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SPECIAL TOPIC

Stretching and Strength Training to Improve Postural Ergonomics and Endurance in the Operating Room

James N. Winters, MD*
Nicole Z. Sommer, MD†
Michael R. Romanelli, MD‡
Chad Marschik, BA§
Leah Hulcher, DPT¶
Brigitte J. Cutler, DPT‖

Background: Plastic surgeons report the highest prevalence of chronic musculoskeletal pain and fatigue among surgical subspecialties. Musculoskeletal pain impacts daily life, career longevity, and economic burden secondary to occupational injury. Poor postural awareness and ergonomic set up in the operating room represent the most common etiology.

Methods: A literature review was performed to highlight the ergonomic set-up, postural pitfalls, occupational injuries, and musculoskeletal pain in the operating room. An institutional survey was administered among resident and attending surgeons regarding musculoskeletal pain, posture, ergonomic education, and future improvements. Literature results, survey data, and intraoperative photographs were analyzed in collaboration with physical therapists and personal trainers.

Results: Survey results demonstrated that 97% of resident and attending respondents experienced musculoskeletal pain and 83% reported a lack of education in posture and ergonomics. The main postural pitfalls included head forward and flexed positioning, abduction and internal arm rotation, and kyphosis of the thoracic spine. The collaborators developed instructional videos to assess posture and biomechanics and demonstrate targeted stretching and strength exercises to address specific neck, back, and shoulder pain.

Conclusions: Poor posture is unavoidable in the operating room at times. These educational videos should be utilized for self-motivated and prophylactic conditioning outside of the operating room to maintain physical well-being throughout a career in plastic surgery. Future focus should be aimed at implementing dedicated ergonomic education and physical wellness programs early in surgical resident training. *(Plast Reconstr Surg Glob Open 2020;8:e2810; doi: 10.1097/GOX.0000000000002810; Published online 13 May 2020.)*

INTRODUCTION

The concept of surgical well-being encompasses multiple aspects including stress, burnout, work–life balance, mental health, and physical demands. A large body of work can be found in the literature on the majority of these topics with suggestions for improvement. However, the concept of physical health among surgeons continues to gain popularity. Occupational injuries in the health services sector represent a significant economic burden with estimates of over ≈$190 billion annually, which ranked third among US industries.[1,2] Many of these occupational injuries go unreported to hospital administration.[3] Surgeons are faced with the dilemma of how to deal with work-related injuries. A surgeon must weigh the options of working through pain, potentially putting themselves at risk for further harm, or to take time off and reduce operative volume, resulting in a loss of revenue.

Work-related musculoskeletal pain in surgeons occurs most frequently in the neck, back, and shoulders, with lack of ergonomic setup and poor posture being quoted as

*From the *Institute for Plastic Surgery SIU School of Medicine, Springfield, Ill.; †Institute for Plastic Surgery SIU School of Medicine, Springfield, Ill.; ‡Institute for Plastic Surgery SIU School of Medicine, Springfield, Ill.; §No hospital affiliation; ¶No hospital affiliation; and ‖No hospital affiliation.*

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the underlying culprit.[4–13] A survey of surgical subspecialties found that plastic surgeons reported the highest ratio of pain while operating, at 94% of respondents.[5] Studies focusing specifically on plastic surgeons found the prevalence of symptomatic musculoskeletal injury involving the neck, back, and upper extremity to be 77.5%–78.3%.[6,14] Prior studies focusing on spine and reconstructive orthopedic surgeons reported that 14%–33% of work-related musculoskeletal disorders required surgical intervention.[15,16] Surgical injuries requiring a leave of absence or early retirement are not uncommon. A systematic review reported this rate to be 12% among surgeons and interventionalists; the rate increased to 22.9% when only otolaryngologists were considered.[10,11,17] Despite this published literature on the negative physical impacts, there remains a paucity of literature recommending solutions to this problem.[9,12,13,18] The aim of this article is to review the common causes of postural pitfalls in the operating room, offer a postural evaluation tool, and provide focused strength and stretching exercises that can be performed outside of the operating room to combat problematic areas.

METHODS

Review of the surgical literature was performed to highlight ergonomic setup, postural pitfalls, occupational injuries, and musculoskeletal pain associated with operating room.

The aim was to determine if these musculoskeletal symptoms, postural deficiencies, and lack of ergonomic awareness were consistent among resident and attending surgeons at SIU School of Medicine. Institutional review board exemption was obtained for a 19-question anonymous survey including details of surgical practice, musculoskeletal symptoms and injuries, prevention and treatment strategies, ergonomic education, and future improvement suggestions. A brief postural assessment video was included with the survey. Participants were asked to evaluate their individual postural deficits in the operating room setting. The survey and video link were emailed to surgical residents and attending faculty at SIU School of Medicine (**see appendix, Supplemental Digital Content 1**, which displays the institutional survey questions, **http://links.lww.com/PRSGO/B379**). Licensed physical therapists and personal trainers reviewed the literature, intraoperative photographs, and institutional survey results to identify common themes in surgeon complaints and postural breakdown. The physical therapists and personal trainers served as expert opinion for developing postural evaluation and treatment recommendations, based off their standard practice algorithms. General guidelines and corrective exercise videos for surgeon utilization were incorporated into the postural assessment tool.

RESULTS

A total of 80 surveys were emailed to the resident (n = 58) and attending surgeons (n = 22) at our institution. The response rates among the resident and attending surgeons surveyed were 40% and 64%, respectively. Total survey response rate was 46%, with 37 participants in the following subspecialties: general surgery, plastic surgery, otolaryngology, vascular surgery, urology, and neurosurgery. The breakdown of respondents was 62% residents (n = 23) and 38% attending staff (n = 14), with the number of years in training or practice ranging from 1 to 44 years. A total of 97% of respondents reported awkward positioning while retracting, assisting, or operating, leading to musculoskeletal pain. Participants were asked how often these aches and pain occur for reporting on the following breakdowns: every case 8%, daily 24%, weekly 30%, monthly 35%, and yearly 3% (Fig. 1). Time-to-onset of these symptoms fell between 0.5 and 3 hours into a surgical case for the majority of respondents: 70% of residents and 50% of attending surgeons (Fig. 2). A delay in perceived symptom onset after 6 hours of operating was reported in 29% of attending staff compared to 13% of residents. The most bothersome anatomic areas reported were neck, thoracic or lumbar spine, and shoulders (Fig. 3). The most frequent postural deficits reported were a head forward or flexed neck position (73.5%), internally rotated shoulders (44%), and a kyphotic thoracic spine (32.34%)

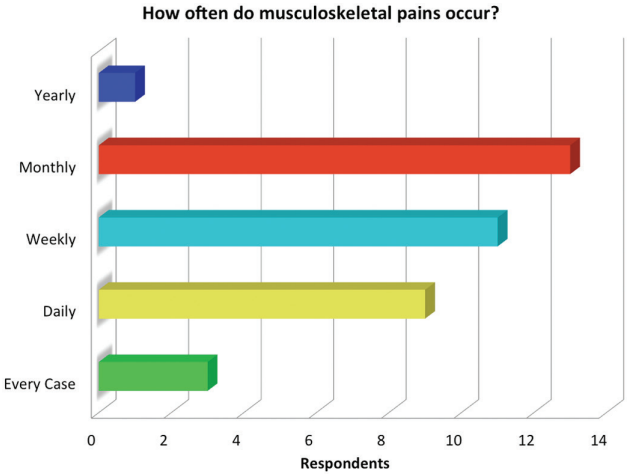

Fig. 1. Survey results: how often do musculoskeletal pains occur? N = 37 respondents.

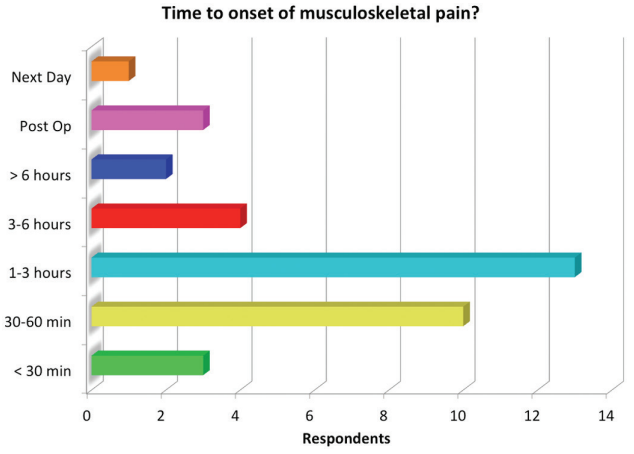

Fig. 2. Survey results: average time-to-onset of musculoskeletal pain after starting an operation? N = 36 respondents.

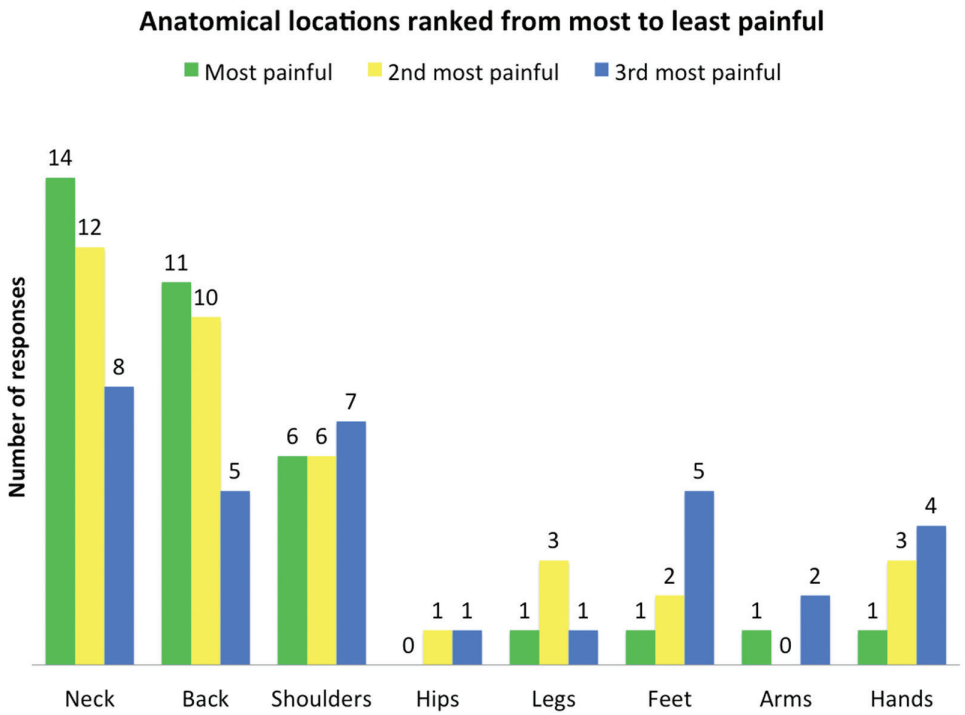

Fig. 3. Survey results: rank the top 3 most painful anatomical areas during surgery. Green represents the number of respondents who ranked each area most painful. Yellow represents the number of respondents who ranked each area second most painful. Blue represents the number of respondents who ranked each area third most painful. N = 37 respondents.

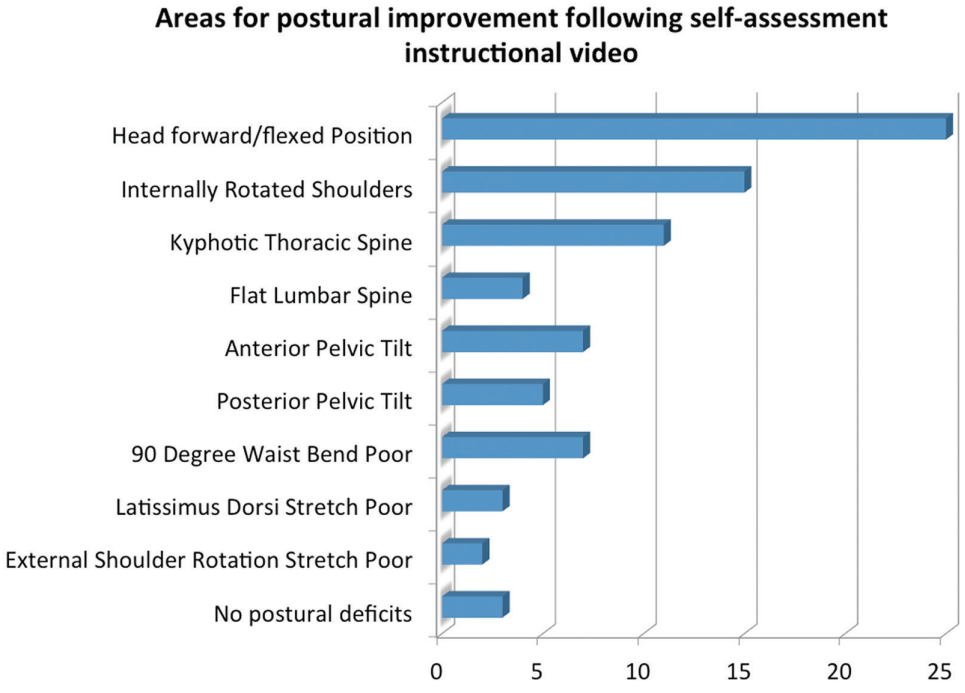

Fig. 4. Survey results: selected areas for individual postural improvement after watching the self-assessment video. N = 34 respondents.

(Fig. 4). The use of headlights, loupes, microscopes, and laparoscopic instruments were commonly reported to exacerbate symptoms. Work-related musculoskeletal injury was reported in 10.8% of participants (n = 4); one injury resulted in time off from operating. Intraoperative risk reduction strategies reported included sitting stools,

stretching or position changes, arm rests, standing pads, timed breaks, and adjusting table height, patient, and monitor positioning. Over one third of respondents reported no stretching or strength training outside of the operating room. When questioned about ergonomic education and posture, 45% denied any formal training as a medical student or resident and 83% reported education on these topics to be insufficient.

The literature review and institutional results were examined in collaboration with licensed physical therapists and personal trainers to gain insight into proper assessment and treatment of common postural deficits seen among surgeons. A head-to-toe postural assessment was created for surgeons to utilize as a tool in evaluating and focusing on key anatomical areas. Basic postural evaluation should be performed in a systematic approach. Anteriorly, the head should be vertical, height of the shoulders and hips should be symmetric, and the knees should be pointing forward. Laterally, the chin should be parallel to the floor, and vertical alignment of the ear, shoulder, hip, and ankle results in natural curvatures of the spine. The postural checklist is provided in Figures 5 and 6, highlighting the poor and proper posture side by side. An educational video was created as a template to identify postural pitfalls among individual surgeons, trainees, or colleagues and recommend targeted individualized corrective exercises to be prescribed. (**See Video 1 [online]**, which displays postural assessment and corrective exercises: part 1.) (**See Video 2 [online]**, which displays postural assessment and corrective exercises: part 2.) (**See Video 3 [online]**, which displays postural assessment and corrective exercises: part 3.) The video includes simple exercises that can be implemented, with limited time requirements, minimal equipment, and performed in an office or hospital setting. A prescribed baseline strength and stretching regimen focusing on each of these trouble areas is highlighted below (Fig. 7). Detailed descriptions and points of performance for these specific exercises focusing on the neck, shoulders, and thoracic spine are included in a separate video. (**See Video 4 [online]**, which displays points of performance for exercises.)

DISCUSSION

The results of this institutional survey are consistent with the data reported in the literature reporting neck, back, and shoulder pain as the most common musculoskeletal complaint among surgeons. Surgically related musculoskeletal pain is multifactorial, but ergonomic set up and posture remain the major inciting factors. A deficit in surgical education on the topic of ergonomics and posture has been identified. Limited resources exist regarding prophylaxis in combating symptomatic neck, back, and shoulder pain to improve career longevity. Surgically related musculoskeletal pain varies based on case duration, equipment, subspecialty, ergonomic operating room set up, and operating posture. One study reported increased myoarticular pain after an operating time of ≈4.3 hours, while another study showed Electromyography (EMG) evidence of fatigue in muscles of static posture, the splenius capitis, upper trapezius, and erector spinae.[19,20]

Laparoscopic instrumentation places added stress on the deltoid and trapezius due to abduction and internal rotation of the arm.[20–22] Correct placement of monitors,

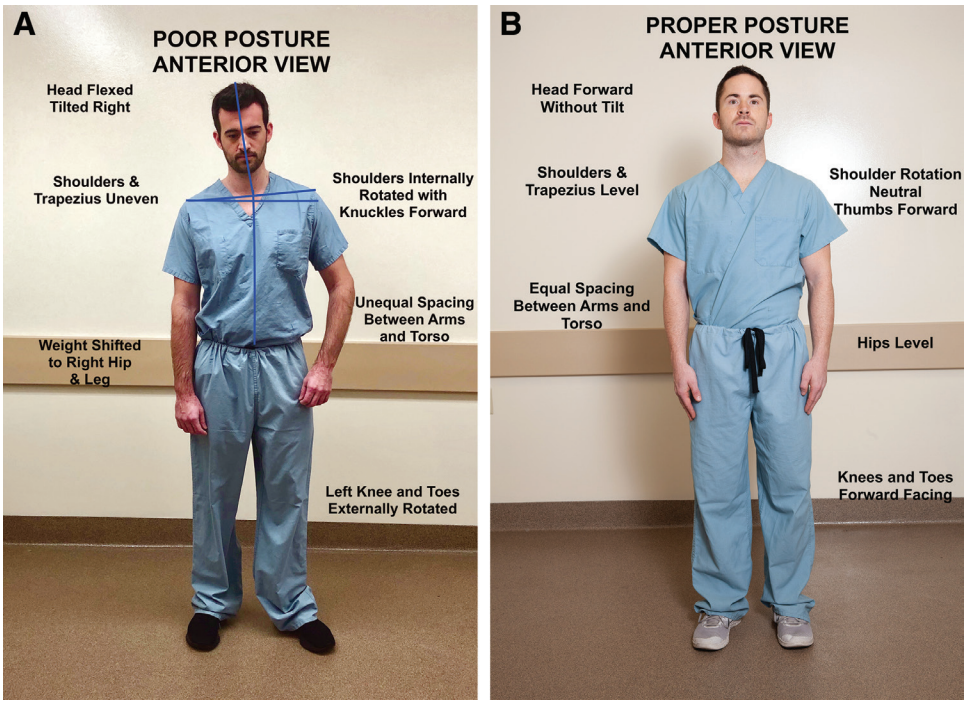

Fig. 5. Postural checklist anterior view: 1, head forward; 2, shoulders level; 3, neutral shoulder vs internal rotation; 4, equal spacing between arms and torso; 5, hips level; 6, knees and toes forward facing. Demonstration of poor posture (A) and proper posture (B).

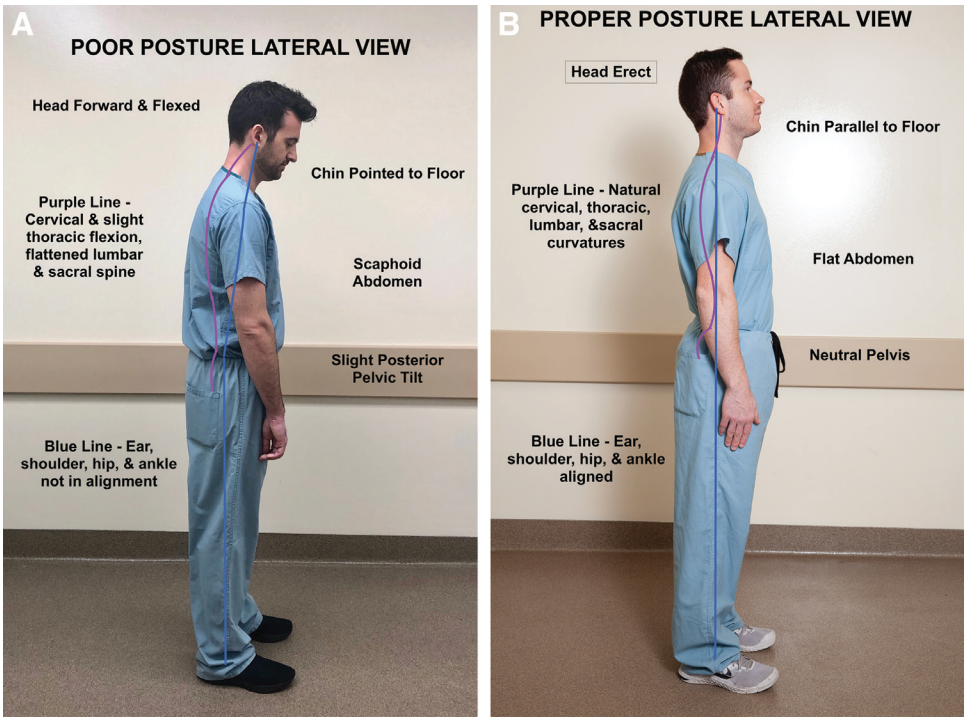

Fig. 6. Postural checklist lateral view: 1, head erect, chin parallel to floor; 2, ear, shoulder, hip, and ankle aligned in vertical plane; 3, natural cervical, thoracic, and lumbar curvature vs excessive kyphosis/lordosis; 4, neutral pelvis vs anterior/posterior pelvic tilt; 5, abdomen flat. Demonstration of poor posture (A) and proper posture (B).

Neck & Head forward/flexion Exercises
1. Wall Chin Tucks (2 sets 30-40 secs)
2. Supine Neck Flexion (2 sets 30-40secs)
3. Lacrosse Ball Upper Trap Release
4. True Lateral Neck Flexion with Depressed Shoulders (2 sets x 5-8 reps)

Shoulders & Internal Rotation Exercises
1. Y's, T's, W's (3 sets, 5-10 reps with 3 second hold)
2. Wall Slide (3 sets: 30 second hold at 90, then 10 slides overhead)
3. Doorway Pectoralis Stretch (2-3 sets, 30-60 sec hold)
4. Pectoralis Minor Release with Lacrosse Ball (1x 1-2min)
5. Latissimus Dorsi Release with Lacrosse Ball (1x 1-2min)
6. Doorway stretch (2-3 sets, 30-60sec hold)

Thoracic Spine Mobility
1. Prone Ws, Ys, Ts Extensions (2 sets x 8-10 reps, hold 3 secs)
2. Foam Roller Extensions (2-3 sets x 30 secs)
3. Puppy Dog Stretch (2-3 sets x 30 secs)
4. Cat-Cow Yoga (2 sets x 5 reps, hold 3 seconds at each position)

Lumbar Spine, Pelvic Tilt & Lower Extremity
1. Waiters Bow with Flat T-Spine (1-2 sets x 5 reps hold for 3-5 seconds)
2. Supine Bent Knee Hip Extension (2 sets x 5-8 reps, hold 3 seconds at top)
3. Prone Single Leg Hip Extension (2 sets x 5-8 reps, hold 3-5 seconds at top)
4. Wall Calf Stretch Varied Angles of Foot (2 sets, 20-30 second hold each angle)
5. Body Weight Squat Flat Footed (3 sets x 10 reps)

Fig. 7. Baseline strength and stretching prescription for problematic areas. (see **Video 2 [Online]** for points of performance for each exercise).

operating table height, and use of armrests with the robot can help reduce the amount of fatigue.[9] Dentists, otolaryngologists, and plastic surgeons have been found to report a higher degree of neck pain than those in other specialties.[5,6,12–14,16,23–26] Operating in the oral-maxillo-facial region requires neck flexion for visualization even with the patient positioned in Trendelenburg. Cervical symptoms are more common when jobs require neck flexion in excess of 15 degrees.[27] Lakhiani et al[12] and Fisher et al[13] detailed cervical spine biomechanics and the increased risk of injury for microsurgeons. Hansraj[28] further evaluated the additional stress in cervical spine posture, with each additional 15 degrees of neck flexion resulting in up to 60 lbs at 60 degrees of flexion. Reconstructive surgeons compound the problem with the addition of loupes and headlights, increasing cervical loading up to 40%.[29,30]

Poor posture and lack of ergonomic movement are cited as the number one culprit of musculoskeletal pain in the majority of studies.[4–13] Kant et al[31] evaluated the postures of operating room staff and found that up to 54% of time was spent in a forward, bent-head stance and 27% of the time was spent in a back twisted and bent stance (Fig. 8). The most common postural breakdowns identified on intraoperative photograph review included head forward in the flexed position, internal rotation and abduction of the shoulders, and a kyphotic thoracic spine. Poor posture can lead to muscle imbalances over time, with repeated shortening of one muscle group and lengthening of its counterpart. Representations of this occur with an Operating Room (OR) table height that is too low, resulting in neck and trunk flexion, shortening the cervical flexors and rectus abdominis, while lengthening the cervical extensors, trapezius muscle, and erector spinae. Table height that is too high, and the arm abductors and internal rotators must shorten, while lengthening the adductors and external rotators. Head forward positioning during microsurgery results in lengthening of the cervical flexors and strain to the capitis muscles[12,13] (Fig. 9). Unfortunately, these postural pitfalls are sometimes unavoidable to plastic surgeons, with examples including cleft surgery, head and neck reconstruction, use of lighted mammary retractors during breast cases, and incorporating multiple trainees into procedures (Fig. 10). These sustained awkward positions contribute to the musculoskeletal discomfort experienced by surgeons.

In 1989, Kroemer[32] first defined work-related musculoskeletal disorders, basic tenets of ergonomics, and suggested avoidance of the following activities: repetitive cycles, prolonged exertion, extreme positions, and static posture. Over 30 years have passed since this description, and surgical training deficits persist in ergonomic and postural education. A survey of 100 surgeons showed that only 9% of surgeons knew ergonomic guidelines and only 3% actually apply these guidelines.[19] A recent survey reported that only 1.5% (2/130) of surgical training programs provided formal surgical ergonomic education.[33] This lack of awareness supports the conclusions of these articles, suggesting that ergonomics and postural awareness should be a focus of surgical education from an early time point.[3,4,9–11,23,24]

Currently, the surgical literature is lacking in its attempts to raise ergonomic awareness and combat musculoskeletal injuries, with the majority of recommendations coming from nursing and physical therapy literature. The Association of Peri-operative Registered Nurses has

Fig. 8. Demonstration of commonly seen flexed and rotated positioning of the trunk while operating.

Fig. 9. Poor posture during microsurgery. Entire torso flexed forward with poor spinal and arm support. Head forward with lengthening of cervical flexors and strain to capitis muscles.

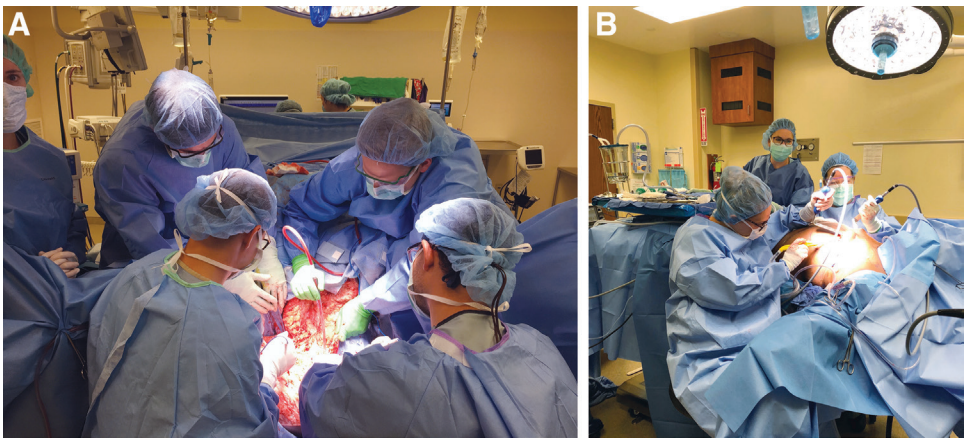

Fig. 10. Intraoperative resident photographs. A, Incorporation of multiple surgeons into a large lymphedematous mass excision. Top left, kyphotic spine, forward and flexed head positioning. Top right, surgeon squatting at legs to achieve height, internally rotated and abducted arms. B, Use of lighted mammary retractor for pocket dissection causes shoulder strain, kyphotic spine, flexed head positioning for visualization.

multiple journal articles highlighting ergonomic tools for transfers, prolonged standing in the OR, and retracting techniques,[34–37] and prior research has focused on advancements in surgical equipment: lighting, retraction, heads up 3-dimensional microscopes, and body support systems.[17,38–41] These surgical instruments are innovative but do not directly address the underlying problem.

The minimally invasive surgery literature pioneered guidelines for ergonomic set up and proper table height when operating to prevent laparoscopic fatigue.[42–44] Catanzarite et al[9] performed one of the largest reviews, with comprehensive ergonomic recommendations based on anatomic body part and specific equipment. Rosenblatt et al[4] expanded on these guidelines and created an educational video regarding OR ergonomics, postural errors, and strategies for avoiding awkward positioning.

Practical application of these principles in the operating theater is often difficult due to surgeon height discrepancies, operative site location, integrating operator and assistants into the exposure, and tolerating inadequate positions to accommodate junior learners.

No matter how much surgeons focus on ergonomics, poor posture will continue to occur in the operating room. Correct posture is a critical adjunct to ergonomics in the OR to prevent and reverse musculoskeletal problems. Posture must be repeatedly practiced and improved upon over time. Postural re-education was developed as a method to improve pain and functional capacity for patients with neck and back pain.[45,46] Strength training and stretching exercise protocols have proven effective at reducing neck, back, and shoulder pain.[47–50] Training regimens have proven effective in correction of head forward positioning and protracted shoulders, commonly seen in microsurgeons.[51–53] Multiple surgical studies recommend improved posture and implementing exercises as a solution to this musculoskeletal pain; however, the detailed specifics of these recommendations are lacking.[6–9,12–17,19–23]

Lack of specific recommendations resulted in collaboration with physical therapists and personal trainers to gain insight into how to assess and treat the common postural deficits seen among surgeons. A simple head-to-toe postural assessment tool and educational video were created to identify individual problematic areas among surgeons. For each problematic anatomical area, specific recommendations regarding exercises, stretches, and points of performance are provided. The exercises are intended to improve postural imbalances, decrease musculoskeletal pain, counteract negative operating room impact, and be performed with minimal equipment outside of the operating room setting. Surgeons should focus on one problematic area during a conditioning session, or choose 1–2 movements from each target area to be performed on a daily basis for a more comprehensive workout.

A self-motivated surgeon and dedicated stretching, strength training, and conditioning program are a must for maintaining a healthy neck, back, and shoulders throughout an entire plastic surgery career. However, a fundamental change in operating room mentality must occur to encompass surgeon comfort and physical well-being on a larger scale.[54] Ideally, formal specialty-specific training in ergonomics, body mechanics, and posture would occur at the resident level. Collaboration with physical therapists to perform direct observation and video evaluations of residents practicing laparoscopic skills, microsurgery, and robotic simulation could detect postural pitfalls early during trainee careers. Continued access to physical and occupational therapists at the hospital would allow postural retraining and access to additional therapies. A multidisciplinary approach, early surgeon buy-in, and repetitive incorporation of ergonomic principles are most likely to be successful in the long term.

Limitations include small sample size of surgeons from a single institution. Selection bias must be considered when reviewing the reported rates of musculoskeletal pain. The reported rates may be confounded secondary to 46% survey response rate. Future aims in this investigation include implementing this training regimen among the surgical subspecialties within our own institution. Logistical

coordination and consistent participation remain challenges to this process. Comparison of musculoskeletal pain among resident physicians pre- and posttraining regimen would add additional scientific impact to future studies.

CONCLUSIONS

Plastic surgeons report high rates of neck, back, and shoulder pain from operating. Proper ergonomic principles and posture are unavoidable at times in the operating room. Postural assessment tools should be utilized for early recognition of postural errors and musculoskeletal imbalances among trainees. Surgeon-specific stretching and strength training outside of the operating room should be implemented as an adjunct to minimize musculoskeletal pain and improve underlying postural deficits. The educational videos serve as a template for specific recommendations to maintain physical well-being and protect career longevity. Future focus should be aimed at implementing dedicated specialty-specific ergonomic education, postural awareness training, collaboration with physical therapists, and physical wellness programs early in surgical residency training.

James N. Winters, MD
Institute for Plastic Surgery
SIU School of Medicine
747 N Rutledge St, 3rd Floor
Springfield, IL 62702
E-mail: jwinters@siumed.edu

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