmanın veya kurumun araştırmacıları ile ilişkinizi etkilemeden, herhangi bir zamanda çalışmaya katılmayı reddedebilirsiniz. Süreç boyunca herhangi bir noktada tek bir soruya cevap vermeme ve görüşmeden tamamen geri çekilme hakkına sahipsiniz; ayrıca, görüşmeciden görüşme materyallerinizi kullanmamasını talep etme hakkına sahipsiniz.

Soru Sorma ve Endişeleri Bildirme Hakkı:

- Bu araştırma çalışması hakkında soru sorma ve bu soruları araştırma öncesinde, sırasında veya sonrasında yanımda cevaplama hakkına sahipsiniz. Çalışma hakkında başka sorularınız varsa, (wisam.zir@gmail.com) adresinden benimle (wessam alzeer) iletişime geçmekten çekinmeyin. sana gönderildi. Katılımınızın bir sonucu olarak ortaya çıkan herhangi bir sorun veya endişeniz varsa, bunları yukarıdaki numaradan araştırmacıya bildirebilirsiniz.

Razı olmak:

- Aşağıdaki imzanız, bu çalışma için araştırma katılımcısı olarak gönüllü olmaya karar verdiğiniz ve yukarıda verilen bilgileri okuduğunuzu ve anladığınızı gösterir. Çalışma araştırmacıları tarafından gerekli görülen diğer basılı materyallerin yanı sıra bu formun imzalı ve tarihli bir kopyası size verilecektir.

Konu adı _____

İmza _____

Araştırmacı adı _____

İmza _____

Appendix 4. Data collection forms (English)

- 1) Name Surname: Telephone Number:
- 2) Birthday:
- 3) Gender: ☐ Female ☐ Male
- 4) Dominant Side: ☐ Right ☐ Left
- 5) Smoking habit: ☐ Never ☐ Quit ☐ Yes
- 6) Alcohol Consumption Habit: ☐ Never ☐ Only Special Days ☐ Several times a month
☐ Few times a week ☐ Regularly everyday
- 7) Do you have any disease? ☐ No ☐ Rheumatismal ☐ Vestibular ☐ Traumatic ☐
Orthopaedic ☐ Neurologic ☐ Different type
- 8) Is there any medication using regularly? ☐ Yes..... ☐ No
- 9) Did you get any surgery ? ☐ Yes..... ☐ No
- 10) Exercise habit: ☐ Never ☐ Less than 3 days ☐ 3 days or more
- 11) Exercise Type: ☐ Never ☐ Fitness ☐ Pilates ☐ Swimming ☐ Strength ☐ Football
☐ Running ☐ Walking ☐ Volleyball ☐ Basketball
- 12) Duration of the exercise:
- 13) How long have you been working?
☐ Less than 5 years ☐ 5 to 9 years ☐ 10 to 15 years ☐ more than 15 years

- Age:
- **Body Mass Index:**

Weight (Kg)	Height (cm)	BMI (kg/m ²)

- **virtual reality test :**

	ROM	Total time	The free pain degrees	The degrees with pain
Forward flexion				
Extension				
Right side flexion				
left side flexion				
Right rotation				
left rotation				

- Digital handheld dynamometer

	Forward flexion	Extension	Right side flexion	left side flexion	Right rotation	left rotation
strength						

- **Virtual reality test :**

	Cervical
Head posture	X= Y= Z=

- **Head length :**

- **Head circumference:**

- **Head depth :**

Appendix 5. Data collection forms (Turkish)

1) Adı-Soyadı: Cep Telefon Numarası:

2) Doğum Tarihi:

3) Cinsiyet:

☐ Kadın ☐ Erkek

4) Boy Uzunluğu (cm):

5) Vücut Ağırlığı (kg): 6) BMI:

7) Dominant Taraf:

☐ Sağ ☐ Sol

8) Sigara İçiyor Musunuz?

☐ Hiç İçmedim ☐ Sigara İçtim Ama Bıraktım ☐ Hala İçiyorum

9) Alkol Kullanıyor Musunuz?

☐ Hayır ☐ Özel Günlerde ☐ Ayda birkaç kez
☐ Haftada birkaç kez ☐ Her gün düzenli

10) Herhangi bir sürekli hastalığınız var mı?

☐ Yok. ☐ Romatizmal ☐ Vestibular ☐ Travmatik
☐ Ortopedik Problemler ☐ Nörolojik Problemler ☐ Diğer

11) Sürekli kullandığınız bir ilaç var mı?

☐ Evet (.....) ☐ Hayır

12) Herhangi bir ameliyat geçirdiniz mi (sünnet hariç)?

☐ Evet..... ☐ Hayır

13) Fiziksel aktivite yapıyor musunuz?

☐ Yapmıyorum. ☐ Haftada 3 günden az ☐ Haftada 3 gün veya daha fazla

14) Egzersizin tipi:

☐ Yapmıyorum ☐ Fitness ☐ Pilates ☐ Yüzme ☐ Vücut Geliştirme
☐ Futbol ☐ Koşu ☐ Yürüyüş ☐ Voleybol ☐ Basketbol

15) Egzersizin süresi:

▪ Katılımcının adı:

▪ Telefon:

▪ Yaş:

▪ Cinsiyet:

▪ vucüt kitle indeksi:

kilo	boy	vucüt kitle indeksi

▪ Sanal gerçeklik testi:

	Eklem hareket açıklığı	Toplam süre	Ağrısız eklem hareket açıklığı	Ağrılı eklem hareket açıklığı
Öne fleksiyon				
Ekstansiyon				
Sağ yana fleksiyon				
Sol yana fleksiyon				
Sağa rotasyon				
Sola rotasyon				

- Dijital el dinanometresi

	Öne fleksiyon	Ekstansiyon	Sağ yana fleksiyon	Sol yana fleksiyon	Sağa rotasyon	Sola rotasyon
kuvvet						

- Sanal gerçeklik testi:

	Cervikal
Baş postürü	X= Y= Z=

- Baş uzunluğu :
- Başın çevre uzunluğu:
- Baş derinliği:

Appendix 6. English version of modified Neck Disability Index

Neck Disability Index

THIS QUESTIONNAIRE IS DESIGNED TO HELP US BETTER UNDERSTAND HOW YOUR **NECK PAIN** AFFECTS YOUR ABILITY TO MANAGE EVERYDAY -LIFE ACTIVITIES. PLEASE MARK IN EACH SECTION THE **ONE BOX** THAT APPLIES TO YOU.

ALTHOUGH YOU MAY CONSIDER THAT TWO OF THE STATEMENTS IN ANY ONE SECTION RELATE TO YOU, PLEASE MARK THE BOX THAT **MOST CLOSELY** DESCRIBES YOUR PRESENT -DAY SITUATION.

SECTION 1 - PAIN INTENSITY

- ☐ I have no neck pain at the moment.
- ☐ The pain is very mild at the moment.
- ☐ The pain is moderate at the moment.
- ☐ The pain is fairly severe at the moment.
- ☐ The pain is very severe at the moment.
- ☐ The pain is the worst imaginable at the moment.

SECTION 2 - PERSONAL CARE

- ☐ I can look after myself normally without causing extra neck pain.
- ☐ I can look after myself normally, but it causes extra neck pain.
- ☐ It is painful to look after myself, and I am slow and careful
- ☐ I need some help but manage most of my personal care.
- ☐ I need help every day in most aspects of self -care.
- ☐ I do not get dressed. I wash with difficulty and stay in bed.

SECTION 3 – LIFTING

- ☐ I can lift heavy weights without causing extra neck pain.
- ☐ I can lift heavy weights, but it gives me extra neck pain.
- ☐ Neck pain prevents me from lifting heavy weights off the floor but I can manage if items are conveniently positioned, ie. on a table.
- ☐ Neck pain prevents me from lifting heavy weights, but I can manage light weights if they are conveniently positioned
- ☐ I can lift only very light weights.
- ☐ I cannot lift or carry anything at all.

SECTION 4 – READING

- ☐ I can read as much as I want with no neck pain.
- ☐ I can read as much as I want with slight neck pain.
- ☐ I can read as much as I want with moderate neck pain.
- ☐ I can't read as much as I want because of moderate neck pain.
- ☐ I can't read as much as I want because of severe neck pain.
- ☐ I can't read at all.

SECTION 5 – HEADACHES

- ☐ I have no headaches at all.
- ☐ I have slight headaches that come infrequently.
- ☐ I have moderate headaches that come infrequently.
- ☐ I have moderate headaches that come frequently.
- ☐ I have severe headaches that come frequently.
- ☐ I have headaches almost all the time.

SECTION 6 – CONCENTRATION

- ☐ I can concentrate fully without difficulty.
- ☐ I can concentrate fully with slight difficulty.
- ☐ I have a fair degree of difficulty concentrating.
- ☐ I have a lot of difficulty concentrating.
- ☐ I have a great deal of difficulty concentrating.
- ☐ I can't concentrate at all.

SECTION 7 – WORK

- ☐ I can do as much work as I want.
- ☐ I can only do my usual work, but no more.
- ☐ I can do most of my usual work, but no more.
- ☐ I can't do my usual work.
- ☐ I can hardly do any work at all.
- ☐ I can't do any work at all.

SECTION 8 – DRIVING

- ☐ I can drive my car without neck pain.
- ☐ I can drive my car with only slight neck pain.
- ☐ I can drive as long as I want with moderate neck pain.
- ☐ I can't drive as long as I want because of moderate neck pain.
- ☐ I can hardly drive at all because of severe neck pain.
- ☐ I can't drive my car at all because of neck pain.

SECTION 9 – SLEEPING

- ☐ I have no trouble sleeping.
- ☐ My sleep is slightly disturbed for less than 1 hour.
- ☐ My sleep is mildly disturbed for up to 1-2 hours.
- ☐ My sleep is moderately disturbed for up to 2-3 hours.
- ☐ My sleep is greatly disturbed for up to 3-5 hours.
- ☐ My sleep is completely disturbed for up to 5-7 hours.

SECTION 10 – RECREATION

- ☐ I am able to engage in all my recreational activities with no neck pain at all.
- ☐ I am able to engage in all my recreational activities with some neck pain.
- ☐ I am able to engage in most, but not all of my recreational activities because of pain in my neck.
- ☐ I am able to engage in a few of my recreational activities because of neck pain.
- ☐ I can hardly do recreational activities due to neck pain.
- ☐ I can't do any recreational activities due to neck pain.

PATIENT NAME _____

DATE _____

SCORE _____ [50]

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Appendix 7. Turkish version of modified Neck Disability Index

BOYUN ÖZÜRLÜLÜK SORGULAMA FORMU

Bu sorgulama formu boyun ağrınızın günlük yaşam aktivitelerinizi yerine getirme yeteneklerinizi nasıl etkilediğini anlamamıza yardımcı olacak şekilde tasarlanmıştır. Lütfen her bölümdeki bir kutucuğu işaretleyiniz. Bir bölümde birden çok yanıt kendinize yakın hissetseniz bile, şu anki durumunuza en yakın olan seçeneği işaretleyiniz.

Bölüm 1 - Boyunda Ağrı Yoğunluğu

- ☐ Şu anda hiç boyun ağrım yok.
- ☐ Şu anda çok hafif derecede boyun ağrım var.
- ☐ Boyun ağrım orta derecede ve gelip gidiyor.
- ☐ Boyun ağrım orta şiddette ve değişkenlik göstermiyor.
- ☐ Boyun ağrım şiddetli fakat gelip gidiyor.
- ☐ Boyun ağrım şiddetli ve değişkenlik göstermiyor.

Bölüm 2 - Kişisel Bakım (giyinme ve temizlenme)

- ☐ Ek bir ağrıya neden olmadan kendime bakabiliyorum.
- ☐ Kendime normal olarak bakabiliyorum fakat bu ek bir ağrıya neden oluyor.
- ☐ Kendi bakımımı yaparken ağrım artıyor, yavaşlıyorum ve dikkatli oluyorum.
- ☐ Biraz yardıma ihtiyacım var fakat kişisel bakımımın çoğunu yapabiliyorum.
- ☐ Kişisel bakımım ile ilgili işlerin çoğunda her gün yardıma ihtiyacım var.
- ☐ Giyinemiyorum. Zorlukla yıkanıyorum ve yataktan çıkmıyorum.

Bölüm 3 – Yük Kaldırma (boyun ağrınız olmadığı zamanlarda kaldırdığınız ağır yüklere eşit ağırlıkta)

- ☐ Ek bir ağrı hissetmeden ağır yükleri kaldırabiliyorum.
- ☐ Ağır yükleri kaldırabiliyorum, fakat ek bir ağrıya neden oluyor.
- ☐ Ağrı yükleri yerden kaldırmama engel oluyor, fakat yükler, örneğin masa üstü gibi uygun bir yere yerleştirilirse kaldırabiliyorum.
- ☐ Ağrı ağır yük kaldırmama engel oluyor, fakat hafif ve orta ağırlıktaki yükler örneğin masa üstü gibi uygun bir yere yerleştirilirse kaldırabiliyorum.
- ☐ Çok hafif yükleri kaldırabiliyorum.
- ☐ Hiçbirşeyi kaldıramıyorum ve taşıyamıyorum.

Bölüm 4 - Okuma

- ☐ Hiç boyun ağrısı hissetmeden istediğim kadar okuyabiliyorum.
- ☐ Hafif bir boyun ağrısı hissederek istediğim kadar okuyabiliyorum.
- ☐ Orta derecede boyun ağrısı hissederek istediğim kadar okuyabiliyorum.
- ☐ Boynumda orta derecede ağrı nedeniyle istediğim kadar okuyamıyorum.
- ☐ Boynumda şiddetli ağrı nedeniyle istediğim kadar okuyamıyorum.
- ☐ Boyun ağrısı nedeniyle hiç okuyamıyorum.

Bölüm 5 - Baş ağrıları

- ☐ Hiç baş ağrım yok.
- ☐ Sık olmayan hafif baş ağrıları var.
- ☐ Orta derecede baş ağrıları var.
- ☐ Sık gelen orta derecede baş ağrıları var.
- ☐ Sık gelen ağır derecede baş ağrıları var.
- ☐ Hemen hemen her zaman baş ağrıları var.

Bölüm 6 – Konsantrasyon

- ☐ İsteddiğim zaman dikkatimi hiç zorlanmadan istediğim kadar toplayabiliyorum.
- ☐ Hafifçe zorlanarak dikkatimi toplayabiliyorum.
- ☐ İsteddiğim zaman biraz zorlanarak dikkatimi toplayabiliyorum.
- ☐ İsteddiğim zaman epeyce zorlanarak dikkatimi toplayabiliyorum.
- ☐ İsteddiğim zaman dikkatimi toplamakta çok fazla zorlanıyorum.
- ☐ Dikkatimi hiç toplayamıyorum..

Bölüm-7 İş (Herhangi bir işte çalışmıyorsanız lütfen G seçeneğini işaretleyiniz)

- ☐ İsteddiğim kadar iş yapabilirim.
- ☐ Her günlük işlerimi yapabilirim, ama daha fazlasını yapamam.
- ☐ Her günlük işlerimin çoğunu yapabilirim, daha fazlasını yapamam.
- ☐ Her günlük işlerimi yapamam.
- ☐ Herhangi bir işi zorlukla yapabilirim.
- ☐ Hiçbir iş yapamamG- Hiç yapmadım

Bölüm 8 - Araba Kullanma

- ☐ Boyun ağrısı hissetmeden araba kullanabiliyorum.
- ☐ Boynumda hafif bir ağrı hissi ile istediğim kadar araba kullanabiliyorum.
- ☐ Boynumda orta derecede ağrı nedeni ile istediğim kadar araba kullanamıyorum.
- ☐ Orta derecede bir boyun ağrısı nedeniyle istediğim kadar araba kullanamıyorum.
- ☐ Boynumda şiddetli ağrı nedeniyle güçlükle araba kullanabiliyorum.
- ☐ Boyun ağrısı nedeniyle hiç araba kullanamıyorum.
- ☐ Hiç yapmadım

Bölüm 9 - Uyku

- ☐ Uyku problemim yok.
- ☐ Uykum çok hafif bozuk (bir saatten az süreyle biraz bozuk).
- ☐ Uykum hafif bozuk (1-2 saat uykusuzluk).
- ☐ Uykum orta derecede bozuk (2-3 saat kadar süren uykusuzluk).
- ☐ Uykum çok bozuk (3-5 saat süreyle uykusuzluk).
- ☐ Uykum tamamen bozuk (5-7 saat süresince uykusuzluktur).

Bölüm 10 – Boş zaman aktiviteleri

- ☐ Tüm boş zaman aktivitelerine boynumda ağrı hissetmeden katılabiliyorum.
 - ☐ Tüm boş zaman aktivitelerine boynumda biraz ağrı hissederek katılabiliyorum.
 - ☐ Boynumdaki ağrı nedeni ile tüm boş zaman aktivitelerinin bir kısmına katılabiliyorum.
 - ☐ Boynumdaki ağrı nedeni ile boş zaman aktivitelerinin çok az bir kısmına katılabiliyorum.
 - ☐ Boynumdaki ağrı nedeni ile boş zaman aktivitelerine hemen hemen hiç katılamıyorum.
 - ☐ Hiç bir aktiviteye hiç bir şekilde katılamıyorum.
 - ☐ Hiç yapmadım
- “Modified with permission of author, 2004”

Hasta Adı _____ Tarih _____

CIRRICULUM VITAE

Kişisel Bilgiler

Adı	Wesam	Soyadı	Alzeer
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