Early Online

The European Research Journal 2025 Original Article

DOI: https://doi.org/10.18621/eurj.1568764 *Physiotherapy and Rehabilitation*

Ergonomics in surgery and work-related musculoskeletal disorders

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ABSTRACT

Objectives: Our study aimed to determine surgeons' work-related musculoskeletal disorders, physical workload, location of the disorder, frequency, characteristics, and effects on daily life. Furthermore, we aimed to draw attention to ergonomics education by investigating surgeons' opinions and attitudes regarding ergonomics.

Methods: Data were collected using survey forms from 37 surgeons who met the appropriate criteria. Sociodemographic characteristics, The Physical Workload Questionnaire was used to evaluate physical workload, the Extended Nordic Musculoskeletal System Questionnaire was used to evaluate the characteristics of painful areas, and the Beck Depression Scale was used to evaluate the psychological status of the surgeons.

Results: Thirty-four (91.9%) of the surgeons reported that they experienced musculoskeletal disorders at least once in their careers due to their professional responsibilities. The most common causes of pain were poor posture, incorrect positioning, and standing too much. The neck, upper back, and waist were the most affected areas, and only 1 (2.7%) surgeon had received ergonomics training.

Conclusions: Musculoskeletal disorders caused by ergonomic difficulties are common in the surgical field. It is critical to developing evidence-based ergonomic training recommendations that hospitals and residency training programs should follow to protect surgeons from preventable injuries that have the potential to significantly harm their careers.

Keywords: Ergonomics, ergonomics in surgery, work-related disorders, pain, musculoskeletal disorders

In recent years, the mental load associated with doctors' work and its impact on their health have garnered significant attention and have been the subject of extensive research [1]. In contrast, the physical demands of the job, particularly for surgeons, have not been the subject of extensive research or attention. Various symptoms, including discomfort, damage, or persistent pain in the muscles, tendons, ligaments, nerves, joints, and bones, caused, or exacerbated by occupational risk factors, are defined as work-related musculoskeletal disorders (WRMD) [2]. In developed countries, it is well known that WRMD contributes significantly to the cost of work-related diseases [3]. It also represents an increasing problem of job instability, decline in activity, switching to another job, and becoming a cause of disability [4]. According to a re-

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How to cite this article: Külekçioğlu S, Dilektaşlı E, Kömürcü E, Kuytu T, Uçak H. Ergonomics in surgery and work-related musculoskeletal disorders. Eur Res J. 2025. doi: 10.18621/eurj.1568764

Received: October 23, 2024
Accepted: December 23, 2024
Published Online: February 3, 2025

cent study, WRMD is responsible for 28% of health workers' missing days without working, and health professionals are exposed to up to three times more risks than the general population, depending on the type of activity carried out, the workload and the position taken during work [5, 6]. Ergonomics involves designing the work environment to suit the worker, rather than forcing the person to adapt to the work setting [7]. Ergonomists view surgeons' environments and working conditions as equal to, or even worse than, some industrial workers [8]. Surveys reveal that 23100% of surgeons in various sub-disciplines suffer from musculoskeletal system diseases (MSD) due to insufficient ergonomic procedures in their work environments [8, 9]. It is a fact that, irrespective of expertise, various types of operations exist. Surgical tasks performed by surgeons necessitate mental acuity, concentration, hand-eye coordination, and precise movement. Additionally, these tasks require maintaining a constant posture for extended periods, often involving prolonged static effort [8, 10-11]. Surgery is a dynamic environment characterized by sudden changes, requiring surgeons to adopt ergonomically limited postural positions to optimize visibility and access to the surgical area. Inadequate ergonomic training and improper ergonomic practices during surgery can result in physical discomfort and suffering, alongside psychological problems, less concentration, and decreased surgical speed and endurance [12, 13]. Moreover, outside of their professional duties, surgeons indicate that work-related musculoskeletal problems (MSD) disrupt sleep, hinder social engagements, and adversely impact quality of life, resulting in premature retirement [14, 15].

This study aims to identify surgeons' work-related musculoskeletal disorders (WRMD), assess the physical burden, determine the location, frequency, and characteristics of the condition, evaluate their influence on daily life, and emphasize the need of ergonomics training by examining surgeons' perspectives and attitudes towards ergonomics.

METHODS

This prospective, cross-sectional study was conducted at Bursa Medical Park Hospital from August 14, 2023, to September 14, 2023, with the approval of the ethics committee, numbered 2023/181, acquired from the Clinical Research Ethics Committee of Istinye University in Istanbul. All procedures were conducted in compliance with the principles of the Helsinki Declaration established by the World Medical Association. Surgeons with a minimum of one year of experience, who accessed the operating room on a weekly basis, maintained an average workweek of 40 hours, and voluntarily participated in the study were included, irrespective of gender and age. Those with less than one year of work experience, those with short working hours, those with systemic or malignant diseases, those who had an operation on the musculoskeletal system, and those who used analgesics regularly in the last month were excluded from the study. Thirty-seven surgeons who met the inclusion criteria were included in the study voluntarily and signed an informed consent form. Questionnaire forms were employed to collect data, which were developed from previously published literature on postural ergonomics in the surgical field. The first part of the survey included sociodemographic characteristics (gender, age, height, weight, surgical expertise, size of the surgery gloves, regular exercise or not), chronic musculoskeletal disease, musculoskeletal system surgeries, presence or absence of ergonomics training, perioperative pain status, sleepiness, predicted causes of pain, age of maximum perceived surgery performance, desire for early retirement, visual analogue scale (VAS) value in the region where the pain is most severe, whether the pain has an impact on daily life or not, whether or not it has been treated, whether there is a need for ergonomic education in the surgeons and whether the time is devoted to training in ergonomics.

In the second part of the forms, we used the Physical Workload Questionnaire (PWQ) to assess physical workload. The questionnaire was developed by Hollman *et al*. [16] and its Turkish validity and reliability study was conducted by Kahraman *et al*. [17]. The PWQ is a self-administered questionnaire designed to evaluate physical workload, and to our knowledge, it is the sole instrument utilized for this purpose in Turkey. It can be utilized in the physical evaluation of augmented workload resulting from body position and intense labour, as well as to mitigate high-risk occupational duties. Weightlifting is questioned when the torso is upright and tilted forward to 60 degrees. Light weights (<10 kg), medium weights (10-20 kg), and

heavy weights (>20 kg) are evaluated in each set of three items. All items are answered on a five-item Likert-type scale ranging from never to very often. To get a raw score, the responses to each item are added. The final scores are calculated by multiplying the raw score by 100 and dividing it by the subscale's highest possible score. A final score ranging from 0 (no workload) to 100 (highest workload) is obtained for each subscale

The Extended Nordic Musculoskeletal Questionnaire (NMQ-E) was used in the third part of the forms. The NMQ-E is a widely used questionnaire designed to assess MDG and its effects on individuals in the workplace. It was used for the first time by Kuorinka *et al*. [18]. The questionnaire consists of different sections covering various body areas and related symptoms. For each part of the body, which is divided into nine parts (neck, shoulder, back, elbow, hand/wrist, waist, hip/thigh, knee, foot/ankle), the age at which the pain occurs, consulting a doctor, using medication, hospitalization, illness. Whether it causes consequences such as taking leave from the workplace or disruption in daily life is evaluated under subheadings. NMQ-E poses binary choice inquiries (yes or no) regarding pain, soreness, or discomfort in nine anatomical locations over the past 12 months, the preceding four weeks, and the day of therapy [19].

In section 4, the Beck Depression Scale (BDS) questionnaire was employed to assess the psychological condition of the surgeons. BDS was created by Beck *et al*. [20]. The scale assesses the risk and vulnerability of adults to develop depression and evaluates the severity of depressive symptoms. The scale does not diagnose depression in an individual but quantifies the severity of their depression through numerical data. The Turkish validation adaptation of the scale employed in this study was conducted by Hisli [21]. The scale comprises 21 items, each representing a depressive symptom. Each item on the scale is evaluated on a range from 0 to 3 points. The maximum score was established at 63. An elevated score correlates with an increase in the individual's depression level. Depression intensity is classified as follows: 0-9 = Minimal, 10-16 = Mild, 17-29 = Moderate, and 30-63 = Severe.

Statistical Analysis

The data were analysed using the IBMR SPSSR Statistics (Version 20.0). The normality of the data distribution was checked by the Kolmogorov-Smirnov/Shapiro-Wilks tests and histograms. The results for characteristics of participants were presented as percentages for categorical variables and mean ± standard deviation for continuous variables because they were distributed normally. Variations of VAS, PWQ, DLA, and Beck values between different age, gender, height, weight, experience, and exercise status groups were analysed with One Way Anava – Tukey post hoc and independent student t-test when appropriate. Associations between WRMD and occupational groups were evaluated using the One-way Anova (Tukey post hoc). The level of significance was set at $P<0.05$.

RESULTS

Demographic characteristics are shown in Table 1. Perioperative pain, numbness, and other characteristics of surgeons are presented in Table 2. Thirty-four out of 37 surgeons (91.9%) reported that they had experienced MSD, especially pain, at least once in their ca-

Table 1. Demographic data of the participants

	Data
Gender, n (%)	
Male	31 (83.8)
Female	6 (16.2)
Age (years)	49.21±7.02
Number of years worked as a surgeon, n (%)	
<10	2 (5.40)
11-20	12(32.43)
>20	23 (62.16)
BMI (kg/m^2)	26.02±3.20)
Height (cm), n (%)	
<160	0
160-170	7 (18.9)
171>	30 (81.27)
Regular exercise, n (%)	
doing	8 (21.62))
not doing	29 (78.37)

Data are shown as mean±standard deviation or n (%). BMI= Body Mass Index

Table 2. Other characteristics of the participants

	Data
Number of MSDs diagnosed	7 (18.91)
Number of surgeons with ergonomic training	1 (2.70)
Perioperative Pain	
No	3 (8.1)
Yes	34 (91.9)
Perioperative Numbness Status	
No	28 (75.67)
Yes	9 (24.32)
Early Retirement Request	
Yes	7 (18.91)
No	30 (81.08)
Previous Musculoskeletal Operation	
Yes	3 (8.1)
No	34 (91.89)
Effects of pain on activities of daily living	
Yes	25 (67.56)
No	12 (32.43)
The need for ergonomic improvement in the operating room	
Yes	30 (81.08
No	7 (18.91)
Those who want to learn about ergonomic surgery	30 (81.08)
Mean VAS valueean±sd)	5.4±2.02
Mean PWQ value (mean±sd)	14.89±5.87
Mean Beck Scale value (mean±sd)	8±4.41

Data are shown as mean±standard deviation or n (%). BMI=Body Mass Index, MSD=Musculoskeletal Disorders, VAS=Visual Analog Scale

Table 3. Risk factors of musculoskeletal symptoms among study participants

	n (%)
Bad position	
Can be fixed	25 (67.56)
Cannot be fixed	9 (24.32)
Standing for a long time	21 (56.75)
Surgery time	21 (56.75)
Bad posture	25 (67.56)
Stand still	20 (54.05)
Stress	13 (35.13)
Lean forward too much	18 (48.64)
Insufficient equipment	5 (13.51)
Table height	12 (32.43)
Type of surgery	17 (45.94)
Temperature of the operating room environment	13 (35.13)
Used materials	6 (16.21)
Monitor position	4 (10.81)

reers due to their professional responsibilities. VAS values were above 5 in 20 surgeons (54%), and pain was found to affect daily life in 25 (67.56%). Only 1 surgeon (2.7%) had received ergonomic training, and 30 surgeons (81.08%) stated that ergonomic improvements were needed in the operating room and that they would spend time on ergonomic training. The mean PWQ was 14.89. The mean Beck depression scale was 8, and symptoms were minimal. Thirteen surgeons had mild depressive symptoms, and 1 surgeon had a moderate depression scale. The most common causes of pain were poor posture and poor positioning (Table 3). The distribution of surgeons and pain areas is shown in Table 4. The neck, upper back and waist were the most affected areas and were the most common reasons for visiting a doctor and using medication. It was determined that the VAS value increased as the surgeon's height increased. A significant difference was found in VAS values in those over and under 170 cm. The Beck depression scale value was significantly higher in surgeons under 45 years of age (Table 5).

DISCUSSION

In our study, we determined that the surgeons had WRMDs, most probably due to increased physical workloads, and lack of ergonomic knowledge and training. They mostly experience discomfort in the neck, upper back, low back, and these disorders adversely affect their daily living activities. In order to mitigate the risk of MSD, Kroemer suggests refraining

Table 4. The distribution of surgeons and pain areas

n (%)	Neck	Shoulder pain	Back Pain	Elbow pain	Wrist-hand pain	Lower Back pain	Hip pain	Ankle-Foot pain	Knee pain
Obstetrics and gynecologic surgery (n=5)	4 (10.8)	4 (10.8)	4 (10.8)	1 (2.7)	1 (2.7)	2 (5.40)	1 (2.7)	1(2.7)	0
General and pediatric surgery (n=6)	5 (13.5)	3 (8.1)	4 (10.8)	1 (2.7)	1 (2.7)	3 (8.1)	3 (8.1)	1 (2.7)	1 (2.7)
Orthopedics surgery (n=6)	6 (16.2)	1 (2.7)	6 (16.2)	1 (2.7)	1 (2.7)	4 (10.8)	1 (2.7)	0	1 (2.7)
Otolaryngologist (n=3)	2 (5.40)	0	2 (5.40)	1 (2.7)	0	1 (2.7)	1 (2.7)	0	0
Urologic surgery (n=3)	3 (8.1)	0	3 (8.1)	0	0	2 (5.40)	1 (2.7)	1 (2.7)	0
Eye surgery (n=4)	4 (10.8)	2 (5.40)	4 (10.8)	0	1 (2.7)	2 (5.40)	0	0	0
Cardiovascular and thoracic surgery (n=5)	3 (8.1)	0	3 (8.1)	0	0	1 (2.7)	1 (2.7)	0	0
Neurosurgery (n=4)	4 (10.8)	1 (2.7)	4 (10.8)	0	0	3 (8.1)	4 (10.8)	0	0
Total (n=37)	31 (83.7)	11(29.7)	30 (81.08)	4 (10.8)	4 (10.8)	18 (48.6)	12 (32.43)	3 (8.1)	2 (5.40)
P value*	0.44	0.30	0.42	0.81	0.96	0.81	**0.04***	0.68	0.63

*One way Anova (Tukey Post hoc)

from engaging in seven specific activities. (1) repetitions, defined as cycle less than 30 seconds or 1 basic activity element present for more than 50% of the total cycle time, (2) prolonged or repetitive exertion where the person uses more than 30% of their strength, (3) body parts held in extreme positions, (4) prolonged static posture, (5) activities with vibrating instruments, (6) exposure to cold or hot, and (7) combinations of the above conditions [22]. Many of these activities and their various combinations are common for surgeons during surgeries.

WRMDs are commonly observed among surgeons, with prevalence rates varying between 23% and 100% according to several studies [23-27]. The existing body of literature exhibits considerable heterogeneity in the observed outcomes, primarily because of the underreporting of illnesses and the logistical limitations inherent in investigations on surgical ergonomics. In our study, this rate was determined as 91.9%. Many studies have investigated surgeons from various specialties regarding MSD. In all studies, including ours, the neck and upper back were the most frequently affected areas; Excessive forward bending of the head and back, poor posture, and incorrect body position are thought to be the most common problems causing WRMD [8, 28-30]. While numerous surgeons pursue medical intervention for musculoskeletal disorders and adjust their practices in response to discomfort, they lack sufficient training. In a study of 244 surgeons, 88% reported MSD, 29% received treatment, and 9% changed their practice due to pain. Only 1% reported to their institution that they were experiencing pain. and only 16% had formal training in ergonomics [31]. In our study, there were no surgeons who changed their practice due to pain or reported their pain to their institution, and only 2% had received ergonomics training. Although 91% had WRMD, only 19% had diagnosed MSD. This situation may be associated with surgeons' lack of ergonomic awareness and training, their intense work, or their attempt to cope with pain on their own. In addition, it is believed that such practice does not exist in surgical culture. In another study, it was observed that all participants who were members of the European Association of Endoscopic Surgery believed that ergonomics were important in the operating room, but only 11% were aware of published ergonomics guidelines [32]. In our study, it was determined that 98% of surgeons did not have

Table 5. Variation of VAS, PWQ, DLA and Beck values according to gender, age, height, weight, experience and exercise status

		VAS	PWQ	DLA	BECK
Gender	Female (n=6)	4.5±2.8	17.7±7.5	4 (67)	8.5±3.6
	Male (n=31	5.4±1.9	14.4± 5.6	21 (68)	7.9±4.7
P value		0.33	0.21	0.65	0.77
Age (years)	<45 years (n=12)	5.8±1.7	14.9±6.6	10 (83)	10.1±4.9
	≥45 years (n=25)	5.0± 2.2	14.8± 5.7	15 (60)	7.0± 3.9
P value		0.27	0.98	0.15	**0.048**
Height (cm)	<170 (n=7)	4.0±3.2	14.0±4.9	4 (57)	7.7± 3.5
	≥170 (n=30)	5.6±1.7	15.1± 6.2	21 (70)	8.1±4.7
P value		0.07	0.68	0.41	0.85
BMI (kg/m^2)	<30 (n=30)	5.4±2.0	15.3±6.0	22 (73)	8.1±4.5
	≥30 (n=7)	4.3±2.9	11.8±5.2	3 (43)	7.3±5.2
P value		0.45	0.16	0.14	0.27
Surgical experience (years)	<10 (n=2)	6.0	12.2 ±1.6	2 (100)	11.0±7.1
	10-20 (n=12)	5.8 ±2	14.3±6.6	10 (83)	8.66±5.6
	>20 (n=23)	5±2.3	15.5±6.0	13 (57)	7.4 ±4.0
P value*		0.73	0.69	0.17	0.44
Regular daily exercise	Yes	5.9 ±2.0	13.8± 3.5	7 (19)	9.8 ±6.0
	No	5.1±2.2	15.2±6.5	18 (49)	7.5±4.0
P value		0.36	0.58	0.18	0.2

Data are shown as mean±standard deviation or n (%). BMI=Body Mass Index, VAS=Visual Analog Scale, PWQ=Physical Workload Questionnair, DLA= Daily Living Activities.

knowledge about ergonomics guidelines, 81% said that improvements were needed in operating room ergonomics, and that they wanted to receive ergonomics training. It was concluded that 92% of surgeons with MSD needed and wanted help in this regard. In a study of 561 spine surgeons, 7.1% had undergone surgery for lumbar disc disease and 4.6% for cervical disc disease; 31.9% of them had to take leave from work due to MSD [33,34]. Similarly, in our study, it was found that 8.1% of the surgeons were operated for cervical or lumbar intervertebral disc disease. A neutral body posture is a comfortable position that can be maintained for long periods of time, supporting the natural curvature of the spine, and giving the body a biomechanical advantage in performing work. Improper working postures can put muscles, tendons, and ligaments at risk. Abnormal loads and stress can damage bones, joints, and cartilage. Consistent with the literature in our study, the most common causes of WRMD were identified as poor posture, poor position, standing for long periods of time, and long surgery time. Although 67% of surgeons thought these problems could be corrected, they did not take any action [35-37]. Various studies have identified several factors that contribute to postural discomfort in surgeons [22,30]. In our study, although all surgeons stated that they adjusted the table height according to their height and surgical procedure during the operation, 32% still blamed the table height for their MSDs. This result may indicate that the surgeon does not tend to raise the table even if the operating table is low, the frequency of table adjustment is associated with poor posture and discomfort during the operation, and the operating tables are adjusted primarily when postural comfort is significantly affected. These findings highlight the lack of ergonomic practice, such as adjusting

the table or patient rather than the person themselves and may reflect limited ergonomic training for surgeons. While adjusting a suitable operating table height while standing certainly promotes better operating posture, the table can be adjusted for only one person at a time, or it can be adjusted to a common suitable height for more than one person assisting the procedure.

Non-ergonomic working style in surgeons may cause an increase in pain intensity and physical workload, negative effects on daily life activities, and an increase in the stress component. In our study, it was evaluated whether surgeons' age, gender, height, BMI, surgical experience, and regular exercise affected VAS, PWQ, DLA, and Beck scales. A significant relationship was detected only in age and Beck depression anxiety scores and the score was higher in young people. Lack of experience in young surgeons may result in poorer job skills and inability to practice. This may be associated with an increase in the stress component and therefore in Beck depression scores. There was a near-significant relationship between height and VAS values, and VAS values increased as height increased. Being tall was thought to cause neck and torso to bend forward, causing neck and back pain. Additionally, when surgeons were divided according to surgical subspecialties and evaluated according to their painful areas, hip pain was seen more frequently only in neurosurgeons. It was thought that it would be appropriate to re-evaluate this difference by increasing the number of cases. There was no significant difference between other subbranches and painful areas.

Each surgical modality carries its own set of ergonomic dangers. Surgeons accept these risks and disclose pain and discomfort from surgery to their institutions infrequently, ignoring them. Despite the existence of ergonomics guidelines, few surgeons are aware of them, and almost none have received training in ergonomics. Because the focus of surgical procedures is on the patient, little attention is paid to proper posture or spinal stability at the same time. Given the prevalence of WRMD among surgeons, it is essential to investigate the effect of ergonomics on surgeons' health. The lack of implementation of this subject matter has the potential to negatively impact the surgeon's capacity to perform, leading to reduced levels of professional fulfilment, increased weariness, and a heightened inclination toward early retirement. One of the key findings is that the provision of ergonomics education can significantly enhance individuals' awareness and effectively mitigate pain-related behaviours and symptoms. It is widely recognized that ergonomic issues can arise either during the period of the assistantship or prior to it, and if left unaddressed, they may persist. Hence, the development of an optimal ergonomics curriculum becomes imperative, with a focus on promoting and reinforcing sound ergonomic practices within the realm of early medical education. Future research should focus on the development of objective methods and recommendations for surgical ergonomics as well as establishing a connection between ergonomic assessments in surgeons and the occurrence of pain and tissue-level damage.

Limitations

The main limitations of this study are its cross-sectional design, the reliance on retrospective recall of symptoms, the lack of distinction between open and closed surgeries in the evaluation, and the small sample size. Further large-scale, long-term, prospective studies are needed to gain a better understanding of the cause-and-effect relationships.

CONCLUSION

WRMDs stemming from ergonomic issues are prevalent within the surgical profession, leading to both physical and psychological consequences. These negative effects contribute to musculoskeletal pain, depression, decreased overall quality of life, and increased productivity losses in the workforce. It is imperative to establish evidence-based ergonomic training guidelines required by hospitals and residency training programs to protect surgeons from preventable injuries that have the potential to significantly impact or end their careers.

Ethical statement

Ethics committee approval (number: 2023/181) was obtained from the from the Clinical Research Ethics Committee of Istinye University in Istanbul.

Authors' Contribution

Study Conception: SK, ED, EK, TK, HU; Study Design: SK, ED, EK, TK, HU; Supervision: SK, ED,

EK, TK, HU; Funding: ED; Materials: SK; Data Collection and/or Processing: SK; Statistical Analysis and/or Data Interpretation: ED; Literature Review: EK; Manuscript Preparation: SK and Critical Review: ED.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

Financing

The authors disclosed that they did not receive any grant during conduction or writing of this study.

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