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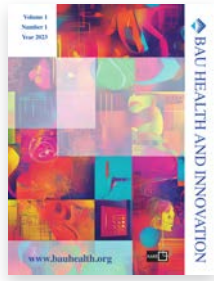

Review

Effect of Ergonomic Factors on Musculoskeletal Disorders in Dentists

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Abstract

The science of ergonomics, by identifying and regulating primary factors, particularly those related to musculoskeletal disorders, plays a pivotal role in their prevention. The profession of dentistry, by its nature, is one of the most susceptible to musculoskeletal disorders. Therefore, the science of ergonomics should be integrated into the dental profession for the prevention and treatment of these disorders. Studies indicate that musculoskeletal disorders are observed in dentists at a rate ranging from 64% to 93%. The primary risk factors contributing to the onset of these disorders include prolonged static postures, repetitive movements, workplace designs, poor positioning, mental stress, physical conditioning, age, and non-job-related factors. Potential disorders that may arise from these risk factors include lumbar and cervical disk herniation, carpal tunnel syndrome, cubital tunnel syndrome, and postural abnormalities. All these potential musculoskeletal disorders entail various negative consequences in terms of both workforce loss and the material and spiritual burdens of resulting ailments. The fundamental aim of ergonomics, encompassing all these aspects, is to prevent these problems, thereby bringing together the dental profession and the science of ergonomics on common ground. Furthermore, through these ergonomic adjustments, the prevention of musculoskeletal disorders will reduce the burden on both healthcare facilities and their employees. The objective of this study is to compile solutions for musculoskeletal disorders observed in dentists by aligning them with the science of ergonomics. Accordingly, subtopics such as auxiliary equipment, clinician practice chairs, clinician posture recommendations, and patient positioning have all been elucidated in this study.

Keywords: Dentistry, ergonomics, musculoskeletal disorders.

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Ergonomics is a scientific discipline that examines and regulates the relationship between an individual practicing any profession and its working environment. It enhances the performance of employees by protecting their physical and mental health. Its main purpose is to make arrangements to prevent disability before it occurs and to increase work efficiency. In this way, it prevents economic and physical losses. The application of ergonomics in the workplace of dentists both improves the quality of service received by patients and optimizes the quality of life of dentists.[1]

Musculoskeletal disorders are quite common among dentists and individuals working in this field. Due to the nature of the profession, working in static positions for prolonged periods of time, poor posture of the neck and shoulders, combined with repetitive movement of the wrists, leads to the inevitable development of these disorders. Since these postures exert biomechanical stress on the joints, the emergence of upper extremity and spine problems such as carpal tunnel syndrome (CTS) has been reported in detail by other studies. Ergonomic practices should become an

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important part of the education of dentists to reduce the incidence of musculoskeletal disorders and lifelong training should be provided on this subject.[1,2]

Different studies on musculoskeletal disorders among dentists have been conducted in many countries. Studies have shown that the prevalence of musculoskeletal disorders among dentists in Germany is 95.8%, in Italy 91%, and in Denmark 83%. Globally, this rate varies between 64% and 93%. In addition, it is known that dentists have high mental stress, which contributes to the occurrence of musculoskeletal disorders.[1] Although systematic reviews and large-scale studies indicate a high prevalence of musculoskeletal disorders among dentists worldwide, research on solutions to these issues is insufficient and incomplete. The aim of this study is to bring together musculoskeletal disorders in dentists and ergonomic science and to compile solution suggestions. In this direction, all subheadings such as auxiliary equipment to be used, clinician practice chairs, clinician posture recommendations, and patient positioning are explained in this study.

Literature Review

Musculoskeletal Disorders among Dentists

Sacroiliac joint (SIJ) pain and dysfunction

The SIJ is the cause of pain in 15–30% of patients with low back pain (LBP). Patients with pain in the SIJ have been shown to have a lower quality of life than patients with chronic obstructive pulmonary disease or moderate heart failure.[1] Between the ages of 40 and 50, the SIJ undergoes fusion and decreases its mobility. This hypomobility may increase pain. Ankylosing spondylitis and osteoarthritis that occur with increasing age are also common causes of SIJ pain. The main mechanism of SIJ injury is excessive rotation caused by axial loading.[2,3]

SIJ dysfunction is a term used when pain occurs in the SIJ. It should not be confused with sacroiliitis. Sacroiliitis is an inflammation of the SIJ and should be included in the differential diagnosis of the SIJ. Like other SIJ pathologies, it produces pain radiating to the lumbar region and buttocks. It may have rheumatologic, infectious, drug-related, or oncologic causes. In the case of sacroiliitis, pain may originate from the SIJ or the posterior sacral ligaments.[4,5]

The prevalence of SIED is 25% in people with chronic LBP. Pain may be bilateral or unilateral but not midline. It is more common in women. The SIJ is more mobile in women and less mobile in men. Therefore, loads on the SIJ and pelvic ligament injuries are more likely to occur in men. [6] Patients with SIED show pain inferomedial to or above the posterior superior iliac spine with the Fortin finger test. However, pain may be seen in the lateral gluteal region or may radiate to the lower extremity. SIED pain is aggravated by climbing up and down stairs, going uphill, falling to the ground after a jump, sitting for long periods of time while driving, or standing for long periods of time.[6,7]

Lumbar disk herniation (LDH)

LDH involves the rupture of the intervertebral disk's fibrous annulus, resulting in the herniation of the nucleus pulposus (NP), which can compress spinal nerves or the cauda equina, triggering an inflammatory response. Patients typically present with clinical symptoms such as pain and neurological deficits. Due to shifts in work and lifestyle habits, the incidence of LDH has risen significantly and is affecting younger individuals, posing a major threat to both the physical and mental well-being of patients, and becoming one of the leading health concerns.[8]

Up to 80% of all people have experienced LBP at some time in their lives. Because of its high prevalence and contribution to disability, LBP is estimated to cost the United States $100 billion annually.[8,9]

Many factors are thought to play a role in the formation of LDH. These include decreased water content in the NP, increased type I collagen in the inner AF and NP, decreased extracellular matrix, apoptosis, and increased matrix metalloproteinase. It is also possible to talk about a genetic process. Genetic origin has been identified in 75% of LDH cases. Dehydration also plays an important role in disk degeneration. Likewise, axial overload is a risk factor for LDH. Since the NP is an immunoreactive area, inflammation in this area will also contribute to the formation of LDHs.[9–11]

95% of LDHs originate at the L4-L5 or L5-S1 levels. Symptoms include radicular pain, LBP, sensory abnormalities and muscle weakness consistent with lumbosacral nerve involvement, restriction of lumbar flexion, and aggravation of pain with sneezing and coughing. Pain worsens with sitting position (nerve load increases by 40%).[10]

Thoracic hyperkyphosis

Thoracic hyperkyphosis is defined as excessive anteroposterior curvature of the thoracic spine of more than 40°. It increases with age, is more common in women, and progresses more rapidly in women. There are three main types: hyperkyphosis associated with Scheuermann's disease, postural hyperkyphosis, and congenital deformities. There is weakening of the posterior structures of the spine with progressive deterioration of posture. Postural kyphosis usually has normal vertebral structures

and the condition is usually benign. In older individuals, reduced muscle integrity can contribute to poor posture, which over time can lead to an increased compressive load on the thoracolumbar spine, thus creating an anterior wedge-like fracture, which we often see in older people with osteoporotic compression fractures. Although the natural history of occurrence is not fully elucidated, the rate of progression is faster in women after the age of 40.[11–13]

Examination is based on observation and lateral radiographs (Cobb angle) and in advanced cases, a hump-like appearance may be seen. Tenderness of the paraspinal muscles is seen on palpation. Short hamstring muscles can be seen in Scheuermann's disease. Loss of joint range of motion (ROM) is seen. Pain in the thoracic region and breathing problems may be observed. Osteoporotic fractures may also occur in elderly individuals.[14,15]

Cervical disk herniation (CDH)

CDHs occur due to cervical disk degeneration and may lead to radiculopathy. Radiculopathy can be defined as the compression of the cervical nerves and the occurrence of pain and sensory or motor changes in the related dermatome or region.[16] SDH increases with age in both men and women and is most common between the ages of 30 and 50. It is more frequently encountered in women. [17–19] The path of the cervical nerve as it exits the neural foramen may make the cervical nerve more sensitive to stretching. This explains the symptom relief that occurs with shoulder abduction in some patients.[14,15]

SDHs most commonly cause symptoms by compressing the C7 root between C6 and 7, followed by the C6 root between C5 and 6 and the C8 root between C7 and T1. Traumatically induced SDHs should be evaluated for spinal cord syndrome or Brown–Sequard syndrome 21. Patients show 75–90% improvement with conservative treatment. Conservative treatment includes the use of a cervical collar, traction, medication, physical therapy, and manual therapy. Symptoms usually resolve in 6 weeks. This is due to phagocytic resorption of the disk herniation. If symptoms persist for more than 6 weeks, surgical intervention is considered and symptom resolution without surgical intervention is unlikely.[19,20]

CTS

CTS is the most common impingement neuropathy encountered by hand and upper extremity surgeons. Its etiology may include work, lifestyle, or genetic predisposition. Repeated exposure to vibration or angular movements in certain positions is thought to be the most common cause of CTS, and certain diseases such as diabetes, pregnancy, and obesity are also associated with increased risk for developing CTS. However, it occurs in women and usually in the elderly population. The diagnosis of CTS is mostly based on clinical findings. These symptoms may include numbness, tingling, or paresthesia in the radial part of the 3rd and 5th fingers. For further diagnosis, electrodiagnostic studies or nerve conduction velocity (EMG) studies may be performed.[21]

CTS is the most common nerve compression syndrome worldwide and is defined as compression of the median nerve at the level of the wrist and associated loss of function. It is mostly idiopathic and affects 7–16% of the adult population. It accounts for 90% of all nerve compression syndromes and is more common in women between the ages of 45 and 64. Risk factors in the workplace include strong grip, repetitive wrist extension and flexion, and exposure to vibration.[21–23]

It presents with nocturnal paresthesia that awakens the patient from sleep at night and becomes more frequent when the patient is awake. There is weakness and loss of sensation in the radial parts of the thumb, index finger, and middle finger, resulting in atrophy of the tenar muscles. Symptoms worsen with prolonged hand flexion and repetitive extension and flexion. The first choice of treatment is conservative treatment, but for moderate to persistent symptoms, non-operative treatments such as injections are considered. However, if the symptoms are severe and axonal damage is detected by EMG, surgical decompression of the carpal tunnel is performed.[24–26]

Forward head tilt

Neck pain has a high epidemiologic prevalence. The prevalence of neck pain is higher in women and increases with age. One in three Europeans has experienced neck pain at some point in their lives. Additional risk factors include lack of physical activity, increased body mass index, low kinesthesia, and incorrect movement patterns. Neck pain has also been associated with poor health status, previous neck injuries, and other risk factors such as occupation, smoking, obesity, and poor posture.[27]

The most common pathologic adaptation associated with the development of neck pain is forward head tilt. Forward head tilt increases the weight on the cervical spine, leading to pathologic myofascial adaptations and muscle imbalances. Weakened muscles include deep neck flexors, scapular stabilizers, and retractors. Muscles that shorten and become overactive include the deep upper cervical extensors, shoulder protractors, and elevators. These muscle imbalances lead to cervical and thoracic instability, resulting in decreased respiratory function, proprioceptive changes, and increased muscle tone.[27,28]

Symptoms may include muscle ischemia, pain, fatigue, decreased cervical ROM, disk degeneration and osteophyte formations, tension headache, temporomandibular joint pain and inflammation, and decreased vital capacity. The craniovertebral angle is used in X-ray radiographs and this method examines the position of C7 relative to the head. Posture exercises are used in treatment.[29–31]

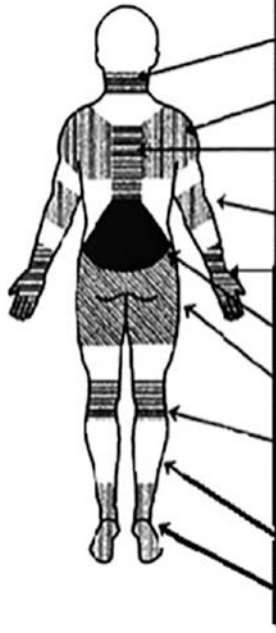
Risk Factors for Work-Related Musculoskeletal Disorders in Dentists

There are many factors that affect the work environment of dentists and these factors can be listed as organizational, ergonomic, psychosocial, etc. and it is very important to identify these factors. The elimination of these factors will contribute to the improvement of the performance of dentists, the quality of dentistry, and the satisfaction of patients. Many studies have been conducted to identify these risk factors and the most important ones are non-ergonomically designed equipment and working under pressure.[32]

Dentists perform time-consuming procedures that require very high concentration in a very small space (and often in a poor position). They remain in asymmetrical positions that favor muscle imbalance for quite a long time. Rotation and inclination of the neck, cervical and lumbar lordosis with forward bending and decreased cervical ROM, and isometric and eccentric contraction of the arms in the same position for long periods of time are risk factors for musculoskeletal disorders among dentists.[33] However, rather than mentioning a single risk factor, we should talk about a combination of all these risk factors. Prolonged static postures, repetitive movements, workplace designs, poor positioning, mental stress, physical conditioning, age, and non-work related factors can all be included in these risk factors. Static forces in specific postures cause intervertebral disk problems and pain in dentists.[34]

Prevalence of Musculoskeletal Disorders in Dentists

Studies have shown that 64–93% of dentists or orthodontists have been exposed to musculoskeletal disorders in the cervical-lumbar region or shoulder at least once in their lives. The prevalence of cervical-lumbar region, shoulder, and wrist disorders, which are among the highest risk areas among healthcare workers, is highest among surgeons and dentists. Among dentists, the prevalence of wrist and shoulder disorders, which are among the most common musculoskeletal disorders, was reported to be 39.4% and 55.1%, respectively (Figs. 1, 2). In another study conducted in 2023, the prevalence of CTS among 3547 dentists was reported as 9.87%.[33,34]



Body Regions	Prevalence [CI95%]
Neck	51.9% [46.7-57.2]
Shoulders	33.2% [24.1-43.8]
Upper Back	33.4% [26.8-40.8]
Elbows	12.9% [7.7-20.6]
Wrists/Hands	33.7% [28.2-39.6]
Lower Back	37.3% [31.5-43.5]
Hips/Thighs	11.9% [8.7-16.1]
Knees	17.6% [11.7-25.5]
Leg	10.5% [7-15.4]
Ankles/Feet	12.9% [3.8-36]

Figure 1. Body regions most affected by musculoskeletal disorders in dentist.[34]

Other studies have shown that the prevalence of musculoskeletal disorders related to the upper extremities among dentists in Germany was 92.6%. The most affected areas were the neck and shoulder, respectively (Fig. 1). Dentists reported a 15% reduction in activities of daily living due to neck and shoulder problems. All of these conditions were more common in women.[35]

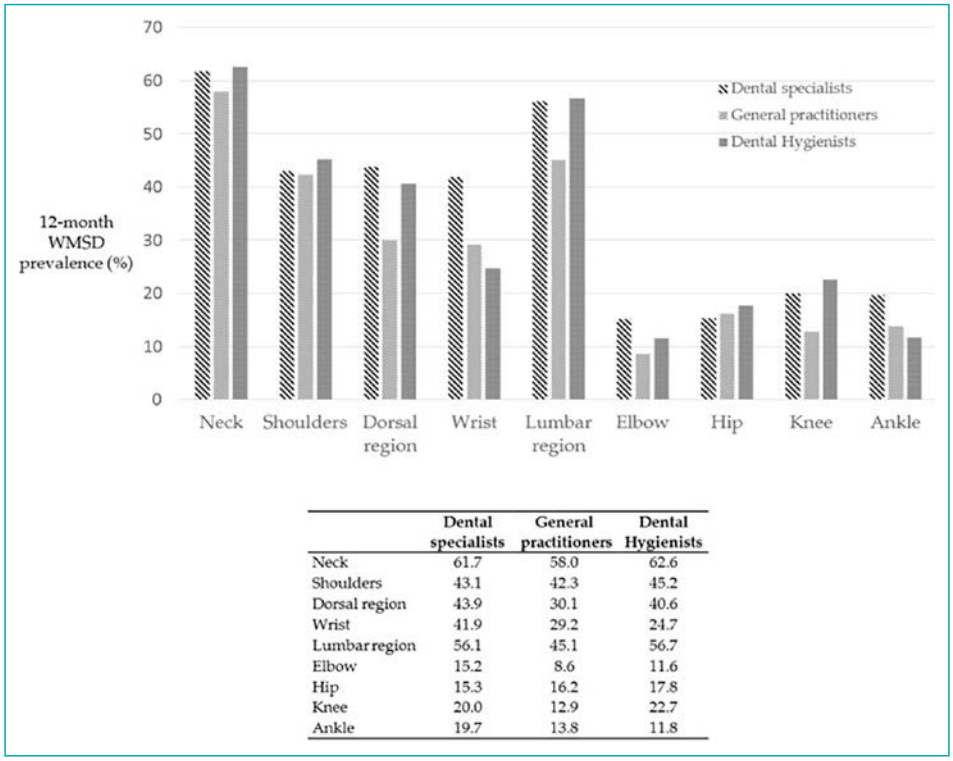
Prevention of Musculoskeletal Disorders in Dentists

Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) can be used to determine the ergonomic arrangements to be made. With this method, the health and ergonomic postures of dentists are evaluated and risk analysis can be performed.[35,36]

RULA and REBA scores are as follows:

1. 1–2 Points: Acceptable posture
2. 3–4 Points: Research required.
3. 5–7 Points (RULA) or 5–8 Points (REBA): Change required.
4. 7+ Points (RULA) or 9–15 (REBA): Changes are urgently needed.

Dable et al. investigated the effect of using ergonomic dental chairs with magnifying glasses on the working position of dentists and showed that ergonomic dental chairs used with magnifying glasses gave better results. Significant improvements were seen in the posture of dentists using



	Dental specialists	General practitioners	Dental Hygienists
Neck	61.7	58.0	62.6
Shoulders	43.1	42.3	45.2
Dorsal region	43.9	30.1	40.6
Wrist	41.9	29.2	24.7
Lumbar region	56.1	45.1	56.7
Elbow	15.2	8.6	11.6
Hip	15.3	16.2	17.8
Knee	20.0	12.9	22.7
Ankle	19.7	13.8	11.8

Figure 2. Body regions affected by musculoskeletal disorders in dental practitioners.[34]

WMSD: Work related muskuloskeletal disorders.

magnifying glasses. Ergonomically supported chairs protect the lordosis by supporting the lumbar region. Hallaj et al.[37–39] reached similar conclusions. Ergonomic dental chairs lead to positive changes in the working life of dentists and magnifying glasses have the same effect. Especially in dental students, the use of magnifying glasses had a positive effect on posture. An ergonomic dental chair with lumbar support has been reported to lead to significant improvements in the posture of dentists. Dental chairs without lumbar support may result in decreased spinal curvature and consequent posterior rotation of the lower extremities. Using a dental chair with arm support also reduces pressure on the neck and shoulders. Therefore, dental chairs with both lumbar and arm support are recommended.

Prismatic spectacles have been shown to reduce neck flexion while working in dental offices. They have also been shown to reduce perceived exertion, reduce pain, and increase workability. In this context, prismatic glasses reduce the incidence of musculoskeletal disorders. The biggest effect was the need for less neck flexion in jobs requiring visual effort. In addition, magnifying glasses with an overhead lamp help to align the light parallel to the operator's line of sight, preventing the shadow effect. They provide sufficient illumination to increase the operator's field of vision, reducing the occurrence of poor posture. However, there is also a study that showed no change in neck pain symptoms in dental operators who wore magnifying glasses for 6 months.[40–42] Excessive dorsiflexion of the wrist in dentists is thought to be one of the factors that increase the prevalence of CTS. Reorganization of working methods and equipment to include the forearm may be an option.[40]

It has been reported to be effective in maintaining physical activity and balanced posture. Studies have shown that regular aerobic and stretching exercises are effective in strengthening the musculoskeletal system in dentists (Fig. 3). Aerobic exercises improve oxygen delivery and blood flow to body tissues while stretching exercises relax and reduce muscle tension caused by incorrect posture. Stretching exercises such as moving the limbs in the opposite direction of repetitive postures between patient visits and chin stretching exercises have been shown to reduce musculoskeletal disorders.[41–43]

The Role of Patient Positioning in Ergonomic Solutions

The primary working area of dentists is the patient's head and especially the mouth. The main reason for the occurrence of musculoskeletal disorders in dentists is the difficulty of reaching the area they intervene. In fact, the main purpose of ergonomics is to provide engineering solutions with scientific foundations to eliminate this transportation difficulty.

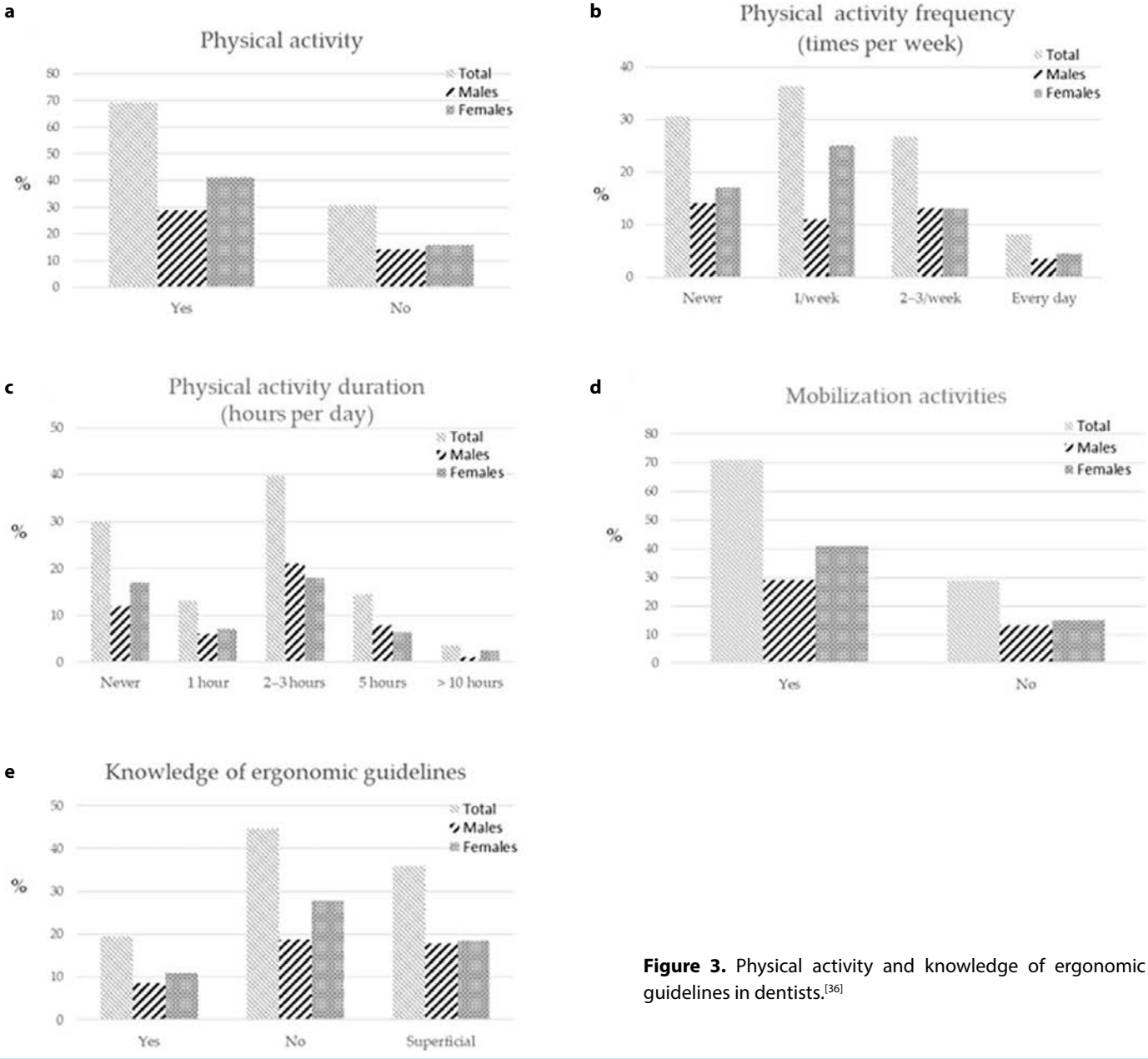


Figure 3. Physical activity and knowledge of ergonomic guidelines in dentists.[36]

Although auxiliary equipment offers solutions to support this situation in the general ergonomic approach, another perspective that can be used to resolve this issue may be to change the patient position. Placing the patient in different positions according to the anatomical location characteristics of the procedure applied to the patient can be presented as an ergonomic solution for dentists.

The focus of ergonomic solutions in dentists should be not only on dentist posture, etc., but also on external factors. In addition to the devices and seats used in the subheadings defined as external factors, the importance of patient positioning should also be mentioned. When the literature was examined, it was determined that although there are a few studies that refer to this issue in a few sentences, there are no studies that focus on this issue. More studies are needed to investigate this new and not yet studied topic for ergonomic science.

Conclusion

Risk management in workplaces where dentists and other professionals operate is critically important from an ergonomic perspective. The ergonomic adjustments to be implemented following risk identification and management should be tailored to the individual and the specific

workplace. In addition, the prevalence of musculoskeletal disorders among dentists appears to be quite high. To prevent these issues, we believe that the use of ergonomic dental chairs, along with magnifying glasses and accompanying light sources, can contribute positively from an ergonomic standpoint. A review of the literature reveals that ergonomic interventions are primarily evaluated from the perspective of dentists, with few or no studies addressing patient positioning. Therefore, we believe that future research incorporating patient positioning into ergonomic studies would provide valuable contributions to the literature.

Disclosures

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