Research Article

Chirurgia (Bucur). 2026 May, Online Ahead of Print

http://dx.doi.org/10.21614/chirurgia.3302

Laparoscopic Surgery: Patient Benefits and Surgeon Challenges. A Systematic Literature Review and Narrative Synthesis

Aaliyah Abimbola[1]*, Gabriella Quiney[2], Nachiket Joshi[2], Gianluca Colucci[1,2]

[1]Brighton and Sussex Medical School, 94 N- S Rd, Falmer, Brighton BN1 9PX, East Sussex, United Kingdom
[2]Worthing Hospital, University Hospitals Sussex NHS Trust, Lyndhurst Rd, Worthing BN11 2DH, West Sussex, United Kingdom

***Corresponding author:**
Aaliyah Abimbola BMBS
Brighton and Sussex Medical School
94 N- S Rd, Falmer, Brighton BN1 9PX, East Sussex, United Kingdom
E-mail: aaliyah.abimbola@nhs.net
ORCID: 0009-0001-0933-5814

Rezumat

Chirurgie laparoscopică: beneficii pentru pacient și provocări pentru chirurg. O analiză sistematică a literaturii și o sinteză narativă

Context: Încă din anii 1990, chirurgia laparoscopică a revoluționat practica chirurgicală, permițând incizii mai mici, recuperare mai rapidă şi reducerea complicațiilor postoperatorii. Cu toate acestea, leziunile musculo-scheletice (MSK) în rândul chirurgilor - în modalități deschise, laparoscopice şi robotice - rămân un risc ocupațional subrecunoscut. Această analiză examinează cauzele, prevalența şi strategiile de prevenire a leziunilor MSK la chirurgii laparoscopici.
Metode: O analiză sistematică a literaturii şi o sinteză narativă a fost efectuată în conformitate cu ghidurile PRISMA. Căutările au fost efectuate în MEDLINE, Embase şi PubMed între august 2022 şi martie 2023, utilizând termeni derivați din PICO. Criteriile de includere au cuprins studii în limba engleză publicate în ultimul deceniu, axate pe leziunile MSK la chirurgii care efectuează intervenții chirurgicale minim invazive (MIS).
Rezultate: Din 321 de publicații analizate, 43 de studii au îndeplinit criteriile de includere. Gâtul, spatele şi umerii au fost regiunile cel mai frecvent afectate. Factorii care au contribuit au inclus posturile susținute non-neutre, echipamentul chirurgical nereglabil sau prost conceput şi lipsa instruirii ergonomice. Leziunile musculo-scheletice au dus la scăderea productivității, epuizare profesională şi, în unele cazuri, absenteism chirurgical.
Concluzie: Strategiile preventive - cum ar fi educația ergonomică, reproiectarea echipamentelor, micropauzele şi antrenamentul de forță - pot reduce semnificativ riscul de leziuni musculo-scheletice în rândul chirurgilor laparoscopici. Integrarea ergonomiei în programa chirurgicală şi în designul locului de muncă este crucială pentru a proteja bunăstarea chirurgilor, a asigura o practică sustenabilă şi a menține o îngrijire de înaltă calitate a pacienților.

Cuvinte cheie: chirurg, musculo-scheletic, durere musculo-scheletică, MSK, proceduri chirurgicale minim invazive, laparoscopie şi robotică

Received: 15.03.2026
Accepted: 20.04.2026

Abstract

Background: Since the 1990s, laparoscopic surgery has revolutionised surgical practice by enabling smaller incisions, faster recovery, and reduced postoperative complications. However, musculo-skeletal (MSK) injuries among surgeons - across open, laparoscopic, and robotic modalities - remain an under recognised occupational hazard. This review examines the causes, prevalence, and prevention strategies for MSK injuries in laparoscopic surgeons.

Methods: A systematic literature review and narrative synthesis was conducted in accordance with PRISMA guidelines. Searches were performed in MEDLINE, Embase, and PubMed between August 2022 and March 2023 using PICO-derived terms. Inclusion criteria encompassed English-language studies published within the last decade focusing on MSK injuries in surgeons performing minimally invasive surgery (MIS).

Results: From 321 screened publications, 43 studies met inclusion criteria. The neck, back, and shoulders were the most frequently affected regions. Contributing factors included sustained non-neutral postures, non-adjustable or poorly designed surgical equipment, and lack of ergonomic training. MSK injuries led to decreased productivity, burnout, and in some cases, surgical absenteeism.

Conclusion: Preventive strategies- such as ergonomic education, equipment redesign, microbreaks, and strength training - can significantly reduce MSK injury risk among laparoscopic surgeons. Integration of ergonomics into surgical curricular and workplace design is crucial to protect surgeon wellbeing, ensure sustainable practice, and maintain high-quality patient care.

Keywords: surgeon, musculoskeletal, musculoskeletal pain, MSK, minimally invasive surgical procedures, laparoscopy, and robotics

Introduction

Laparoscopic surgery has fundamentally transformed modern surgical practice since its introduction in the 1980s. By minimising incision size, reducing postoperative pain, shortening recovery periods, and decreasing hospital stays, laparoscopic techniques have yielded substantial benefits for patients, surgeons, and healthcare systems alike (1). Despite these advantages, the physical demands placed on surgeons during laparoscopic procedures present a major occupational health concern.

Laparoscopic surgery requires surgeons to maintain static, non-neutral postures for extended periods while manipulating rigid instruments through fixed trocars, often without the benefit of adjustable or ergonomically designed equipment. These working conditions significantly increase the risk of developing musculoskeletal (MSK) injuries compared with other surgical modalities such as open or robotic surgery (2). The cumulative effect of repetitive strain and sustained awkward positions can lead to chronic pain, reduced surgical efficiency, and long-term occupational disability (2).

MSK injuries not only affect individual surgeons but also contribute to burnout, decreased career longevity, and potentially compromised patient outcomes (3). Given the growing prevalence of minimally invasive surgical techniques across multiple specialties, it is increasingly important to understand and address the ergonomic risks faced by laparoscopic surgeons.

This review systematically examines the prevalence, causes, and consequences of MSK injuries in laparoscopic surgery, as well as evidence-based prevention and mitigation strategies. By synthesising the current literature, the study aims to highlight key ergonomic challenges and propose recommendations for protecting surgeon health while sustaining high-quality surgical performance.

Methods

Study Design

A systematic literature review and narrative synthesis was conducted to evaluate the causes, prevalence, and prevention strategies of musculoskeletal (MSK) injuries among laparoscopic surgeons. The review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure methodo-logical transparency and reproducibility.

Search Strategy

A comprehensive literature search was performed across MEDLINE, Embase, and PubMed data-bases between August 2022 and March 2023. Only articles published in English within the preceding ten years were included. The search combined both controlled vocabulary and natural language terms to capture the full range of relevant studies.

Search terms were developed using the PICO frame-

Table 1. PICO table illustrating how keywords and the search strategy was formulated

PICO Element	Definition	Examples
Population	Surgeons performing minimally invasive surgery	Laparoscopic surgeons
Intervention	Prevention and management of musculoskeletal injuries Ergonomic training, equipment adaptation	
Comparison	Other surgical modalities	Robotic or open surgery
Outcomes	Reduced prevalence of MSK disorders and improved ergonomic safety	Reduced pain, fatigue, and absenteeism

work (Population, Intervention, Comparison, Outcomes), as shown in *Table 1.* Boolean operators ("AND", "OR") were used to combine search terms.

Key terms included: surgeon, musculoskeletal, musculoskeletal pain, MSK, minimally invasive surgical procedures, laparoscopy, and robotics.

Research Question: "Protect the surgeon's joints: How can musculoskeletal problems be prevented and managed in surgeons performing minimally invasive surgery?"

Study Selection Process

The initial search identified 321 records: Embase (n = 271), MEDLINE (n = 39), and PubMed (n = 11). Fourteen additional records were identified through citation searching. After removing 23 duplicates, 298 titles and abstracts were screened. Following this phase, 45 full-text articles were reviewed for eligibility.

Of these, 43 studies met inclusion criteria. Reasons for exclusion included:

1. Studies unrelated to surgeon injuries (n = 5);
2. Studies unrelated to minimally invasive surgery (n = 2);
3. Duplicates (n = 2).

The study selection process is summarised in the PRISMA flow diagram (*Fig. 1*).

Study Characteristics

The final dataset comprised 43 studies, including systematic reviews, meta-analyses, randomized controlled trials (RCTs), cross-sectional studies, and observational studies. Authors represented multiple countries (e.g., China, Japan, Germany, UK, USA), and surgical specialties such as general surgery, urology, and gynaecology were widely represented.

Table 2. Search strategy applied across MEDLINE, Embase, and PubMed databases

Search Terms	Combined Using
Surgeon*	AND
(Minimally invasive surgical procedures OR Laparoscopy)	AND
(Musculoskeletal OR Musculoskeletal pain OR MSK)	OR
Robotics	-

All studies were published in English. The diversity of study types and international representation allowed for a broad understanding of the ergonomic challenges in laparoscopic surgery.

Results

Epidemiology of Musculoskeletal Injuries

Across the studies reviewed, the neck, back, and shoulders were consistently reported as the most commonly affected regions of musculoskeletal (MSK) injury among laparoscopic surgeons (1-4). Gender differences were noted: female surgeons more frequently reported neck and shoulder discomfort, whereas male surgeons more often experienced lower back pain. Overall, women were found to have a higher prevalence of MSK injuries than men (5).

Although surgical experience sometimes correlated inversely with injury prevalence, the cumulative

Table 3. Inclusion and exclusion criteria used during screening

Inclusion Criteria	Exclusion Criteria
Studies published within the last 10 years	Studies not written in English
Studies focusing on MSK injuries among surgeons	Studies focusing on patient injuries
Studies related to minimally invasive or laparoscopic surgery	Studies reporting only on open surgery
Studies including surgeons from all specialties	Non-MSK-related occupational injuries
Research addressing prevention or ergonomic interventions	Injuries sustained outside the operating theatre

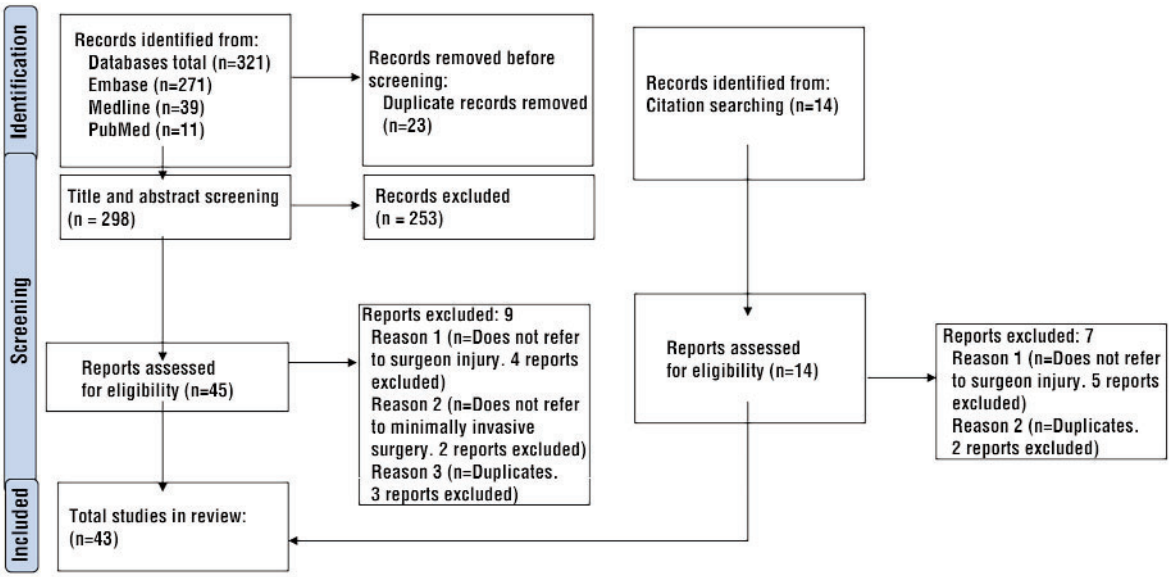

Figure 1. PRISMA flowchart

nature of strain suggested that MSK injuries accrue over time regardless of seniority (2-4).

Impact of Injuries

MSK injuries had significant professional and personal consequences. Many surgeons required medical intervention, including physiotherapy, analgesia, or even surgery. Wu et al. reported that 30% of 789 surveyed surgeons experienced MSK symptoms requiring treatment (4). Voss et al. found that 65.7% of affected surgeons underwent treatment, with 56.5% receiving physiotherapy or occupational therapy and 17.4% undergoing surgical procedures (5).

Work disruption was also common. One study found that 19% of surgeons missed work because of injury-related symptoms (3). Among those, 15% were absent for one week, 6% for two to four weeks, and 1% for more than four weeks.

MSK injuries were linked to burnout and reduced job satisfaction. Almost half of surveyed surgeons (49%) believed their injury could limit future surgical performance (3). Participants also described sleep disruption, irritability, and emotional fatigue, all of which contributed to decreased work quality (6-8).

Shugaba et al. found that musculoskeletal and cognitive fatigue are strongly correlated (9). Surgeons experiencing physical discomfort demonstrated slower reaction times, reduced attention, and impaired information processing - factors that can directly compromise intraoperative performance (9).

Aetiology of Injuries

Prolonged static postures

Sustained non-neutral postures were identified as the leading cause of injury, accounting for approximately 67% of cases. During lengthy procedures, surgeons often maintain static or awkward positions that increase strain on the neck, shoulders, and lower back (8,9).

Wells et al. reported that 20% of surgeons experienced discomfort after one hour of operating, 39% after two hours, 66% after four hours, and 85% after six hours (3).

Inadequate equipment adaptability

Non-adjustable or poorly designed laparoscopic instruments and monitors were a major source of ergonomic stress. Improper monitor positioning caused neck flexion and visual strain, while inappropriate operating table height led to lumbar arching and back pain (10,11).

Rigid laparoscopic instruments lacking size or angle adjustability forced surgeons into unnatural postures, further increasing fatigue and risk of injury (12).

Lack of ergonomic awareness and training

Limited ergonomic knowledge among surgeons was a key contributor to MSK injuries. In a survey of 61 laparoscopic surgeons, those with poor ergonomic awareness had significantly higher rates of injury (13). Across several studies, a lack of formal ergonomic

training during both residency and consultant years was highlighted as a major gap (2-4, 13-15).

Underreporting of injuries

Several studies demonstrated that MSK injuries among surgeons are underreported. Approximately 30% of surgeons were unaware of institutional injury-reporting systems (13). Moreover, over 80% continued to operate despite pain (4,5,13,16,17).

Only 14–66% of injured surgeons formally reported injuries or sought institutional support. Cultural expectations and stigma surrounding self-care in surgery were cited as barriers to seeking help (13). Consequently, the true incidence of MSK injury is likely underestimated.

Assessment Methods

Various tools were used across studies to evaluate ergonomic strain and injury risk:

- Electromyography (EMG): measured muscle activation and fatigue levels;
- Rapid Upper Limb Assessment (RULA): assessed arm and neck posture;
- Rapid Entire Body Assessment (REBA): evaluated full-body posture;
- Self-report surveys: captured subjective pain, fatigue, and working conditions.

These methods quantified biomechanical stress while survey data helped identify demographic risk factors, including gender, age, and experience level (3).

Findings from ergonomic assessments

Across EMG, RULA, and REBA analyses, neck strain, shoulder discomfort, and lower back stiffness were the most common findings (2). EMG data indicated elevated activity in the trapezius, latissimus dorsi, and cervical muscles, confirming high workload in these regions (2,18).

Surveys supported these objective findings: 66.9% of surgeons reported back pain and 65.4% reported neck or shoulder pain (5). RULA and REBA assessments demonstrated that neck flexion, spinal twisting, and lateral bending were key risk factors for MSK injury during laparoscopic procedures (22-26).

Discussion

This systematic review highlights that musculoskeletal (MSK) injuries are a significant occupational hazard for laparoscopic surgeons. Although minimally invasive surgery offers clear benefits to patients, it poses sustained physical demands on surgeons, leading to pain, fatigue, and long-term disability. The findings show that static posture, poorly adjustable equipment, and a lack of ergonomic awareness are major contributors to these injuries. Despite widespread prevalence, reporting remains inconsistent, suggesting the problem is underestimated within the surgical community.

The Burden of Musculoskeletal Injury

MSK injuries among surgeons are not new; however, the shift towards laparoscopic and robotic modalities has introduced new ergonomic challenges. The neck, back, and shoulders are consistently reported as the most affected areas (1-4). Chronic strain in these regions can lead to reduced dexterity, prolonged recovery, and potentially shortened careers. Although laparoscopic surgery minimises trauma for patients, the occupational cost to surgeons is substantial (4).

Gender-Specific Considerations

This review identified gender differences in both the prevalence and perception of MSK injuries. Female surgeons reported higher rates of discomfort, particularly in the neck and shoulders (27,28). This may partly be due to the non-ergonomic design of theatre equipment, which historically catered to male body dimensions. A "one-size-fits-all" design is increasingly unsuitable for today's diverse surgical workforce.

Furthermore, studies suggest that men may underreport injuries due to cultural or social factors (29,30). Traditional gender norms and professional expectations in surgery can discourage help-seeking behaviour, contributing to underestimation of the problem. Future ergonomic designs should consider gender-inclusive dimensions and equipment adjustability to support all surgeons equally.

The Consequences of MSK Injury

Financial and institutional costs

The cost of ergonomic neglect extends beyond the individual surgeon. Work absence, medical expenses, and premature retirement have significant financial implications for hospitals and health systems (3,13). Davis et al. demonstrated that integrating ergonomic training during residency is cost-effective, preventing long-term injury while reducing institutional costs (13).

In the United States, a 2010 survey of hospital chief financial officers reported that an average general surgeon generates over $2.1 million in annual net revenue. Thus, a two-week absence could cost more than $80,000 in lost revenue (13). These

figures underline that protecting surgeon health is also an economic imperative.

Impact on patient care

MSK injuries indirectly affect patient outcomes through staff shortages, surgical delays, and decreased concentration. Wells et al. found that approximately 19% of surgeons missed work due to injury (3), resulting in postponed operations and extended waiting lists. Prolonged waiting times can heighten both psychological and financial stress for patients (5).

Although direct causation between surgeon injury and poorer patient outcomes is difficult to prove, evidence suggests that fatigue and pain impair surgical performance (31). Given that up to 87% of surgeons experience discomfort while operating (31), the broader implications for patient safety warrant serious consideration.

Preventive and Mitigating Strategies

Ergonomic training

The literature consistently supports formal ergonomic education as a cornerstone of injury prevention (28, 32-34). Ergonomic awareness enables surgeons to identify high-risk postures and adapt intraoperative positioning accordingly. Training can also target specific modifiable risk factors, such as neck flexion and shoulder elevation, which are the leading causes of discomfort (6,7,35).

Surgeons who have undergone ergonomic training report tangible benefits, with 88% stating it prompted positive behavioural changes in their practice (36). Programmes that include biomechanical feedback, simulation-based posture analysis, and collaboration with physiotherapists or ergonomists are particularly effective. A multidisciplinary approach is essential to promote long-term musculoskeletal health and prevent occupational burnout.

Microbreaks and strength training

Evidence indicates that prolonged static positioning during surgery is a major risk factor for injury (3). Incorporating microbreaks - brief, structured rest periods can alleviate muscle tension and delay fatigue (5,37,38). The benefits of short breaks increase significantly for operations lasting over three hours.

In addition, strength and conditioning programmes are protective against MSK injury. Maintaining general muscle fitness supports posture endurance and reduces strain (38-43). Simple stretching for five minutes every two hours can also reduce fatigue and improve focus (5).

Equipment adaptation and ergonomic design

The adaptability of surgical equipment plays a decisive role in surgeon wellbeing. Adjustable operating tables, monitors, and arm supports can greatly reduce strain. Ramakrishnan et al. recommend that table height should be approximately 5-10 cm below elbow level to optimise posture (10). Ergonomic floor mats and arm rests have also been shown to reduce back and shoulder discomfort (38-43).

Monitor height should correspond to each surgeon's eye level to minimise neck flexion, and seated procedures should include adjustable chairs with lumbar support (38-43). Improving the variability and adjustability of instruments - combined with ergonomic training, offers the best protection against long-term injury.

Technological Innovation: The Role of Robotic Surgery

Robotic-assisted surgery offers distinct ergonomic advantages over conventional laparoscopy, including improved seating, reduced arm elevation, and enhanced instrument precision. However, it is not entirely injury-free; issues such as prolonged wrist flexion and visual strain remain. Continued research into robotic ergonomics and user-adjustable systems is needed to optimise surgeon safety and performance.

Limitations of the Evidence Base

The included studies varied widely in methodology, sample size, and surgical speciality. This heterogeneity limited the ability to perform direct comparisons or meta-analysis. The Scale for the Assessment of Narrative Review Articles (SANRA) was used to evaluate study quality (*Table 4*) (38).

Potential biases included selection, performance, attrition, and publication bias, along with confounding factors such as surgeon fitness level, patient characteristics, and case complexity. Few studies investigated the impact of surgeon MSK injuries on patient outcomes, highlighting an important gap in the literature.

Further research is needed to develop standardised ergonomic assessment methods and evidence-based interventions applicable across surgical disciplines.

Table 4. Summary table of included articles

Title	Population	Study description and measures	Laparoscopic/ robotic/open	Injuries/ Strain identified	Causes of MSK injuries explored	Protective and preventative measures identified	Consequences of injuries identified
1.	Review of 298 studies	Systematic review EMG Survey to measure cognitive fatigue	Laparoscopic vs robotic	Degenerative spinal disease, rotator cuff pathology and degenerative lumbar spine disease.			
2.	290 surgeons Mean age 46.2 years and mean BMI 25.6 kg/m^2	Cross-sectional Online survey - 52 questions (individual and work place factors)	Laparoscopic and robotic	Neck/shoulder		X	X
3.	13 French cancer centres. 369 patients were recruited (176 robotic procedures and 193 laparoscopic)	Randomised trial MSK strains (Borg scale) and perceived workload (NASA-TLX scoring)	Laparoscopic vs robotic	Hands and arms, neck and legs			
4.	31 surgeons	Meta-analysis EMG	Laparoscopic vs robotic	Deltoids, trapezii, biceps	X		X
5.	3 consultant general surgeons	Observational Ambulatory strain gauge to measure cervical mobility	Laparoscopic vs open	Back, shoulders, neck			X
6.	1 surgeon (male)	Observational Inertial measurement units o measure angles of tspine and neck. RULA scoring system	Laparoscopic	Spine and neck			
7.	5152 surveyed surgeons	Systematic review and meta-analysis	Laparoscopic	Cervical spinal stenosis, lumbar disc herniation, carpal tunnel syndrome. Eye strain.	X		
8.	24 surgeons (13 male and 11 female)	Observational IMUs assess postures Pre-/post-surgical questionnaires to assess intraoperative workload and to identify risk factors	Laparoscopic vs open	Neck, upper back and lower back pain			
9.	462 surgeons across Germany, UK and USA	Observational Online survey - 17 questions across four categories: demographics, intra operative discomfort, effects on performance and anticipated consequences	Laparoscopic	Back, neck and shoulders			
10.	1 surgeon, 18 operative procedures	Observational EMG	Laparoscopic vs robotic	Neck, back and shoulder			
11.	436 surgeons (71% male)	Observational 20 questions in 4 categories: demographics, systems, ergonomics and physical symptoms.	Robotic	Neck stiffness, finger and eye fatigue	X		
12.	20 surgeons	RCT 3 phases of testing whilst wearing exosuit 1st: tests of manual dexterity 2nd: effect on shoulder pain and fatigue 3rd: surgeon experience	Robotic	Shoulder, back and neck pain			
13.	24 surgeons	Observational Physical discomfort was evaluated using Brog scale	Laparoscopic vs robotic	Shoulder, back and neck pain	X		
14.	113 bariatric surgeons	Observational Online, web-based survey which included demographics, physician visits, discomfort and procedure duration.	Laparoscopic, open and robotic	Shoulder, back and neck pain		X	
15.	5 surgeons (3 females, 2 male)	Observational EMG	Laparoscopic and robotic	Degenerative lumbar spine disease, rotator cuff pathology, degenerative cervical spine disease and carpal tunnel	X		X
16.	4 surgeons	Observational REBA and RULA	Robotic surgery	Shoulder, back and neck pain	X	X	X
17.	569 surgeons	Observational survey	Laparoscopic	Neck, shoulder, upper back, lower back,			
18.	174 surgeons	Cross-sectional survey	Laparoscopic, open and robotic	Neck, back and shoulder			
19.	7 surgeons	Observational survey	Robotic surgery	Neck, back and shoulder		X	
20.	129 surgeons	Observational survey Interviews and standardised Nordic questionnaire (SNQ)	Laparoscopic	Lower back, neck, upper back, shoulder and hand			

Table 4. Cont'd

Title	Population	Study description and measures	Laparoscopic/ robotic/open	Injuries/ Strain identified	Causes of MSK injuries explored	Protective and preventative measures identified	Consequences of injuries identified
21.	1 surgeon	Observational REBA	Laparoscopic and robotic	Neck, back and shoulder			
22.	1619 gynaecological surgeons	Systematic review and meta-analysis	Laparoscopic	Neck, back and shoulder			
23.	18 surgeons	Observational Videos used to analyse ergonomics	Laparoscopic	Neck, shoulders, elbows			X
24.	13 surgeons	Observational EMG	Laparoscopic and robotic				X
25.	241 surgeons	Observational Questionnaire collected demographics, ergonomic issues, MSK symptoms and the awareness of the ergonomic guidelines.	Laparoscopic	Leg, hand, wrist, shoulder, neck and back			
26.	35 articles, including 7112 respondents	Systematic review Predominantly surveys	Laparoscopic	Neck, back and shoulder			
27.	16 surgeons	Observational EMG and self-reported fatigue	Laparoscopic and robotic	Upper body, shoulder and neck			X
28.	12 surgeons (7 women and 5 men)	Observational Survey and EMG	Laparoscopic and robotic	Neck, shoulder, arms, back and legs			X
29.	28 surgeons - varying experience, age, sex, weight, height and hand size. All R handed	Non-randomised, experimental comparative study Comparison of ring vs piston (PH) operated handles completing 3 tasks in a simulated theatre Measurement of EMG activity and task time	Laparoscopic	X	X		
30.	13 experienced (>6yrs) colorectal surgeons (12 male, 1 female), varying age, height, BMI and working hours.	Cross-sectional observational EMG and Postural observations every 10 mins and perceived physical exertion	Laparoscopic vs robotic	Back and neck pain			
31.	N/A	Narrative review Comparing classic laparoscopic technique with less invasive laparoscopic surgery	Laparoscopic	X	X		X
32.	1 experienced general surgeon performing robotic and laparoscopic surgery	Cross sectional comparative study between laparoscopic and robotic surgery Questionnaire based assessment of mood and behaviour, fatigue assessment (piper fatigue scale), EMG, inertia sensor at T7 to measure kinematic variables, single leg balance test (pre/post-surgery) and handgrip test pre/post op	Laparoscopic vs robotic	Focus on fatigue at point of surgery, however fatigue linked to pain/MSK problems using references			
33.	Surgeons who are members of ACS (Tennessee)	Survey retrospective / cross-section 25 item study: covering injury rate, impact and reporting rate	Not grouped according to technique (all included)	Back, neck and hand Injury rate 40%	X		
34.	53 surgeons (19 women), in 12 specialties in 115 cases	Cross-sectional observational IMU to assess body position Also recorded reported pain	Laparoscopic and open	Neck		X	
35.	42 surgeons Variety of specialties and experience levels	Interventional non-randomised and retrospective study Survey on demographics and self-reported strain over 12 months and impact of strain.	Robotic	Neck and shoulders			
36.	Studies regarding ergonomics of laparoscopic ENT surgery	Literature reviewed with studies including a variety of data collection techniques (surveys, body posture degree measure)	Laparoscopic	Neck and eye strain Hands and forearm stress			X
37.	5 surgeons Mean height 172.7 cm, mean weight 75.7 kg, mean glove size 7.	Observational 17 hours of video footage of 14 robotic surgical procedures was collected. RULA and Strain Index (SI) calculated	Robotic	X			X

Table 4. Cont'd

Title	Population	Study description and measures	Laparoscopic/ robotic/open	Injuries/ Strain identified	Causes of MSK injuries explored	Protective and preventative measures identified	Consequences of injuries identified
38.	Survey = 127 oncology surgeons at a tertiary centre Mat trial = 20 surgeons of variety specialties tried a gel floor mat vs not using	Cross section/retrospective survey and observational randomised trial Survey = 31 questions of demographics, pain, injury and impact. Foot mat trial = self-reported pain and calf diameter pre/post-op (small subgroup also used compression stockings).	Laparoscopic and open	Cervical spine pain, carpal tunnel, peripheral neuropathy, tendinitis, vertebral disc injuries.			
39.	13 French cancer centres. 369 patients were recruited (176 robotic procedures and 193 laparoscopic)	Randomised trial MSK strains (Borg scale) and perceived workload (NASA-TLX scoring)	Laparoscopic vs robotic	Hands and arms, neck and legs			
40.	436 surgeons (71% male)	Observational 20 questions in 4 categories: demographics, systems, ergonomics and physical symptoms.	Robotic	Neck stiffness, finger and eye fatigue	X		
41.	24 surgeons	Observational Physical discomfort evaluated using Borg scale	Laparoscopic vs robotic	Shoulder, back and neck pain	X		
42.	18 surgeons	Observational Videos used to analyse ergonomics	Laparoscopic	Neck, shoulders, elbows			X
43.	241 surgeons	Observational questionnaire collected demographics, ergonomic issues, MSK symptoms and awareness of ergonomic guidelines.	Laparoscopic	Leg, hand, wrist, shoulder, neck and back			

Table 5. SANRA Quality Evaluation Criteria for Narrative Reviews (Baethge et al., 2019)

Criterion	Description	Assessment in This Review
1. Stated Aims	Clear objectives or questions guiding the review	Defined: prevalence, causes, prevention of MSK injuries
2. Justification of Importance	Relevance to the readership	Addresses an under-recognised occupational health issue
3. Literature Search Description	Transparency and detail of search process	PRISMA and PICO frameworks described
4. Referencing Quality	Use of relevant and current evidence	Comprehensive and up-to-date citations
5. Scientific Reasoning	Logical structure and evidence-based argumentation	Supported by quantitative and qualitative data
6. Data Presentation	Clear and coherent data summarisation	Results presented through tables, discussion, and conclusions

Conclusion

Musculoskeletal (MSK) injuries among laparoscopic surgeons represent a critical yet under-recognised occupational challenge. This review demonstrates that sustained non-neutral posture, inadequate equipment design, and insufficient ergonomic awareness are the primary contributors to surgeon injury. The consequences extend beyond individual wellbeing, influencing institutional productivity, healthcare costs, and potentially patient safety.

Integrating ergonomic training and evidence-based preventive strategies - such as microbreaks, strength conditioning, and equipment optimisation into surgical education and clinical practice is essential. Institutions should prioritise ergonomic standards and foster a culture that supports injury prevention, early reporting, and rehabilitation.

Protecting the physical health of surgeons is fundamental to sustaining a safe and effective surgical workforce. A proactive approach to ergonomics will benefit not only surgeons but also the quality, safety, and continuity of patient care.

Conflicts of Interest

The authors declared no potential conflicts of interest.

Data Availability

The data supporting this review are derived from publicly available studies as cited in the reference list.

References

1. Blencowe NS, Waldon R, Vipond MN. Management of patients after laparoscopic procedures. BMJ. 2018;360:k120. doi:10.1136/bmj.k120
2. Alleblas CCJ, De Man AM, van den Haak L, Vierhout ME, Jansen FW, Nieboer TE. Prevalence of musculoskeletal disorders among surgeons performing minimally invasive surgery. Ann Surg. 2017;266(6):905–912. doi:10.1097/SLA.0000000000002420
3. Wells AC, Kjellman M, Harper SJF, Forsman M, Hallbeck MS. Operating hurts: a study of EAES surgeons. Surg Endosc. 2019;33(3):933–941. doi:10.1007/s00464-018-6574-5
4. Wu L, Liu S, Lommen J, Pudwell J, Pelland L, Bougie O. Prevalence of musculoskeletal pain among gynaecologic surgeons performing laparoscopic procedures: a systematic review and meta-analysis. Int J Gynaecol Obstet. 2023;161(1):151–158. doi:10.1002/ijgo.14775
5. Voss RK, Chiang YJ, Cromwell KD, et al. Do no harm, except to ourselves? A survey of symptoms and injuries in oncologic surgeons and pilot study of an intraoperative ergonomic intervention. J Am Coll Surg. 2017;224(1):16–25. doi:10.1016/j.jamcollsurg.2016.10.031
6. Dalager T, Jensen PT, Eriksen JR, Jakobsen HL, Mogensen O, Søgaard K. Surgeons' posture and muscle strain during laparoscopic and robotic surgery. Br J Surg. 2020;107(6):756–766. doi:10.1002/bjs.11453
7. McCrory B, LaGrange CA, Hallbeck M. Quality and safety of minimally invasive surgery: past, present, and future. Biomed Eng Comput Biol. 2014;6:1–11. doi:10.4137/BECB.S13257
8. Stucky CC, Cromwell KD, Voss RK, et al. Surgeon symptoms, strain, and selections: systematic review and meta-analysis of surgical ergonomics. Ann Med Surg (Lond). 2018;27:1–8. doi:10.1016/j.amsu.2018.01.002
9. Shugaba A, Lambert JE, Bampouras TM, Nuttall HE, Gaffney CJ, Subar DA. Should all minimal access surgery be robot-assisted? A systematic review into the musculoskeletal and cognitive demands of laparoscopic and robot-assisted laparoscopic surgery. J Gastrointest Surg. 2022;26(7):1520–1530. doi:10.1007/s11605-021-05248-1
10. Ramakrishnan VR, Montero PN. Ergonomic considerations in endoscopic sinus surgery: lessons learned from laparoscopic surgeons. Am J Rhinol Allergy. 2013;27(3):245–250. doi:10.2500/ajra.2013.27.3908
11. Gutiérrez-Díez MC, Benito-González MA, Sancibrián R, Gandarillas-González MA, Redondo-Figuero C, Manuel-Palazuelos JC. A study of the prevalence of musculoskeletal disorders in surgeons performing minimally invasive surgery. Int J Occup Saf Ergon. 2018;24(1):111–117. doi:10.1080/10803548.2016.1272628
12. Anand S, Sandlas G, Pednekar A, Jadhav B, Terdal M. A comparative study of the ergonomic risk to the surgeon during vesicoscopic and robotic cross-trigonal ureteric reimplantation. J Laparoendosc Adv Surg Tech A. 2021;31(8):865–872. doi:10.1089/lap.2020.0540
13. Davis WT, Fletcher SA, Guillamondegui OD. Musculoskeletal occupational injury among surgeons: effects for patients, providers, and institutions. J Surg Res. 2014;189(2):207–212. doi:10.1016/j.jss.2014.03.037
14. Hislop J, Tirosh O, McCormick J, Nagarajah R, Hensman C, Isaksson M. Muscle activation during traditional laparoscopic surgery compared with robot-assisted laparoscopic surgery: a meta-analysis. Surg Endosc. 2020;34(1):31–38. doi:10.1007/s00464-019-07196-2
15. AlSabah S, Al Haddad E, Khwaja H. The prevalence of musculoskeletal injuries in bariatric surgeons. Surg Endosc. 2019;33(6):1818–1827. doi:10.1007/s00464-018-6474-8
16. Franasiak J, Craven R, Mosaly P, Gehrig PA. Feasibility and acceptance of a robotic surgery ergonomic training programme. JSLS. 2014;18(4):e2014.00166. doi:10.4293/JSLS.2014.00166
17. Morton J, Stewart GD. The burden of performing minimal access surgery: ergonomics survey results from 462 surgeons across Germany, the UK and the USA. J Robot Surg. 2022;16(6):1347–1354. doi:10.1007/s11701-022-01348-7
18. Yang L, Wang T, Weidner TK, Madura JA, Morrow MM, Hallbeck MS. Intraoperative musculoskeletal discomfort and risk for surgeons during open and laparoscopic surgery. Surg Endosc. 2021;35(11):6335–6343. doi:10.1007/s00464-020-08069-8
19. Thurston T, O'Neill C, Bennett P, et al. Assessment of muscle activity and fatigue during laparoscopic surgery. Surg Endosc. 2022;36(9):6672–6678. doi:10.1007/s00464-021-08915-2
20. Athanasiadis DI, Monfared S, Asadi H, Colgate CL, Yu D, Stefanidis D. An analysis of the ergonomic risk of surgical trainees and experienced surgeons during laparoscopic procedures. Surgery. 2021;169(3):496–501. doi:10.1016/j.surg.2020.07.013
21. Zihni AM, Ohu I, Cavallo JA, Cho S, Awad MM. Ergonomic analysis of robot-assisted and traditional laparoscopic procedures. Surg Endosc. 2014;28(12):3379–3384. doi:10.1007/s00464-014-3614-7
22. Owada Y, Watanabe K, Kondo H, et al. Prevalence of work-related musculoskeletal disorders among general surgeons in Japan. Surg Today. 2022;52(10):1423–1429. doi:10.1007/s00595-022-02449-0
23. Dwyer A, Huckleby J, Kabbani M, et al. Ergonomic assessment of robotic general surgeons: a pilot study. J Robot Surg. 2020;14(3):387–392. doi:10.1007/s11701-019-00991-3
24. Krämer B, Neis F, Reisenauer C, et al. Save our surgeons (SOS): an explorative comparison of muscular and cardiovascular demands, posture, perceived workload and discomfort during robotic vs laparoscopic surgery. Arch Gynecol Obstet. 2023;307(3):849–862. doi:10.1007/s00404-022-06810-1
25. Liu S, Kim H, Yoon J, et al. Solving the surgeon ergonomic crisis with a surgical exosuit. Surg Endosc. 2018;32(1):236–244. doi:10.1007/s00464-017-5665-2
26. Alhusuny A, Cook M, Khalil A, Johnston V. Visual symptoms, neck/shoulder problems and associated factors among surgeons performing minimally invasive surgeries: a comprehensive survey. Int Arch Occup Environ Health. 2021;94(5):959–979. doi:10.1007/s00420-020-01631-0
27. Dalsgaard T, Jensen MD, Hartwell D, Mosgaard BJ, Jørgensen A, Jensen BR. Robotic surgery is less physically demanding than laparoscopic surgery: paired cross-sectional study. Ann Surg. 2020;271(1):106–113. doi:10.1097/SLA.0000000000003433
28. Seidler ZE, Dawes AJ, Rice SM, Oliffe JL, Dhillon HM. The role of masculinity in men's help-seeking for depression: a systematic review. Clin Psychol Rev. 2016;49:106–118. doi:10.1016/j.cpr.2016.09.002
29. Høhn A, Gampe J, Lindahl-Jacobsen R, Christensen K, Oksuzyan A. Do men avoid seeking medical advice? A register-based analysis of gender-specific changes in primary healthcare use after first hospitalisation at ages 60+ in Denmark. J Epidemiol Community Health. 2020;74(7):573–579. doi:10.1136/jech-2019-212827
30. Giberti C, Gallo F, Francini L, Signori A, Testa M. Musculoskeletal disorders among robotic surgeons: a questionnaire analysis. Arch Ital Urol Androl. 2014;86(2):95–98.

doi:10.4081/aiua.2014.2.95
31. González-Sánchez M, González-Poveda I, Mera-Velasco S, Cuesta-Vargas AI. Comparison of fatigue accumulated during and after prolonged robotic and laparoscopic surgical methods: a cross-sectional study. Surg Endosc. 2017;31(3): 1119–1135. doi:10.1007/s00464-016-5080-5
32. Craven R, Franasiak J, Mosaly P, Gehrig PA. Ergonomic deficits in robotic gynaecologic oncology surgery: a need for intervention. J Minim Invasive Gynecol. 2013;20(5):648–655. doi:10.1016/j.jmig.2013.03.014
33. Meltzer AJ, Martin ND, Stone DH, et al. Measuring ergonomic risk in operating surgeons by using wearable technology. JAMA Surg. 2020;155(5):444–446. doi:10.1001/jamasurg.2020.0040
34. Carbonaro N, Tognetti A, Lorussi F, et al. A wearable sensor-based platform for surgeon posture monitoring: a tool to prevent musculoskeletal disorders. Int J Environ Res Public Health. 2021;18(7):3734. doi:10.3390/ijerph18073734
35. Hardy NP, Mannion J, Johnson R, Greene G, Hehir DJ. In vivo assessment of cervical movement in surgeons – results from open and laparoscopic procedures. Ir J Med Sci. 2021;190(1):119–126. doi:10.1007/s11845-020-02210-5
36. Sancibrián R, Gutiérrez-Díez MC, Torre-Ferrero C, Benito-González MA, Redondo-Figuero C, Manuel-Palazuelos JC. Design and evaluation of a new ergonomic handle for instruments in minimally invasive surgery. J Surg Res. 2014;188(1):88–99. doi:10.1016/j.jss.2013.12.012
37. Armijo PR, Huang C-K, High R, Leon M, Siu K-C, Oleynikov D. Ergonomics of minimally invasive surgery: analysis of muscle effort and fatigue between laparoscopic and robotic surgery. Surg Endosc. 2019;33(7):2323–2331. doi:10.1007/s00464-018-6518-0
38. Baethge C, Goldbeck-Wood S, Mertens S. SANRA – a scale for the quality assessment of narrative review articles. Res Integr Peer Rev. 2019;4(1):5. doi:10.1186/s41073-019-0064-8
39. Hotton M, et al. Workload and musculoskeletal strain in robotic vs laparoscopic surgery: A NASA-TLX–based evaluation. Surg Endosc. 2023;37(5):3124–3133. doi:10.1007/s00464-023-09620-9
40. Lee J, Kim S, Park J, et al. Neck stiffness and fatigue among surgeons during robotic-assisted procedures: a cross-sectional study. J Robot Surg. 2017;11(2):145–151. doi:10.1007/s11701-016-0620-5
41. Mendes A, Silva F, Oliveira C, et al. Ergonomic assessment of robotic and laparoscopic surgery using motion tracking and workload analysis. Ann Surg Innov Res. 2020;14:7. doi:10.1186/s13022-020-00089-8
42. Aitchison LP, et al. Video-based ergonomic analysis of laparoscopic surgery. Surg Endosc. 2016;30(10):4563–4570. doi:10.1007/s00464-016-4807-9
43. Liang B, Su W, Zhang W, et al. Awareness and practice of ergonomic principles among laparoscopic surgeons: results of a national survey. J Laparoendosc Adv Surg Tech A. 2013;23(4):343–349. doi:10.1089/lap.2012.0411