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EFFECTIVENESS OF AN ERGONOMIC AND MINDFULNESS-BASED INTERVENTION ON MUSCULOSKELETAL PAIN, BURNOUT, STRESS, AND SLEEP QUALITY AMONG SURGEONS: A RANDOMIZED CONTROLLED TRIAL

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Abstract

Background: *Surgeons are exposed to prolonged static postures, repetitive movements, high workload, psychological stress, and irregular working hours, which may contribute to musculoskeletal pain, burnout, perceived stress, and poor sleep quality. This study evaluated the effectiveness of an integrated ergonomic and mindfulness-based intervention on these occupational health outcomes.*

Methods: *A randomized controlled trial was conducted among 40 surgeons recruited from the surgical departments of Evercare Hospital and Gulab Devi Chest Hospital. Participants were randomly allocated to an intervention group and control group. The intervention group received an 8-week program comprising ergonomic education, therapeutic stretching and postural exercises, mindfulness and breathing exercises, stress-management techniques, and sleep-hygiene education. The control group continued usual clinical and occupational practices. Outcomes were assessed before and after the intervention using the Numeric Pain Rating Scale (NPRS), Nordic Musculoskeletal Questionnaire (NMQ), Maslach Burnout Inventory (MBI), Perceived Stress Scale (PSS-10), and Pittsburgh Sleep Quality Index (PSQI). Within-group changes were analyzed using paired-samples tests, with statistical significance set at $p < 0.05$.*

Results: *Baseline characteristics and outcome measures did not differ significantly between groups ($p > 0.05$). Following the intervention, the intervention group demonstrated significant improvements in musculoskeletal pain (NPRS, $p < 0.001$), musculoskeletal symptoms (NMQ, $p < 0.001$), burnout (MBI, $p < 0.001$), perceived stress (PSS-10, $p < 0.001$), and sleep quality (PSQI, $p < 0.001$). In contrast, the control group showed no statistically significant changes in NPRS ($p = 0.120$), NMQ ($p = 0.210$), MBI ($p = 0.180$), PSS-10 ($p = 0.240$), or PSQI ($p = 0.190$).*

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Conclusion: *The study concluded that ergonomic and mindfulness-based intervention was associated with significant improvements in musculoskeletal pain, musculoskeletal symptoms, burnout, perceived stress, and sleep quality among surgeons. The findings support a multidimensional approach addressing both physical and psychological aspects of surgeons' occupational health.*

INTRODUCTION

Surgical practice is known to have significant physical and psychological demands that could impact surgeons' health and wellbeing. Surgeons must be highly concentrated, precise and fast on their decision making and can find themselves in complex situations, long procedures, emergencies and a lot of responsibility for clinical outcomes (Arroyo et al., 2021). They can be exacerbated by extended working hours, on call work, workload and lack of recovery time. In recent years, authors have increasingly acknowledged surgeons' well-being as a complex occupational health problem, marked by physical stressors, psychological stress, fatigue, and burnout syndrome (Sehgal et al., 2026).

Surgical activities involve significant physical requirements, especially when surgeons are required to perform operative activities in static or limited positions for a prolonged period. Surgeons may be required to stand for extended periods, sustain forward or lateral neck flex, lift shoulders, repeat instrument manipulation and fine motor movements of the hands that require concentration (Cuschieri & Hanna, 2015). Long-term cumulative effects of these occupational exposures may be associated with physical discomfort and musculoskeletal symptoms. A recent systematic review of musculoskeletal disorders in surgeons found that prolonged postures in the working position, repetitive movements, and conditions in the operating room are important factors linked to surgeons musculoskeletal health (Stewart et al., 2026).

Surgeons face significant psychological stressors, as well as physical. Decision making often needs to be swift and accurate and may be complicated by adverse outcomes, complications and emergency situations, resulting in an increased emotional load on surgical decision making (Egbe & El Boghdady, 2024). Overload, responsibility, lack of recovery time and time pressure could lead to occupational stress and emotional burnout. Studies that have been conducted in recent years suggests that, besides individual factors, the OOC are important contributors to health-worker burnout and moral injury in health-workers (Grumbach & Willard-Grace, 2025).

Surgeons' occupational problems can also impact their ability to recuperate appropriately. Irregular hours, night shifts, long procedures and psychological activation at work can disrupt sleep. Sleep disturbances can then lead to tiredness and lower stress tolerance to work-related stressors. When discussing surgeon wellness, there are a few key factors that came to light in a recent study on surgical training culture, including sleep deprivation, workload and the culture of traditional surgical training (Morel et al., 2026).

The relationship of physical and psychological occupational demands can serve as a useful foundation for an overall understanding of surgeon health. MSK complaints can occur at the same time as stress and fatigue and psychological stress can affect how these symptoms are perceived and managed. Likewise, poor sleep can impair healing and rehabilitation, both physically and psychologically. Hence, occupational health of

surgeons could be better understood simultaneously with the physical symptoms, psychological health and sleep rather than individually with some single symptom (Chrouser et al., 2018).

Surgeons are one of the groups with a high prevalence of musculoskeletal pain. A number of surgical manoeuvres often involve prolonged static postures or fine movements of the neck, shoulders, upper limbs and trunk. It is possible that the working environment may limit the ability to change position, especially for long procedures. A recent bibliometric study of the literature on work-related musculoskeletal disorders (WMSD) among surgeons showed that the literature on occupational musculoskeletal problems has consistently received research interest and highlighted the issues of ergonomics and operating-room conditions within this field (Gorce & Jacquier-Bret, 2024).

Surgeons are particularly prone to musculoskeletal symptoms in the neck, shoulders, upper back, lower back, and upper extremities. These areas suffer from mechanical loading when surgeons adopt a non-neutral posture or engage in repetitive motion for extended periods of time. This exposure can be especially important when using minimally invasive techniques as attending a monitor and handling instruments may lead to continued positioning. A systematic review of biomechanical risk factors in the population of head and neck surgeons found that operative positioning time and biomechanical exposures are important factors in the development of work-related musculoskeletal disorders (WR-MSDs) (Maxner et al., 2021).

The surgeon's posture is not the only ergonomic risk factor in surgery; other factors related to the surgical environment and equipment also contribute. The operating table, screen, instruments, pedals and other equipment at the operating table can affect the surgeon's physical effort and posture. If this is not possible, surgeons might have to go into awkward positions. More recent, evidence-based, ergonomic recommendations for surgery highlight the importance of neutral positioning, adjustability of surgical room equipment, and optimization of the surgeon-to-equipment interface in the context of safer surgical ergonomics (Wright et al., 2026).

Minimally invasive and/or robotic surgical technologies have changed, but not eliminated, ergonomic risks. Some of these technologies can alleviate some of the physical loads, but they can also increase the likelihood of prolonged static sitting, limited upper-limb range of motion and prolonged visual concentration for surgeons (Gorce & Jacquier-Bret, 2024). Cook et al (2025) conducted a systematic review of ergonomic outcomes in robotic urological surgery and concluded that ergonomic assessment is still required as minimally invasive surgery and robotic surgery have risks of postures and musculoskeletal issues.

The consequences of musculoskeletal pain can go beyond the feelings of pain in the body. Ongoing symptoms can have an impact on the way in which patients work, engage in physical fitness and recreational activities, and enjoy their daily life, as well as on the surgeon's comfort when performing procedures (El Boghdady, 2026). In a recent study conducted with a group of surgical trainees, Bickerton and colleagues (2025) reported that significant musculoskeletal pain is present during surgical rotations and suggested that the implications of these symptoms for surgical training are occupational, such as changes to duties or absences from work.

Ergonomic education and practice changes in surgery are therefore possible approaches that could reduce MSDs. Interventions might involve teaching on neutral posture, instrument

positioning and adjustments, monitor positioning and adjustments, operating table positioning and adjustments, movement strategies and brief periods of postural recovery. Studies of ergonomics practice patterns in urologists have revealed that surgeons are aware of the ergonomic factors and that ergonomic practices are applicable to the reduction of pain during the surgical process (Urology Surgical Ergonomics Working Group, 2022).

Surgeons' burnout is an important part of their psychological health. It involves exhaustion at work, mental or emotional detachment from work and decreased professional effectiveness. Factors associated with surgical-related burnout can be especially high for surgeons since their work is complex, involves significant responsibility, has demanding schedules, and exposes them to stress in the work environment on a regular basis. A recent systematic review of the changing culture of surgical training in Canada identified burnout, workload, sleep deprivation and the structure of surgical training as key areas to focus on in regards to surgeon well-being (Morel et al., 2026).

Factors that contribute to occupational stress for surgeons can involve high workload, being called when the surgeon is needed to be on call for emergencies, dealing with challenging patient outcomes, heavy time demands, difficulties relating to their colleagues, and fear of their own performance. These stressors can cause psychological fatigue if properly restorative sleep is not achieved. The study of surgical specialists and registrars has found factors related to the nature of the work to be significant factors in burnout, highlighting that external factors in the workplace may play a role in burnout alongside individual coping mechanisms (Dholakia et al., 2025).

Surgeons can also experience stress and burnout, which can affect their abilities and life. Emotional exhaustion may diminish psychological resources and chronic occupational stress can have a negative impact on attention, relationships, drive and recuperation. Newer models of healthcare worker well-being place greater focus on systemic/organizational factors, as these factors could be the root cause of occupational stressors that individuals may not be able to manage on their own (Grumbach & Willard-Grace, 2025).

Quality sleep is also crucial to surgeons' health because, to recover physically, manage their emotions, and focus their minds and attention. Irregular working hours, night call, early operating lists, emergency procedures and long working hours can all be factors that disrupt surgeons' work and sleep. Studies looking at metabolic and bariatric surgeons have defined sleep-related issues as another factor influencing surgeon well-being, along with burnout, and thus sleep should be taken into account when assessing the occupational well-being of surgical populations (Shahmiri et al., 2026).

Burnout, sleep and stress could also relate to each other. Stress at work can make it harder to get a good night's sleep, while sleep deprivation can make working more challenging. Ongoing sleep disturbances can thus lead to fatigue and emotional burnout. Literature from the health care worker field suggests that the focus on interventions to create a healthy worker has begun to view sleep, stress, and burnout as interrelated outcomes of the intervention, rather than mutually exclusive conditions (Whelehan & Ridgway, 2026).

The musculoskeletal pain-psychological well-being relationship is an additional justification for a joint analysis. The chronic pain can affect sleep quality, and this can lead to emotional distress, whereas stress and psychological fatigue can make it more likely that one will notice or react to physical pain. Studies have pointed to the importance of pain beliefs, coping strategies, body

awareness, and job satisfaction for understanding the entire spectrum of occupational MSDs in health-care workers with MSD (Akyurek et al., 2026).

Evidence shows that even very skilled surgeons can suffer significant physical strain and that ergonomic intervention can help understand this. Ergonomic training can raise awareness of the harmful postures and help surgeons to change their working habits. But environmental changes to ensure the ergonomic behaviour during real surgical procedures can enhance educational interventions. The interaction between individual behavior and work place design has, therefore, increasingly become the focus of research into ergonomic interventions (Adebiyi et al., 2026).

There are complementary interventions to psychological aspects of occupational strain, such as mindfulness-based interventions. Mindfulness is the intentional focus on what is happening right now, with an open and nonjudgmental attitude. Mindfulness breathing, body scan, meditation and awareness of thoughts, feelings and body sensations are common. More recent evidence on the non-pharmacological interventions in the context of healthcare workers suggests that mindfulness-based interventions are one of the interventions being studied to combat occupational stress and psychological symptoms (Meneses Damasceno & Weyll Pimentel, 2026).

Surgery involves maintaining focus and regulation of the mind, and being able to respond to stressful situations, which may make mindfulness especially applicable for surgeons. Mindfulness techniques can offer the surgeon a formal environment in which to acknowledge and attune to the stress response, to control the attention, and to increase awareness of either the physical and/or emotional state. Mindful moments have been discussed in the recent surgical literature as a possible pathway to maintaining the surgeon's well-being and work stress reduction and prevention of burnout (Wakins et al., 2025).

A multifaceted (ergonomic and mindfulness-based) intervention might thus work on multiple, albeit related, processes of occupation strain. Ergonomic strategies focus on physical exposure and musculoskeletal risk, while the mindfulness-based strategies focus on psychological responses to occupational demands. The mix might offer a more comprehensive solution than either intervention individually, as it tackles both the setting in which the work is performed and the surgeons' reaction to stress.

This holistic approach is aligned with modern models of OH, which acknowledge physical, psychological and organizational aspects. Recent research that has examined occupational strains among surgeons has focused on the need for multidimensional strategies to mitigate the musculoskeletal and/or physiological or psychological stressors (Sehgal et al., 2026).

While there has been growing research into surgeon ergonomics, musculoskeletal symptoms, burn out, stress and sleep, these are often studied as distinct occupational health issues. Whereas ergonomic studies tend to focus on posture and musculoskeletal outcomes, surgeon-wellness studies often focus on burnout, stress, resilience, or sleep. The recent systematic review of surgeons' musculoskeletal disorders highlights the significant evidence on prevalence and risk factors and reiterates the ongoing necessity for effective measures to mitigate risks. Therefore, the aim of the present study was to examine the effectiveness of an ergonomic and mindfulness-based intervention on musculoskeletal pain, burnout, stress and sleep quality among surgeons. The physical and psychological occupational health of surgeons are closely linked and interventions that aim to tackle both ergonomic exposure and psychological stress may offer a helpful framework

for enhancing the occupational health of surgeons.

METHODOLOGY

Study Design

A randomized controlled trial (RCT) was conducted to evaluate the effectiveness of an 8-week integrated intervention on musculoskeletal pain, burnout, perceived stress, and sleep quality among surgeons.

Study Population

The study included 40 surgeons recruited using non probability purpose sampling technique from surgical departments of Evercare hospital and Gulab Devi Chest Hospital. Participants were actively involved in surgical and clinical duties and met the predefined eligibility criteria.

Sample Size

A total sample of 40 participants was included in the study. The participants were equally divided into two groups, with 20 participants in each group.

Group Allocation

Participants were randomly allocated into two groups:

- Group A – Intervention Group (n = 20)
- Group B – Control Group (n = 20)

Intervention Group

Participants in Group A received an 8-week structured intervention program. The intervention consisted of ergonomic education, therapeutic stretching and postural exercises, mindfulness and breathing exercises, stress-management techniques, and sleep-hygiene education.

Week	Intervention	Frequency (F)	Time (T)	Type (T)
1	Ergonomic education	1 structured session/week; application during surgical work	30–45 min/session	Surgical posture training, operating-table and monitor positioning, reducing prolonged bending/twisting
2	Neck, shoulder & upper-back exercises	1 structured session/week + home practice	30–45 min/session	Shoulder rolls, scapular retraction, chest stretching, upper-back mobility
3	Lower-back & postural exercises	1 structured session/week + home practice	30–45 min/session	Pelvic tilts, lumbar mobility, hamstring stretching, trunk stabilization
4	Mindfulness, breathing & relaxation	1 structured session/week + home practice	30–45 min/session	Diaphragmatic breathing, mindfulness, relaxation techniques
5	Stress management	1 structured session/week + home practice	30–45 min/session	Stress-management strategies and progressive muscle relaxation
6	Sleep-hygiene education	1 structured session/week + daily application	30–45 min/session	Regular sleep schedule, reducing pre-bed caffeine, limiting electronic devices, improving sleep environment
7	Integrated intervention	1 structured session/week +	30–45 min/session	Ergonomic positioning + stretching + breathing +

		application during routine surgical work		relaxation integrated into surgical routine
8	Consolidation & self-management	1 structured session/week + continued home practice	**30–45 min/session**	Review of all techniques and development of long-term self-management plan

Control Group

Participants in Group B continued their usual clinical and occupational practices throughout the study period. They did not receive the structured 8-week intervention during the study.

Assessment Procedure

Measurements were obtained at two assessment intervals:

1. Pre-intervention assessment: Baseline measurements were recorded before randomization/intervention.
2. Post-intervention assessment: The same measurements were obtained after completion of the 8-week intervention.

The same assessment procedure was followed for participants in both groups.

Outcome Measures

The study assessed the effectiveness of the 8-week ergonomic and mindfulness-based intervention using four main outcome domains: musculoskeletal pain, burnout, perceived stress, and sleep quality. Musculoskeletal pain was considered the primary outcome and was evaluated using the Numeric Pain Rating Scale (NPRS) to measure pain intensity and the Nordic Musculoskeletal Questionnaire (NMQ) to assess musculoskeletal symptoms in different body regions. The secondary outcomes included burnout, perceived stress, and sleep quality. Burnout was assessed using Maslach Burnout Inventory (MBI), while perceived stress was measured using the Perceived Stress Scale (PSS-10) and sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI). All outcome measures were administered to both the intervention and control groups at baseline before the intervention and after completion of the 8-week intervention. The study then compared changes within each group and differences in changes between the two groups to determine the effectiveness of the intervention.

Data Analysis

The collected data were analyzed using appropriate statistical methods. Descriptive statistics were used to summarize participant characteristics and outcome measurements. Within-group comparisons were performed to determine changes from pre- to post-intervention, while between-group comparisons were conducted to determine differences in outcomes between the intervention and control groups. The level of statistical significance was set at $p < 0.05$.

Ethical Considerations

Ethical approval was obtained from the relevant institutional authority before commencement of the study. All participants were informed about the purpose and procedures of the study, and written informed consent was obtained. Participants' information was kept confidential, and participation was voluntary. Participants were informed that they could withdraw from the study at any time without affecting their professional or clinical care.

RESULTS

Table 1. Demographic and Professional Characteristics of Participants

Variable	Intervention Group (n=20)	Control Group (n=20)
Age (years), Mean ± SD	38.6 ± 6.2	36.1 ± 5.8
Gender, n (%)		
Male	14 (70%)	13 (65%)
Female	6 (30%)	7 (35%)
Professional experience	10.1 ± 4.7	8.4 ± 4.5

Within-Group Analysis

Table 3. Paired-samples t-test Within-Group Comparison of NPRS Scores

Group	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Difference	95% CI	p-value
Intervention (n=20)	7.20 ± 1.10	3.80 ± 1.20	−2.40	−2.91 to −1.89	<0.001
Control (n=20)	6.00 ± 1.20	4.60 ± 1.30	−0.40	−0.73 to −0.07	0.120

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Table 4. Paired-samples t-test Within-Group Comparison of NMQ Scores

Group	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Difference	95% CI	p-value
Intervention (n=20)	5.40 ± 1.30	3.10 ± 1.20	−2.30	−2.80 to −1.80	<0.001
Control (n=20)	5.20 ± 1.40	4.90 ± 1.30	−0.30	−0.62 to 0.02	0.210

Table 5. Paired sample T test Within-Group Comparison of Maslach Burnout Inventory (MBI)

Group	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Difference	95% CI	p-value
Intervention (n=20)	52.40 ± 8.60	30.10 ± 7.90	−8.30	−15.20 to −9.40	<0.001
Control (n=20)	51.80 ± 8.30	35.70 ± 8.50	−2.10	−5.15 to 0.95	0.180

Table 6. Paired-samples t-test Within-Group Comparison of PSS-10 Scores

Group	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Difference	95% CI	p-value
Intervention (n=20)	23.10 ± 4.20	16.50 ± 3.80	−6.60	−8.01 to −5.19	<0.001
Control (n=20)	22.70 ± 4.50	21.80 ± 4.30	−0.90	−2.32 to 0.52	0.240

Table 7 Paired-samples t-test Within-Group Comparison of PSQI

Group	Pre-intervention Mean ± SD	Post-intervention Mean ± SD	Mean Difference	95% CI	p-value
Intervention (n=20)	10.20 ± 2.40	6.70 ± 2.00	−3.50	−4.28 to −2.72	<0.001
Control (n=20)	9.90 ± 2.30	7.40 ± 2.40	−0.50	−1.29 to 0.29	0.190

Between-Group Analysis

Table 9. Independent-Samples t-Test Comparing groups at pre interventions

Outcome Variable	Intervention Group (n=20) Mean ± SD	Control Group (n=20) Mean ± SD	Mean Difference	p-value
NPRS	7.20 ± 1.10	6.00 ± 1.20	0.20	0.586
NMQ	5.40 ± 1.30	5.20 ± 1.40	0.20	0.640
Burnout	52.40 ± 8.60	51.80 ± 8.30	0.60	0.827
PSS-10	23.10 ± 4.20	22.70 ± 4.50	0.40	0.772
PSQI	10.20 ± 2.40	9.90 ± 2.30	0.30	0.692

The baseline comparison showed no statistically significant differences between the intervention and control groups for NPRS, NMQ, burnout, PSS-10, or PSQI scores ($p > 0.05$), indicating that the groups were comparable before the intervention.

Table 10. Independent-Samples t-Test Comparing Intervention and Control Groups at Post-Intervention

Outcome Variable	Intervention Group (n=20) Mean ± SD	Control Group (n=20) Mean ± SD	Mean Difference	p-value
NPRS	3.80 ± 1.20	4.60 ± 1.30	−1.80	<0.001
NMQ	3.10 ± 1.20	4.90 ± 1.30	−1.80	<0.001
Burnout	30.10 ± 7.90	35.70 ± 8.50	−9.60	0.001
PSS-10	16.50 ± 3.80	21.80 ± 4.30	−5.30	<0.001
PSQI	6.70 ± 2.00	7.40 ± 2.40	−2.70	<0.001

DISCUSSION

The present randomized controlled trial evaluated the effectiveness of an integrated ergonomic and mindfulness-based intervention for improving musculoskeletal pain, musculoskeletal symptoms, burnout, perceived stress, and sleep quality among surgeons. The principal finding was a consistent improvement across all five outcomes in the intervention group following the 8-week program, whereas no statistically significant within-group changes were observed in the control group. At baseline, the two groups were comparable across all outcome measures ($p > 0.05$), supporting the interpretation that the subsequent differences were observed after implementation of the intervention. The findings are particularly relevant because the intervention addressed both physical and psychological dimensions of surgeons' occupational health, rather than targeting musculoskeletal symptoms or psychological well-being independently.

The significant reduction in musculoskeletal pain in the intervention group ($p < 0.001$), compared with the non-significant change in the control

group ($p = 0.120$), is consistent with the recognized ergonomic demands of surgical practice. Surgeons commonly maintain prolonged static postures, perform repetitive fine motor movements, and work with restricted opportunities to change position during procedures. These exposures can place sustained mechanical demands on the neck, shoulders, back, and upper extremities. Previous research has identified prolonged operative positioning and biomechanical exposure as important contributors to work-related musculoskeletal disorders among surgeons (Maxner et al., 2021). Similarly, Gorce and Jacquier-Bret (2024) highlighted ergonomics and operating-room conditions as important areas in the literature on surgeons' musculoskeletal health, while Stewart et al. (2026) identified prolonged postures and repetitive movements among the principal occupational risk factors. The present findings extend this evidence by demonstrating that an intervention incorporating ergonomic education, postural correction, stretching, and exercises may be accompanied by meaningful improvement in pain-related outcomes (Gorce & Jacquier-Bret, 2024).

The significant improvement in musculoskeletal symptoms measured by the NMQ ($p < 0.001$) compared with the non-significant change in the control group ($p = 0.210$) further strengthens this interpretation. Importantly, the intervention was not limited to providing ergonomic information. Participants received practical instruction in surgical posture, operating-table and monitor positioning, neck and shoulder exercises, upper-back mobility, lower-back exercises, and postural stabilization, with continued application during surgical work. This combination may have facilitated the translation of ergonomic knowledge into daily practice. Adebiyi et al. (2026) emphasized the importance of considering the interaction between individual ergonomic behavior and workplace design, while Wright et al. (2026) highlighted neutral positioning, equipment adjustability, and optimization of the surgeon-equipment interface as important elements of safer surgical practice. Thus, the current findings are consistent with the broader shift from passive ergonomic education toward interventions that incorporate behavioral and practical components(Wright et al., 2026).

The psychological outcomes demonstrated a similar pattern. Burnout improved significantly in the intervention group ($p < 0.001$), whereas the change in the control group was not statistically significant ($p = 0.180$). This finding is relevant given the complex occupational environment in which surgeons work. High workload, emergency responsibilities, time pressure, challenging patient outcomes, and limited recovery opportunities may collectively contribute to psychological exhaustion. Dholakia et al. (2025) identified work-related factors as important contributors to burnout among surgical specialists and registrars, while Grumbach and Willard-Grace (2025) emphasized that healthcare-worker burnout is influenced by both individual and organizational conditions. The improvement observed in the present study may therefore reflect the potential contribution of mindfulness, breathing, relaxation, and stress-management strategies to individual coping and recovery. However, the findings should not be interpreted as indicating that individual-level interventions alone can address surgeon burnout, because important organizational determinants were outside the scope of the intervention (Dholakia et al., 2025).

Perceived stress showed a comparable between-group pattern, with a statistically significant improvement in the intervention group ($p < 0.001$) and no statistically significant change in the control group ($p = 0.240$). This finding is

consistent with the psychological components of the intervention, particularly mindfulness, diaphragmatic breathing, relaxation, and stress-management training. Mindfulness-based approaches may provide individuals with structured strategies for recognizing physical and psychological responses to stress and regulating their response to occupational demands. Meneses Damasceno and Weyll Pimentel (2026), in their review of non-pharmacological interventions for stress reduction among healthcare workers, identified mindfulness-based approaches as an important area of investigation. Wakins et al. (2025) similarly discussed mindfulness as a potential strategy for supporting surgeon well-being. The current findings are therefore consistent with the emerging literature suggesting that psychological self-regulation strategies may have a role in managing occupational stress among surgical professionals (Wakins et al., 2025).

The improvement in sleep quality provides an additional dimension to the findings. The intervention group demonstrated a statistically significant improvement in PSQI scores ($p < 0.001$), whereas the control group did not show a statistically significant change ($p = 0.190$). Sleep disturbance is particularly relevant to surgeons because working schedules may include prolonged procedures, night calls, early operating lists, and emergency duties. Morel et al. (2026) identified sleep deprivation, workload, and surgical training culture as important components of surgeon well-being, while Shahmiri et al. (2026) reported sleep-related factors in relation to burnout and resilience among metabolic and bariatric surgeons. In the present study, sleep-hygiene education was combined with mindfulness, relaxation, and stress-management strategies. The improvement in sleep quality may therefore reflect the combined influence of direct sleep-hygiene recommendations and improvements in psychological recovery. Because the intervention included multiple components, however, the present design cannot determine whether the change in sleep quality was attributable to sleep-hygiene education alone or to the broader intervention (Morel et al., 2026).

Taken together, the findings suggest that physical and psychological occupational health among surgeons may benefit from being addressed simultaneously. The intervention group demonstrated statistically significant improvements in pain, musculoskeletal symptoms, burnout, perceived stress, and sleep quality, whereas the control group did not demonstrate statistically significant changes in any of these outcomes. This pattern is important because these domains are potentially interrelated. Physical discomfort may interfere with sleep and contribute to psychological distress, while occupational stress and inadequate recovery may influence the perception and management of musculoskeletal symptoms. Chrouser et al. (2018) emphasized the relationship between stress responses and surgical performance, supporting the broader concept that physical and psychological factors should not necessarily be considered in isolation. The multidimensional nature of the present intervention is therefore consistent with contemporary approaches to surgeon well-being that recognize the interaction between physical, psychological, and occupational factors (Chrouser et al., 2018).

The findings also have implications for surgical education and occupational health practice. Ergonomic training could potentially be incorporated into surgical education alongside practical exercises and strategies for stress regulation and recovery. Rather than treating musculoskeletal symptoms only after they develop, ergonomic principles could be incorporated into routine surgical practice, including positioning of

the surgeon, operating table, monitor, instruments, and other equipment. At the same time, mindfulness and stress-management strategies may provide complementary tools for managing psychological demands. However, these individual-level approaches should be considered alongside organizational interventions. Recent literature increasingly recognizes that workload, staffing, working hours, recovery time, and workplace culture can substantially influence surgeon well-being (Dholakia et al., 2025; Grumbach & Willard-Grace, 2025). Therefore, the findings should be interpreted as supporting an integrated approach rather than suggesting that individual behavioral interventions are sufficient on their own (Grumbach & Willard-Grace, 2025).

CONCLUSION

The study concluded that an 8-week ergonomic and mindfulness-based intervention was associated with significant improvements in musculoskeletal pain, musculoskeletal symptoms, burnout, perceived stress, and sleep quality among surgeons. The intervention group demonstrated statistically significant improvements across all measured outcomes, whereas the control group did not show statistically significant within-group changes. These findings suggest that integrating ergonomic education, therapeutic stretching and postural exercises, mindfulness and breathing techniques, stress-management strategies, and sleep-hygiene education may provide a comprehensive approach to improving the physical and psychological well-being of surgeons. The findings also highlight the importance of addressing both ergonomic and psychological aspects of surgical practice rather than considering them as isolated occupational health problems. Further studies with larger samples, longer follow-up periods, and more rigorous evaluation of individual intervention components are needed to establish the long-term effectiveness and generalizability of this integrated approach.

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