ASGE Guideline on the Role of Ergonomics for Prevention of Endoscopy-related Injury (ERI): Methodology and Review of Evidence

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Bubble text: Communication from the ASGE Standards of Practice Committee

Acronyms:

ACG	American College of Gastroenterology
ASGE	American Society for Gastrointestinal Endoscopy
CI	Confidence interval
ERCP	Endoscopic retrograde cholangiopancreatography
ERI	Endoscopic Related Injury
GI	Gastrointestinal
GE	Gastroenterologists
GRADE	Grading of Recommendations Assessment, Development and Evaluation
IQR	Interquartile range
MA	Meta-analysis
MIS	Minimally invasive surgery
OR	Odds ratio
0SHA	Occupational Safety and Health Administration
PICO	Populations in question, intervention, comparator, outcomes of interest
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses
RCT	Randomized controlled trial
RR	Relative risk
SOP	Standards of Practice
SR	Systematic review
SRMA	Systematic review and meta-analysis
TSE	Third space endoscopy

REBA	Rapid Entire Body Assessment
RULA	Rapid Upper Limb Assessment
TSMB	Targeted Stretching Microbreaks
NASA-TLX	National Aeronautics and Space Administration Task Load Index
SURG-TLX	Surgery Task Load Index

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This guideline document was prepared by the Standards of Practice Committee of the American Society for Gastrointestinal Endoscopy (ASGE) using the best available scientific evidence and considering a multitude of variables including, but not limited to, adverse events, patients' values, and cost implications. The purpose of these guidelines is to provide the best practice recommendations, which may help, standardize patient care, improve patient outcomes, and reduce variability in practice.

We recognize that clinical decision-making is complex. Guidelines, therefore, are not a substitute for a clinician's judgment. Such judgements may, at times, seem contradictory to our guidance due to many factors that are impossible to fully consider by guideline developers. Any clinical decisions should be based on the clinician's experience, local expertise, resource availability, and patient values and preferences.

This document is not a rule and should not be construed as establishing a legal standard of care, or as encouraging, advocating for, mandating, or discouraging any particular treatment. Our *guidelines should not be used in support of medical complaints, legal proceedings and/or litigation, as they were not designed for this purpose.*

INTRODUCTION

Endoscopists are at high risk for endoscopy-related injuries (ERIs) with an occurrence approaching 89%.[1-19] ERI is a work-related musculoskeletal disorder due to repetitive strain especially when coupled with non-neutral body postures. [13, 20] In the early stages of work-related musculoskeletal disorders, the aching and tiredness of the affected limb occur during the work shift, but disappear at night and during days off work. There is no reduction in work performance. In the intermediate stages, the aching and tiredness occur early in the work shift and persist at night, and may result in a reduced capacity for repetitive work. In the late stages, aching, fatigue and even weakness persist at rest and result in disability[21, 22] Not only is this an undue burden on the health and productivity of endoscopists, but it also highlights the need for a better understanding of the risk factors for ERI. For that reason, it is important to develop a comprehensive set of tools for training in ergonomics. Therefore, the American Society for Gastrointestinal Endoscopy (ASGE) Standards of Practice Committee (SOP) has developed evidence-based guidelines on the role of ergonomics for prevention of ERI in GE based on GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) methodology. [23, 24] The aim of this document is to describe the methodology used in this process including formulation of clinical questions, literature searches, data analyses, panel composition, evidence profiles, and other considerations like cost-effectiveness, and health equity. For each clinical question, this document includes outcomes of interest and evidence that was considered by the panel in making final recommendations. A separate document provides a summary of the main findings and final recommendations of the ASGE SOP committee for strategies to prevent ERI.

METHODS

Formulation of clinical questions

The panel addressed five questions relevant to the role of ergonomics in prevention of ERI in endoscopists using GRADE methodology (**Table 1**). For these questions, we followed the PICO format: P, population in question; I, intervention; C, comparator; and O, outcomes of interest. For all clinical questions, potentially relevant patient-important outcomes were identified *a priori* and rated from “critical” to “important” through a consensus process.

Literature search and study selection criteria

For each PICO question, we searched for existing high-quality systematic reviews and if unavailable conducted de novo systematic review and meta-analyses (SRMA) to address the pertinent questions.

A health sciences librarian developed the search strategy and searched the following databases on 4/20/2020 for all PICOs. This included PubMed (coverage 1946 – Present), Embase and Embase Classic (coverage 1947 – Present), Cochrane Library (coverage 1898–present), and Web of Science (coverage 1900-present). The searches were limited to English language articles. To broaden the results, references from all relevant articles were also reviewed to identify additional articles. Full articles were retrieved for all relevant titles for which an abstract was not available. Articles were included if they were determined to be related to ergonomics in gastrointestinal (GI) endoscopy. More specifically, articles were included if they addressed the prevalence, risk factors, or mechanism of injury in endoscopists; if they measured posture or forces during endoscopy; or if they provided recommendations on strategies to reduce injury in endoscopists. Studies that addressed ergonomics in other types of fiberoptic endoscopy (e.g., laparoscopic surgery) were also included.

A combination of subject headings (when available) and keywords were used and provided in **Appendix 1**. Cross-referencing (snowballing) and forward searches of the citations from articles fulfilling inclusion criteria and other pertinent articles were performed using Web of Science. Forward searches were performed through August 2022. Citations were imported into EndNote x9.2 (Clarivate Analytics, Philadelphia, PA), duplicates were removed using the Bramer method and uploaded into Covidence (Melbourne, Australia) for screening.[25]

Data extraction and statistical analysis

Three independent reviewers (S.P, R.S.K, and D.F) performed data extraction for all of the systematic reviews and cross-sectional studies for PICO's 1 through 5.

Studies were first screened by title, abstract, and then by full text by two independent reviewers (S.P. and D.F.) and all conflicts were resolved by consensus with the third reviewer (R.S.K.). When applicable, available systematic reviews were updated based on literature review as described above. S.P. and N.T. additionally performed data extraction for the meta-analyses for assessing prevalence of ERI and risk factors using Covidence (Melbourne, Australia).

The summary statistics included the odds ratio (OR), risk ratio (RR) and/or proportion. Pooled effects were calculated using random effects models given anticipated differences in the populations of the source studies. Heterogeneity was quantified using the I^2 statistic and assessed by sensitivity analyses. Studies were weighted based on size. Publication bias was assessed using funnel plots. Statistical analyses were performed using STATA 14.2 (College Station, TX).

Panel composition and conflict of interest management

On November 15th, 2021, we assembled a panel of stakeholders to review evidence and make recommendations. The panel consisted of lead authors (S.P., R.S.K., D.F.), content experts independent of the SOP committee (A.S., S.C.G.), GRADE methodologist (N.T.), SOP committee members with expertise in methodology, systematic reviews and meta-analysis, and was chaired by the SOP chair (B.Q.). There were no patient representatives since the study focused on ERI among endoscopists. Therefore, every panel member (all practicing endoscopists) served as "representatives" on this panel. Per ASGE policy, members were asked to disclose conflicts of interests (https: //www.Asge.org/forms/conflict-of-interest-disclosure and https://www.asge.org/docs/default-source/about-asge/mission-andgovernance/asge-conflict-of-interest-and-disclosure-policy.pdf). Panel members who received funding for any technologies or companies associated with any of the PICOs or had other relevant conflicts of interest were asked to disclose before the discussion and did not vote on the final recommendation addressing that specific PICO question. The primary methodologists (S.P. and N.T.) and primary authors were excluded from all votes.

Certainty in evidence, outcomes and definitions

The certainty in the body of evidence (also known as quality of the evidence or confidence in the estimated effects) was assessed using the GRADE framework (**Table 2**).[26-28]

The primary questions of interest were the rates of ERI, predictors of ERI (including gender, hand size, and procedure volume), and interventions to reduce risk of ERI. These interventions included dedicated ergonomic training, micro and macro breaks, neutral monitor position, neutral bed heights, anti-fatigue mats, and use of ancillary devices. Other outcomes reported include scores on ergonomics tests, pain in joints, and pre-existing ergonomic assessments. For each intervention, we also considered cost, cost-effectiveness, acceptability, and feasibility.

External review

The guideline was reviewed by the GIE Editorial Board, Governing Board, and made available for public comment on the ASGE website.

RESULTS

1) RATES AND SITES OF ERI

For this question, we performed a systematic review and meta-analysis. Our search identified 17 survey studies assessing the prevalence of ERI among 5,227 GI endoscopists responding to the surveys. Fourteen of the 17 included studies evaluated practicing gastroenterologists,[1, 2, 4-14, 29] one study was in colorectal surgeons[3] and two studies were in GI trainees.[30, 31] Outcomes of interest were overall rate of ERI amongst endoscopists and most common sites for ERI. We found that the overall rate of ERI was 57.7% (95% CI, 48.8%-66.1%, I^2=93%). The most common sites of ERI included hands and fingers, back, and neck.

2) PREDICTORS OF ERI:

Our systematic review identified 24 survey studies in the GI literature. [1-14, 16-19, 30-35] These studies were conducted in USA (n = 11), Canada (n = 2), Italy (n = 1), Germany (n = 2), UK (n=2) Japan (n=2), South Korea (n = 1), Portugal (n =1) and Pakistan (n=2). Fifteen studies included endoscopists practicing all forms of GI endoscopy. One study included colonoscopists only, two included endoscopists who perform endoscopic retrograde cholangiopancreatography (ERCP) and two included endoscopists who performed third space endoscopy. There were four studies in GI trainees and one study in pediatric gastroenterologists. A summary of all the survey studies can be found in Table 3. We identified two major ERI predictors, which included gender of endoscopist and procedure volume.

a. *Gender of the endoscopist:*

Our systematic review identified eight eligible studies, which included 3,355 GI respondents.[5, 9, 10, 13, 14, 29]. Two of such studies were specific to GI trainees.[30, 31] The overall rate of ERI in female endoscopists was 62.4% (95% CI, 46.7% to 75.9%), while the overall rate of ERI in male endoscopists was 45.5% (95% CI, 28.1% to 64.0%). Harmonization of comparative studies revealed that female endoscopists had higher odds of developing ERI than male counterparts (OR= 1.79, 95% CI, 1.35 to 2.38, p value <0.01), I^2=64%).

The panel also noted that injury mechanisms may differ between male and female endoscopists based on one study. [13] A study published in abstract form recently highlighted the different endoscopy styles between male and female endoscopists. Female GI endoscopists prefer holding the endoscope with the umbilical cord inside the forearm, use the right hand to turn the small wheel, and use a pediatric colonoscope to perform colonoscopy. [29]

b. *Procedure Volume:*

A systematic review was used to address the outcome of endoscopy volume as a predictor of ERI. Our systematic review identified 24 survey studies in the GI literature between 1994 and 2022.[1-14, 16-19, 30-35] In most studies, higher rates of ERI were related to greater number of hours performing endoscopy and greater number of years performing endoscopy. [1-6, 8-10, 13, 16, 17, 19] Pawa et al. conducted a survey study of physician members of the American College of Gastroenterology with 1,698 respondents.[13] On multivariable analysis, the number of hours performing endoscopies per week (p=0.009) and the number of years in practice (p=0.02), were the predominant predictors of ERI. Morias et al. surveyed 171 endoscopists in Europe and reported that the number of years in practice (>15 years, p=0.03) was an independent risk factor of ERI.[10] Notably, an independent association was observed between female gender and musculoskeletal injury (MSI) and severe pain.[10] Ridtitid et al. surveyed 684 ASGE members and found that higher procedure volume (> 20 endoscopies /week, p <0.001), longer scope hours per week (>16 hrs/week, p< .001), and a higher total number of years performing endoscopy (p=0.004), were associated with higher rates of ERI.[9] Endoscopy volume as a risk factor appears consistent with other specialties and caregivers as well.[3] A more recent international survey involving 82 physicians and 22 nurses who perform endoscopy showed that using the endoscope for more than 15 hours/week ($\chi2$ = 4.18, P = 0.04) or performing more than 15 procedures/week ($\chi2$ = 5.42, P = 0.02) were related to ERI.[19]

ERI in interventional endoscopists is also being increasingly reported, though these studies are limited by their small sample size. *Campbell et al.* surveyed 203 ASGE members who performed ERCP (ranging from 1 to 500 per year) and found that 46% attributed their pain [neck pain (24%) and lower back pain (17%) being the most prevalent] to performing ERCPs. [12] This was particularly true for those who performed ≥100 ERCP per year when compared to those who performed ≤50 ERCP. Furthermore, 16% attributed musculoskeletal injuries such as De Quervain's tenosynovitis (n= 32) and 12% attributed cervical radiculopathy (n=25) to performing ERCP. A second survey of 114 ERCP endoscopists showed that performing ≥150 ERCPs per year was a risk factor for ERI, notably back pain (57%), neck pain (46%) and hand pain (33%). [2]

An international survey of 45 endoscopists representing 10 countries studied the prevalence of ERI after third space endoscopy (TSE) procedures. Twenty-two of the 31 endoscopists who reported ERI believed that their symptoms began after starting TSE. Additionally, 48.9% of all endoscopists reported more symptoms after TSE compared to ERCP/EUS.[11] *Matsuzaki et al.* studied ERI in 110 endoscopists who perform TSE and found a positive correlation between ESD volume and risk for ERI. The authors found that longer upper ESD procedure times (total time: ≥ 181 min/month, OR: 5.7; 95%CI: 1.3–25.0), lower ESD (total time: 1–90min/month, OR 4.9; 95 %CI: 1.1– 22.0), and lower gastrointestinal treatment (total time: ≥526 min/month, OR: 5.6; 95 % CI: 2.3–13.3) were significantly associated with low back symptoms. Moreover, lower ESD was a risk factor for symptoms in the left shoulder (total time: 91–180min/month, OR: 5.0; 95% CI: 1.2–20.2).[16]

Our systematic review revealed 4 survey studies in GI trainees in which emergence of ERI was seen as early as less than one year of performing endoscopy, with increasing occurrence over time.[30, 31 32]

3) INTERVENTIONS TO REDUCE RISK OF ERI

We preface by noting that our search identified very few randomized controlled trials and other high-quality prospective trials addressing any of the questions. Therefore, the quality of the evidence was rated as "low" to "very low" in most evidence profiles.

Question 1: In those performing GI endoscopies, should ergonomics education be implemented to reduce the risk of ERI?

Recommendation 1. The ASGE recommends ergonomics education to reduce the risk of ERI.

(*Strong recommendation, very low quality of evidence*).

Outcomes of interest varied, ranging from scores on ergonomics tests, pain in joints, and formalized ergonomic assessments. The range of training options reported in the literature is wide and can be broadly dichotomized into didactic training and physical therapy-led training. The range of didactic training interventions have varied. These included informal short written guides or posters hanging in the endoscopy unit and ASGE videos[36] which resulted in improved awareness of ergonomics (based upon improvement on post-training test scores). Another similar study looked at the outcomes on a written test taken by 58 fellows after a six-minute teaching video and noted a similar increase in correct post-training answers.[37] Two studies examined the effect of didactic training with formalized physical assessments such as the Rapid Upper Limb Assessment (RULA) which considers biomechanical and postural load requirements of job tasks on the neck, trunk and both upper extremities, and the Rapid Entire Body Assessment (REBA) which uses a systematic process to evaluate both upper and lower parts of the musculoskeletal system for biomechanical and musculoskeletal disease risks associated with the job task being evaluated. For both the REBA and RULA, a higher score equates to a higher risk for injury. Khan et al. compared REBA scores in 30 post-graduate trainees who underwent a formal ergonomics-training curriculum to 25 historical controls who did not.[38] The curriculum in this study consisted of a one-hour lecture, 5-minute video, expert feedback and an ergonomics checklist for reference. During two colonoscopies six weeks post-training, the authors reported improved REBA scores in those who underwent ergonomics training compared to the subjects who did not. A surgical study compared RULA scores for both upper extremities during laparoscopic exercises in 13 subjects who underwent formal training beforehand and 13 others who did not.[39] Ergonomics training consisted of a written guide, personal instructions, and verbal coaching. The intervention group had improved RULA scores for both exercises when compared to the control group.

A few studies demonstrate that formalized ergonomics training given by physical therapists is beneficial. Markwell et al. studied pain and posture assessment in eight endoscopists at various levels of experience (ranging from fellows to experienced attendings).[40] Ergonomics training consisted of an assessment by a physical therapist and an individualized “wellness plan”. The endoscopists reported 63% of pain sites were reduced in intensity or resolved. A group from the University of Miami reported the benefits of physical therapist-led modules and microbreaks training for 36 medical students or surgery residents [41] and 15 GI fellows.[42] When comparing pre- and post-therapy training surveys, a high percentage of the subjects reported the training being valuable (93-100%). Furthermore, a large majority of them (85-100%) reported immediate decrease in physical discomfort.

Certainty in the Evidence:

Details of outcomes and certainty of evidence are noted in the evidence profile (Table 4). The quality of evidence ranged from very low to low. Data was mostly rated down for imprecision due to small number of studies and indirectness due to extrapolation from surgical studies.

Other Considerations

No studies assessed the cost or cost-effectiveness of ergonomics training to reduce the risk of ERI. While posters as well as video-based didactic training are overall low-cost interventions, physical therapy assessments and individualized plans may add additional costs.

Discussion

Overall, the panel found the risk of ERI is far costlier than the intervention. Given the high risk of ERI in GEs, the panel made a strong recommendation despite low quality of evidence. The panel noted that the specific forms of ergonomics training vary and can be achieved by didactic training, online teaching, or be led by physical therapists. Didactic training can include informal short written guides, posters and short videos (including those from the ASGE).[36] The sustainability of these benefits have been demonstrated in assessments as far out as 6 weeks post-training. [38] Available resources for ergonomics didactics include the ASGE training curriculum [43] , the ASGE video " Ergonomic Essentials for your Practice"[44] which can be accessed at ASGE's GI LEAP website (https://learn.asge.org), the VideoGIE series on endoscopy ergonomics [45-47]and YouTube videos on endoscopy Ergonomics. [48, 49]

Question 2: *In those performing GI endoscopies, do breaks decrease the risk of ERI?*

Recommendation 2: The ASGE suggests that GI endoscopists take microbreaks and scheduled macrobreaks to reduce the risk of ERI.

(*Conditional recommendation, very low quality of evidence*).

Microbreaks are short biologically meaningful movement breaks lasting 30 seconds to 2 minutes.[13] Targeted stretching microbreaks (TSMBs) are 1.5 min stretching breaks at 20 – 40-minute intervals throughout each surgical case targeting the neck, shoulders, back, wrists, hands, knees and, ankles.[50, 51] Macrobreaks are defined as scheduled breaks which are 15 – 45 -minutes long and built into a day's endoscopy schedule[13]

We performed a systematic review of published literature on this topic. Only one cross sectional study was found in the GI literature, which evaluated the role of microbreaks and macrobreaks in endoscopy. Due to paucity of GI literature, we extended our search to include laparoscopic surgery literature. Two additional studies were identified in the surgical literature. All were full text publications.

In a cross-sectional study of endoscopists with 0.5 to 58 years in practice (mean= 21.1, SD = 12), the likelihood of developing ERI was lower among endoscopists who took microbreaks (OR = 0.69 [0.54 - 0.87], p=0.016) and macrobreaks (OR = 0.72 [0.57 -0.92], p=0.002,) as compared to those who did not take any breaks. The duration of macrobreaks by quartiles (1-15 min, 16-30 min, 31-45 min, and 46-60 min) was not significantly associated with ERI (P = 0.50). Taking a break for any of these durations (or microbreaks) was associated with a lower likelihood of ERI.[13]

In a multicenter cohort study, 66 surgeons (academic and private) were taught how to perform TSMBs during surgery at 20 – 40 minute intervals targeting the neck, shoulders, upper back, lower back, wrists, hands, knees and ankles.[50] Five standardized exercises were used involving neck flexion, extension and lateral rotation, backward shoulder rolls with chest stretch, upper back and hand stretch, low back flexion and extension and forefoot and heel lifts for lower extremity and ankle stretches. Each participant rated pain/fatigue, and physical and mental performance based on the validated Nordic Musculoskeletal questionnaire, the National Aeronautics and Space Administration Task Load Index (NASA-TLX), and the Surgery Task Load Index (SURG-TLX). TSMBs improved physical post-procedure pain scores in all evaluated anatomical regions: scores for the neck ($p=0.01$), right and left shoulder ($p<0.001$), right and left hand ($p=0.03$), and lower back ($p=0.04$). Participants using TSMB perceived improvements in physical performance (57%) and mental focus (38%). Most surgeons (87%) planned to incorporate TSMBs into their practice. Additionally, TSMBs did not impact operative duration ($p>.05$).[50] Another non-randomized crossover study of 56 surgeons in 4 academic centers showed that microbreaks were associated with improvement in shoulder pain ($p=0.006$) and improved the overall physical performance in 57% of the participants. [51] Mental focus improved in 34.4%, remained the same in 53.3% and diminished in 12.4%. Additionally, 87% of the surgeons wanted to incorporate microbreaks in their surgical routine. Importantly, the microbreaks did not prolong the duration of the surgery.[51] A systematic review of ergonomics training and intraoperative microbreaks in the surgical literature identified four studies, all of which demonstrated microbreaks to be beneficial to surgeons from reduced reported muscle discomfort to improved mental focus and surgeons' overall well-being.[52]

Successful interventions to protect minimally invasive surgery (MIS) practitioners drew potential solutions from office and industry ergonomics. An evidence-based creation of a one-minute targeted microbreak activity every 20 – 40 minutes during MIS procedures was developed addressing posture correction, normalization of tissue tension, and relaxation/stress reduction by Human Factors Engineering Lab at Mayo Clinic. Printed files in PDF format to guide surgeons through a set of stretches are available for use.[53] A web-app reminding surgeons to take sterile field microbreak stretches was piloted in a small sample.[53] Twelve surgical days were followed with a median of six microbreaks day per surgeon. Results showed improved physical performance and fatigue (91.7%)), better mental focus (83.3%), and less pain/discomfort (100%).

Based on the above analysis and panel discussions, we concluded that there were benefits of microbreaks and macrobreaks in reducing pain and possibly preventing ERI and therefore made a conditional recommendation for both types of breaks.

Certainty in the evidence

Details of outcomes and certainty of evidence is noted in the evidence profile (Table 5). While assessing the certainty of evidence, we rated down evidence for imprecision due to small number of studies and patients, and overall judged the quality of evidence to be "very low".

Other considerations

We did not find any study, which addressed cost effectiveness of micro or macrobreaks. We identified minimal to no risks physically or to procedure duration associated with microbreaks and potentially strong benefits in reducing pain and preventing ERI. Microbreaks should be implemented as an integral component of the ergonomics curriculum / program within every endoscopy unit. Scheduled macrobreaks may require administrative support.

Discussion

The panel recognized that longer procedural times were required in more complex interventional procedures and agreed that until data on optimal work and rest schedules in endoscopy is available, the surgical literature could be used to provide guidance on breaks. The panel also considered the importance of breaks in any form including passive rest breaks to allow the muscle groups to rest and offset the static load incurred from prolonged standing times. Evidence suggests that dynamic active stretching exercises are more effective than static stretches. [54]

Of note, microbreaks are widely used in other industries and occupations. Occupational Safety and Health Administration (OSHA) recommendations for prevention of musculoskeletal disorders in the work place while doing computer related tasks were also discussed and included stretching the torso, fingers, hands, and arms frequently throughout the day in addition to taking several short rest breaks to give our muscles, tendons, and ligaments a chance to recover from the strain of performing an endoscopy.[55]

Question 3: In those performing GI endoscopies, should a neutral monitor position be used to reduce the risk of ERI?

Recommendation 3: The ASGE recommends a neutral monitor position during endoscopies to reduce the risk of ERI.
(*Strong recommendation, very low quality of evidence*).

Summary of evidence: The monitor placement is an important determinant of torso and head posture. An ergonomics stance during endoscopy involves neutral neck and back position without hyperextension or flexion, even weight distribution between both legs, and avoidance of knee hyperextension.[20] Monitor booms and mobile stands facilitate flexible positioning.

Our search did not identify any gastroenterology studies to inform this question. However, we identified three published laparoscopic surgical studies assessing the optimal monitor position.[56-58] The outcomes of interest included task performance, neck muscle strain, and EMG activity of the neck muscles. Neck strain was lowest when the monitor was positioned in front at the surgeon's eye level.[56] Task performance was best when monitor was directly in front (not to the right or to the left) of the laparoscopic surgeon.[57] The optimal distance between the monitor and surgeon was reported to be 90 cm and 182 cm and the maximum distance at which the finest details of an image could still be seen was 139 cm to 303 cm.[58] Extrapolating from these studies, Shergill et al. concluded that monitors should be placed directly in front of the endoscopist just below the eye level with an optimal viewing angle of 15 to 25 degrees below the horizon from the eyes with a viewing distance of 52 to 182 cm. [20] To accommodate the 5th percentile female to the 95th percentile male eye height, the monitor should be adjustable from 93 to 162 cm above the floor. [20]

Certainty in evidence:

While assessing the certainty of evidence, we rated down evidence for indirectness and imprecision. The overall quality of evidence was “very low” (**Table 6**).

Cost effectiveness

We did not find any study that addressed cost effectiveness of adjustable monitors. The panel felt that even though there was a cost factor involved in making monitors adjustable with the use of monitor booms and mobile stands, this cost was justified to reduce the high prevalence of upper body and neck injuries seen in endoscopists due to working in non-neutral positions. [10, 17]

Discussion

The monitor placement is an important determinant of torso and head posture. High monitor placement leads to excessive cervical extension and neck strain.[59, 60] All endoscopy units should make a concerted effort to make the monitors adjustable in their unit to match the above listed requirements to accommodate individual endoscopists.

Based on our analysis and panel discussions, we concluded that the benefits of placing the monitors directly in front of the endoscopists facilitates work at a neutral position, reducing the risk for ERI. We made a strong recommendation for a neutral monitor position.

Question 4: In those performing GI endoscopies, should neutral bed position be used to reduce ERI?

Recommendation 4: The ASGE recommends the use of neutral bed height to reduce the risk of ERI.
(*Strong recommendation, very low quality of evidence*).

For this question, we performed a systematic review. No studies were identified in GI literature. Our search yielded two observational surgical studies, which studied optimal procedure table position in laparoscopic surgery.

The first study involved 21 laparoscopic surgeons performing a two-hand, 1/4th circle cutting task at 5 laparoscopic instrument handle heights relative to the surgeon's elbow height (-20,-10,0, + 10,+ 20cm) relative to elbow height in a randomized sequence for two repetitions.[61] Each task was rated for difficulty and discomfort on a visual analog scale. In addition, EMG measured the physical workload from the right deltoid and trapezius muscle. Statistically significant increases in subjective rating of discomfort, deltoid, and trapezius EMG activity and arm elevation were seen if the bed was above elbow height or > 10 cm below elbow height. Higher bed heights were associated with significantly increased shoulder fatigue. If physicians had to flex their trunks during a task to accommodate a lower table height of -20 and -10 cm, then there was an increase in discomfort in procedures with higher difficulty ratings despite the lower level of upper arm muscle work at these levels.

A second study involved surgeons working in a surgical simulation device called the pelvi-trainer.[62] This was a two-part study. The first part was dynamic and involved a 5-minute precision task of picking up chips with a dissection forceps with an angled ring handle and placing these chips over the pins of an object. Six different operating surface heights were used with the monitor placed in front of the surgeon. Extreme joint excursion was measured with video analysis. This study assessed the optimal operating surface height during manipulation of instruments. The second part was to hold the laparoscope for 15 minutes and assess the optimal surface height where muscle fatigue did not set in. This was based on the principle that static muscle loading can cause fatigue and decrease the muscle activity. [63] EMG of biceps brachii was done. Subjects answered questionnaires after completing each task as well. This study found that an optimal table height of 70% to 80% of elbow height allowed the joints to stay in neutral position over 90% of the procedure time and allowed the muscle activity to remain below 15% of the maximum.

Certainty in evidence:

While assessing the certainty of evidence, we rated down evidence for indirectness, due to lack of prospective studies in GI literature and imprecision due to small number of studies and patients. Therefore, the overall quality of evidence was "very low". (**Table 7**).

Discussion

Based on these results, optimal table height should be adjusted to allow holding of the endoscope between elbow height and 10 cm below elbow height. The panel agreed that the endoscope insertion tube should be held between elbow height and 10 cm below elbow height. This allows the endoscopists to work from a neutral elbow, shoulder, and back position reducing the risk for ERI. We made a strong recommendation for a neutral table position.

Question 5: In those performing GI endoscopies, should anti-fatigue floor mats be used to prevent ERI?

Recommendation 5: The ASGE suggests the use of anti-fatigue mats to reduce the risk of ERI.

(*Conditional recommendation, very low quality of evidence*).

For this question, we performed a systematic review, which was limited to surgical literature only. No studies were identified in GI literature. Our search yielded two studies, which studied optimal procedure table position during surgery.

Prolonged standing has been directly implicated in lower extremity fatigue and discomfort, lower extremity swelling, venous blood restriction, low back pain, and whole body tiredness. [64] Survey based studies assessing the prevalence of ERI have reported discomfort in the feet, legs, and back which have been attributed by the respondents to prolonged standing. [3] Much of this discomfort has been related to venous pooling and maintained static postural muscle contractions. [65] Cushioned mats are often recommended in standing workplaces and are thought to decrease fatigue by causing minor postural instability, leading to subtle movements of the legs and increased blood flow to reduce foot and leg injuries.[65] Even though subjective ratings of fatigue and discomfort in the lower extremities improved with the use of soft flooring,[64] objective evidence as measured by changes in EMG muscle tone, leg volume, and postural movements is lacking.[65] However, the selection of matting requires caution because certain mats could have the reverse effect (e.g., anti-slip mats). Similarly, too much cushioning (e.g., thick foam mats) is also not recommended as it can increase slipping. OSHA has provided some guidance in assessing various workplace injuries and assessment of ergonomics.[66] However, limited data is available to assess its utilization in gastrointestinal endoscopy or its potential role in decreasing ERI in gastrointestinal endoscopy. Factors specific to the endoscopy suite would include ease in cleaning mats as well as disposable mats given the types of procedures performed in GI.[22]

Certainty of Evidence:

The evidence ranged from very low to low and was rated down for indirectness and imprecision as seen in **Table 8**.

Other Considerations:

Although the urology data is encouraging, evaluating medium and long-term ERI in endoscopists is warranted. Further study of anti-fatigue mats in gastrointestinal endoscopy should include cost-effectiveness and overall room efficiency.

Discussion:

The initial question addressed, was the use of floor gel mats in preventing ERI. The panel agreed that the intent was to evaluate anti-fatigue mats, but without specification of type or material. One issue raised by the panel was the question of time efficiency: how do anti-fatigue mats, especially the use of multiple mats for the nurses and technicians in the room, affect the time to clean rooms in between cases and its subsequent effect on room turnover. The use of specific mats does not appear to risk patient, safety and based on a subset of data from *Haramis et al.* demonstrating an increase in errors with those not using a gel mat, mats may even improve patient safety. [67] The panelists also queried whether shorter length procedures (e.g., upper endoscopies) require anti-fatigue mats, or if they should be used for cases anticipated to be longer in duration or that may involve challenging ergonomics such as ERCP.

Based on available data and panel discussion, we concluded that the benefits of using anti-fatigue mats outweigh the potential risks. A conditional recommendation was made for using anti-fatigue mats during gastrointestinal endoscopy; however, the overall quality of evidence was very low.

GUIDELINE UPDATE

ASGE guidelines are reviewed for updates approximately every 5 years, or in the event that new data may influence a recommendation. Updates follow the same ASGE guideline development process.

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TABLES AND FIGURES: ERGONOMICS METHODOLOGY

Table 1: List of PICO questions addressed:

1. Individuals who perform GI Endoscopy	Ergonomic Training	No Training	1) Prevalence of ERI 2) Type of ERI	Critical Critical
2. Individuals who perform GI Endoscopy	Micro breaks TSMB Macro breaks	No Breaks	1) Prevalence of ERI 2) Type of ERI	Critical Critical
3. Individuals who perform GI Endoscopy	Neutral Monitor Position	Non Neutral Monitor Position	1) Prevalence of ERI 2) Type of ERI	Critical Important
4. Individuals who perform GI Endoscopy	Neutral Bed Position	Non Neutral Bed Position	1) Prevalence of ERI 2) Type of ERI	Critical Important
5. Individuals who perform GI Endoscopy	Floor Mats	No Floor Mats	1) Prevalence of ERI 2) Type of ERI	Critical Important

ERI, endoscopy- related injury

Table 2: A) GRADE categories of quality of evidence and corresponding meaning and interpretation B) Implications of the strength of GRADE recommendations on various stakeholders[26]

A)	**Quality of evidence**	**Meaning**	**Interpretation**
	High	We are confident that the true effect lies close to that of the estimate of the effect.	Further research is very unlikely to change our confidence in the estimate of the effect.
	Moderate	We are moderately confident in the estimate of the effect; the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.	Further research is likely to have an impact on our confidence in the estimate of the effect and may change the estimate.
	Low	Our confidence in the estimate of the effect is limited; the true effect may be substantially different from the estimate of the effect.	Further research is very likely to have an impact on our confidence in the estimate of the effect and is likely to change the estimate.
	Very low	We have very little confidence in the estimate of the effect; the true effect is likely to be substantially different from the estimate of the effect.	Any estimate of the effect is very uncertain.
B)	**Implications for**	**Strong recommendation**	**Conditional recommendation**
	Patients	Most individuals in this situation would want the recommended course of action, and only a small proportion would not.	Most individuals in this situation would want the suggested course of action, but many would not
	Clinicians	Most individuals should receive the test. Formal decision aids are not likely to be needed to help individual patients make decisions consistent with their values and preferences	Recognize that different choices will be appropriate for individual patients and that you must help each patient arrive at a management decision consistent with his or her values and preferences. Decision aids may be useful in helping individuals to make decisions consistent with their values and preferences
	Policymakers	The recommendation can be adopted as policy in most situations. Compliance with this recommendation according to	Policymaking will require substantial debate and involvement of various stakeholders

		the guideline could be used as a quality criterion or performance indicator.	

Table 3: Summary of Survey Studies

Author	Country	Population	Sample size	ERI %	Age	Risk Factors	Affected Area	Years in practice	Mean (SD) time spent in endoscopy	% seeking intervention; % Requiring surgery	% Time off work
Buschbacher (1994)	USA	ASGE members	265	57%	Mean (SD) 47.8+/- 8.6	Amount of time spent per week spent doing endoscopy	Low back pain (13%) Thumb pain (10%) Neck pain (10%) Elbow pain (8%) Carpal Tunnel Syndrome (4%) Shoulder Pain (3%) Hand Numbness (3%) Other (6%)	All > 0.5 y	12.4 hrs./ wk.	NA; 3.2%	NA
O'Sullivan (2002)	Canada	Endoscopists who perform ERCP	114	67%	NA	Number of years performing ERCP (>150 ERCPs/ year) Poor ergonomic room design	Back Pain (57%) Neck Pain (46%) Hand Pain (36%) Elbow (8%)	Mean (SD): injured, 14.7 (7) y; non injured, 11.6 (5.9) y	NA	55%; 8%	NA
Liberman (2005)	Canada	International members of American Society of Colon and Rectal Surgery	582	39%	Mean (SD) 48 +/- 9.5	Number of colonoscopies performed per week (> 30 colonoscopies/week)	Back (23%), neck (30.1%) Feet (33.6%) Shoulders (up to 8.9%), elbows (up to 9.7%) Hands (up to 23.4%)	Mean (SD): 14.8 (8.6) y	2.4 (1.9) d/wk.	64%; 2.6 %	1.3%
Byun (2008)	South Korea	Endoscopists practicing in general hospitals or health promotion center willing to participate	55	89.1%	Median age 39	Different sites of incidence and pain amongst experienced and beginners, Standing and posture during endoscopy	Shoulder (52%) Back (32%) Neck (25%) Right wrist (17%) Left finger (14%) Left wrist (12%)	Median duration 3.25 y	19.5 (7.7) h/wk.	28.6% , 0%	2%

Battevi (2009)	Italy	International; Endoscopists attending a GI conference in Italy	179	40%	NA	Number of endoscopies performed per month	Shoulder (16.9%) Elbow (9%) Wrist-hand (25.8%)	NA	NA	NA;NA	NA
Hansel (2009)	USA	USA; Mayo Clinic GI & non procedure-oriented internists and subspecialists	72 GI vs 104 control	73.6%	25-35: 5.6% 36-45: 47.9% 46-55: 36.6 % 56 -65: 9.9%	Angulation tip control, Torqueing with right hand, Standing for prolonged periods of time	Back (18.8%), neck (10.4%) Hands/fingers (16.7%), thumb (18.8%)	6 or more years	51.4%: 10hrs/week 13.9%: 21hrs/wk.	35.8%, 0%	13.2 %
Geraghty (2011)	UK	GI endoscopists	58	57%	NA	> 10 colonoscopies /wk.	Most common in back, neck and left thumb. Carpal tunnel and De Quervain's syndromes (7%)	N/A	N/A	NA; 5 % 17% required reduced workload. Average 3 days of work lost per endoscopist	NA
Kuwabara (2011)	Japan	Endsocopists and non endoscopoists in Hiroshima university hospital and its affiliates	190 GI vs 120 control	43%	41.4 +/- 6.7	Age > 40 years	Low back (26%) Neck (9%) Right shoulder (9%) Left thumb (8%) Hand and wrist (17%)	16.2 ± 8.1 years	11.9 ± 8.7 hours/wk.	26% ; NA 3% reduced workload	NA
Riditid (2015)	USA	ASGE members	684	53%	50.8	> 16 hours per week > 20 procedures / week Procedure volume Cumulative time spent in endoscopy	Back and neck (29.3%) Shoulder (10.2%), Elbow (10.5%) Hand (10.2%) Thumb (27.6%) Carpal tunnel syndrome (5.8%)	0-15 yrs.: 42.8 % 16 - 30 yrs.: 36.6% > 30 yrs. :20.6%	0-15 hrs. /wk.: 35.8%; 16 - 30 hrs. /wk.: 54.7%; > 30 hrs. /wk. : 9.5%	68.5 % ; 13.3%	18.5%
Austin (2019)	USA	**GI fellows**	165	20%	67%: 31 – 35 yrs., 23%: 28–30 yrs., 10%: > 36 yrs.	Female gender was associated with higher rate of injury	hand-related pain (n =28 [64%]), neck/upper back pain (n=10 [23%]), shoulder pain (n=8 [18%]), low back	≤ 4 years	N/A	73%; 2%	11%

							pain (n=8 [18%]), hand numbness/carpal tunnel syndrome (n=7 [16%]), and elbow pain (n=6 [14%]).				
Villa (2019)	USA	**GI fellows**	156	47%	25-30 yrs. 9%? 31-35 yrs.: 48% 36-40 yrs.: 16% 41+ yrs.:2%	More injuries were associated with lack of ergonomics training	Right wrist (53 %) Left thumb (42 %) Back (27 %) Neck (22%)	≤ 4 years	N/A	47% ;0%	4%
Campbell (2020)	USA	ASGE members who performed ERCP	203	Pain:46 % Injury: 32	NA	Respondents who performed fewer ERCPs tended to be less likely to have pain attributed to ERCP, especially when they performed≤50 ERCPs:	Neck pain (24%) Lower back pain (17%) De Quervain's tenosynovitis (16%) Cervical radiculopathy (12%).	1 to >20 years	N/A	NA; NA	NA
Morais (2020)	Portugal	Members of the Portugese Society of Gastroentero logy (SPG)	171	75.4	36 (26–78)	Female gender (odds ratio [OR] 2.443, 95 % confidence interval [CI] 1.166–5.121; P = 0.018) ≥ 15 years in practice (OR 3.514; 95 % CI 1.490–8.284; P = 0.004) proportion of time performing EGD (OR 0.974, 95 % CI 0.951–0.997; P = 0.026) independently associated with ERI	neck pain (30.4 %) Thumb pain (29.2 %).	Median time 9 years (range 0.5–45.0).	25 hours / wk. (range 3–52), with a higher proportion of time spent performing EGD and colonoscopy (median 30% and 6%, respectively).	NA; 1.7 22.7% did less endoscopy 61.3 % changed endoscopic technique 7.0 % reported sitting while performing endoscopy. 15.1% wore orthopedic shoes 21.8% more breaks between procedures 33.6 % of respondents reduce PA outside work.	10.1 %,

Han (2020)	USA	Endoscopists practicing TSE representing 10 countries across four continents.	45	69	45.6 [SD 7.2] years	No variables were significantly associated with development of ERI on univariate logistic regression	Shoulders (42.2 %) Back (37.8 %) Neck (33.3 %) Wrist (24.4 %) Foot (11.1 %)	12.3 (SD 8.9) years mean experience of 5.8 (SD 3.1) years performing TSE.	33.8 (SD 14.6) procedures /wk. mean total TSE volume over the course of a career was 460.2 (SD 642.6, median 180) procedures	NA; 2.2% 6.7% reduced their clinical schedule	(2.2 %),
Al-Rifale (2021)	UK	Members of the British Society of Gastroenterology, European Society of Gastrointestinal Endoscopy, and National Nurse Endoscopy Group	319	79.6	31 to 60 years (89.5%); 1.0% were less than 30 years old and 9.5% were over age 60.	Female endoscopists were found to have a significantly higher rate of CRI (P = 0.004) and to be more likely to require time off work (P = 0.0001) 42 % thought that repetitive limb strain caused ERI 40% believed that torqueing the scope & challenging body position were precipitating ERIs.	Lower back (36.5 %), Neck (35.2 %) Left thumb (33.9 %).	0-5 years:18.2 % 6-10 years : 19.7%; >10: 62.1%	<6 hours/wk. : 14.4% >6hours/wk. : 85.6%	NA; 4.3 % 30.7% made modifications in their practice	6.3%
Pawa (2021)	USA	ACG members	1698	75.2	men: mean age 52 (+/- 12.3) years, Women: mean age 45.4+/- 9.9 years	Number of years performing endoscopy (P=0.022) and number of hours performing procedures per week (p=0.009) were independently associated with ERI, Men and women tended to report different sites of ERI.	Thumb (63.3%) Neck (59%) Hand/finger (56.5%) Lower back (52.6%) Shoulder (47%) Wrist (45%).	21.11 ±12.06	< 15 hours, n = 508, 29.92% 15-30 hours, n = 976, 57.48% > 30 hours, n = 214, 12.60%	47.70% ;9.3% s	20.5%
Kamani (2021)	Pakistan	National GI conferences	61 endoscopists and 31 non endoscopists	95.08%	44.02±7.8	-	Back (41%) Leg (23%), Hand (19.7%)	≤20 yrs. :58 >20 yrs.: 3	≤5 hr/wk :53 >5 hr/wk:8	48.4 % ;NA	N/A

Matsuzaki (2022)	Japan	Endoscopists at University hospital and affiliates.	110	79.1	NA	Positive correlation between volume of ESD and lower gastrointestinal treatment and risk of ERI in back and left shoulder	Neck 47.3%, low Back 41/8% Right shoulder 28.2% Left shoulder 27.3%	> 4 years	Working hours (h/wk., mean ± SD) 54.8 (11.4)	NA;NA	17.3%
Sturm (2022)	Germany	Members of German Society of Gastroenterology and German society for endoscopy and imaging methods	151	76.8	49.4±10.4	Age is an independent risk factor for ERI. Professional experience and work time	Neck (53.6%) Back (50.3%) Shoulder (39.1%) Thumb (33.1%)	21.0±10.1 yrs	6.2±2.1 hours/day	35.8 %; 3.3% (36.4 %) impairment of leisure time activity (15.9%) reduced the number of endoscopic procedures,	9.9%
Pawa (2022)	USA	ACG GI trainee members	168	54.8	32.27 (± 2.77)	ERI is reported to occur as early as GI fellowship	Thumb (58.7%) Hand/finger (56.5%) Wrist (47.8%)	≤ 4 years	< 15 hours, n = 93, 55.36% 15-30 hours, n = 58, 34.52% > 30 hours, n = 17, 10.12%	20.83% 1.2%	2.98% reported taking time off for any injury
Miller (2022)	USA	?	64	84	44.4± 10.8	Activity-limiting MSK symptoms/injuries affect over 50% of endoscopists with negative impact on procedural volume and efficiency.	Hand wrist finger (50%) Back (37.5%) Foot/plantar fasciitis (26.6%)	18.9± 10.8yrs	185.5 ± 117.7/ Year	NA;NA Respondents reported pain that limited normal work duties (37.5%), normal work technique (25%), caused sleep disruption (9%), limited daily routine (32.8%), limited work quality/satisfaction (29.7%),	10.9%
Wenley (2022)	USA	Pediatric GI and trainees who attended NASPGHAN 2019 annual meeting	146 50/146 trainees	34.7%	NA	Women were more likely to experience ERI compared to men (43.4% vs. 23.4%; *p* = 0.013). Maneuvers contributing to ERI were standing in an awkward position (46.0%), application of torque (44.0%), prolonged standing (42.0%), tip angulation	Neck/upper back (44.0%) Thumb (42.0%) Hand/finger (38.0%), Lower back (36.0%)	Fellow 50 (34.2%) 1–5 y: 33 (22.6%) 6–10 21 (14.4%) 11–1514 (9.6%)	Hours/week 0-5:82(56.2%) 6-10:42(28.8% 11-15:15 (10.3%) 16-20:4(2.7%) >20:3(2.1%)	24% , NA	8%took time off 32% adjusted their practice

						adjustment (38.0%), and patient positioning (20.0%). 20.9% of participants had formal training in ergonomics.		16–20 9 (6.2%) > 2019 (13.0%)			
Shah (2022)	Pakistan	3 tertiary centers in Karachi and included endoscopists, nurses and technicians	56	75% with only 33.3% attributed symptoms to endoscopy.	35.09 (18-62)	None	Neck (41.1%) Lower back (32.1%) Shoulder (21.4%) Thumb (12.5%) Hand (23.2%) Elbow (8.9%) Carpal tunnel syndrome (CTS) (7.1%)	5 years: 48.9% >5 years: 51%	Mean number of endoscopies per week :63.85	33.9% , NA	21.4% of our respondents had to take time off from work due to endoscopy-related pain
Bessone (2022)	Germany	Worldwide online survey, for doctors and nurses currently performing endoscopy	204	89 % doctors 11% Nurses	25–34 yrs. :19 35–44 yrs. : 69 45–54 yrs. : 75, 55–64 yrs. 36 > 65 yrs.: 5	Female clinicians more prone to ERI(P = 0.001) > 15 hours/week (P = 0.041) or performing more than 15 procedures/week (P = 0.020) Taller physicians reported a higher incidence knee and ankle injury (both P < 0.05) Physicians performing a leisure activity involving the use of the fingers (e.g. videogames, playing a musical instrument) reported more ERI in the thumb (P = 0.052).	Neck 45.7 % Shoulder 36.4% Thumb 36.4% Wrist 31.8%	85 % of the responders had at least five years of experience, and 73 % had experience in ERCP	>10 hours/week	53%; 2%	NA

Table 4: Evidence profile for PICO 1: ergonomic training vs no training to reduce the risk of endoscopy related injuries

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Knowledge of Ergonomic techniques									
1	observational studies	not serious	not serious	not serious	serious	none	**Ahmed et al. 2016 (abstract)** • 58 GI fellows. • **Prospective non-randomized value of video training** • Pre-training test • 6 min teaching video • Post test • 20% increase in right answers	⊕◯◯◯ Very low	CRITICAL
Decrease in Rapid entire body assessment (REBA) score									
1	case control	not serious	not serious	serious	serious	none	**Khan et al. GIE 2020** • 15 fellows vs. 15 historical control • Simulation + ergonomic training vs. simulation training alone • **REBA score was improved in the intervention group** • Median REBA score was 6 vs 11; p< .001 • Ergonomic training: didactics, video based teaching, ergonomic specific feedback, ergonomic checklist.	⊕⊕◯◯ Low	CRITICAL

Improvement in post intervention scores

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
1	observational studies	not serious	not serious	not serious	serious	none	**Ali et al. 2019** _prospective non randomized non blinded_ - • pre and post-intervention survey + questions on principles on endoscopic procedure ergonomics. • 1 month intervention education: poster + 22min ASGE video. • 32 staff members (56% no prior training). • Avg score pre-intervention 30%, increase to 69% (no p ?provided) scores increased re: mechanism of injury and specific ergonomics recommendation.	⊕◯◯◯ Very low	CRITICAL
Physical therapy assessment									
1	observational studies	not serious	not serious	not serious	serious	none	**Markwell et al.** 2021 • Intervention: Physical therapist assessment of 2 colonoscopies and creation of individualized wellness plan. • Assessment: Pain (Nordic Muscoloskeletal Questionnaire), Static posture assessment dynamic posture assessment procedure suite ergonomic assessment • Results: 63% pain sites were reduced in intensity or resolved.	⊕◯◯◯ Very low	CRITICAL
Better RULA scores									
1	randomized trials	not serious	not serious	serious	serious	none	**Van't Hullenaar et al. 2018 (surgeons)** • Standard Davinci training(n=13) vs. std training+ ergonomic training (n=13) (written guide, person instruction and verbal coaching) • Outcome: increase in RULA score Intervention group with better RULA score for both R and L side of body for exercises($p<.05$).	⊕⊕◯◯ Low	CRITICAL

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
ergonomics curriculum									
1	Observational Studies	not serious	not serious	serious	serious	none	**Sussman et al. DDS 2020 *Retrospective study*** • 2 modules 60 min each lead by physical therapists • pre survey and post survey (after modules) • 100% of participants felt this was a valuable topic, feel better, perform better • ALL reported immediate decrease in physical discomfort (mean 4.8/5) after engaging in the exercises • 100% of fellows indicated they felt this ergonomics training would likely help them to "physically perform better during procedures" • 100% of fellows reported a reduction of physical discomfort (pain, aching) immediately after doing the exercises during Module 2.	⊕⊕◯◯ Low	CRITICAL
Targeted Ergonomics Training									
1	Observational Studies	not serious	not serious	serious	serious	none	**Allespach et al. Journal of Surgical Education. 2020** • 36 third year medical students and surgical residents PGY1-7 • 3 modules lead by PT. Modules included didactics on ergonomics, posture, micro break model, stretching exercises. • Pre and post lecture surveys. • 93% felt that ergonomics training would help them perform better in OR • 85% felt reduction of physical discomfort after performing exercises and micro breaks model would help. Pain decreased most in neck (22 %) and lower back. (22%)	⊕⊕◯◯ Low	CRITICAL

Table 5: Evidence profile for PICO 2: Micro breaks and scheduled macro breaks compared to no breaks to reduce the risk of endoscopy related injuries

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Decrease in ERI									
1	observational studies	not serious	not serious	not serious	not serious	none	**Pawa et al. AJG 2021** • ACG survey -554 respondents took **micro breaks** (ERI = 69%) vs 894 respondents who did not take micro breaks. (ERI 75 %), OR=0.69 (0.54 - 0.87), p=0.016 • 464 respondents took **macro breaks / split schedules** (ERI 71%) vs 1219 who did not take breaks or had split schedules (ERI 78%.) OR = 0.72 [0.57 -0.92], p=.002	⨁⨁◯◯ Low	CRITICAL
Improvement in post procedure pain score									
2	observational studies	not serious	not serious	serious	serious	none	**Park AE et al. Annals of Surgery, 2017.** • 66 surgeons (academic and private) • Taught how to perform targeted stretching micro breaks (TSMB) • Micro breaks with associated with (1) Improvement in post procedure pain p >.05 (2) Physical performance: 57% (3) Mental focus: 38% 87% planned to continue TSMB. Operative duration did not differ(p>.05) **Hallbeck et al. Applied Ergonomics. 2016** • 56 surgeons in 4 academic centers • Taught micro break techniques Micro breaks associated with: 1) improvement in shoulder pain p=.006, 2) overall improvement in physical performance (57% reported improvement) 3) and mental focus (34% improvement, 12% reported decline) • Did not negatively affect surgical time.	⨁◯◯◯ Very low	IMPORTANT

Table 6: Evidence profile for PICO 3: Use of neutral monitor position vs non-neutral position to reduce the risk of endoscopy related injuries

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Monitor Distance									
1	observational studies	not serious	not serious	very serious	very serious	none	**Shallaly et al. Surg Endosc 2006.** • 14 laparoscopic surgeons • Find range of optimal working distance of standard 14-inch diagonal CRT monitor for laparoscopic surgery. • Both maximum and minimal distance variable between individuals • Surgeon should be within 3 feet to 10 feet distance from the monitor when performing surgery	⨁◯◯◯ Very low	CRITICAL

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
2	observational studies	not serious	not serious	not serious	serious	none	Mattern et al. Surg Endosc 2005 • 18 subjects with no prior surgical experience • Simulated laparoscopic suturing by threading pearls with curved needle using two needle holders • Influence of monitor position on task performance and neck muscle strain monitor positions were used: A) frontal at eye level, B) frontal at height of operating field, C) 45 degrees to right side of eye level. • EMG activity of main neck muscle was significantly lower for position A compared to B and C. (p <005) • Task performance (measured by number of pearls threaded) was highest for position B. statistically significant for position B compared to C (p=.0008) and but there was no statistical difference between position A and B or A and C. Haveran et al. Surg Endosc 2007 • 12 experience surgical residents and 12 non-experience trainees • One handed task with their dominant hand in a laparoscopic trainer. • Camera location was fixed and monitor location was varied to the right /left/ center and vice versa for 6 positions. • Best performance when monitor was directly in front rather than either on right or left side.	⨁◯◯◯ Very low	CRITICAL

Table 7: Evidence profile PICO 4: Use of neutral bed height vs non-neutral height to reduce the risk of endoscopy related injuries

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
Procedure difficulty and Post procedure discomfort									
2	observational studies	not serious	not serious	serious	serious[a]	none	**Berquer et al. Surg Endosc, 2002.** • 21 surgeons performed a 1/4th circle cutting task at 5 laparoscopic instrument handle heights *-20,-10, 0, 10, 20" relative to elbow height. • Difficulty and discomfort rated on VAS. • Skin conductance, EMG signal and arm orientation • Statistically significant changes in subjective rating of discomfort, deltoid and trapezius EMG, arm elevation. • Laparoscopic surgery physicians had to flex their trunks during a task to accommodate a lower table height, and then there was more discomfort with higher difficulty rating. • Optimal table height in this study was between elbow height and 10 cm below the elbow height. **Veelen et al. Journal of Laparoendoscopic & adv surgical techniques, 2002** • Two pelvi-trainer tests were performed • test 1 on 6 different operating surface heights. Extreme joint excursion was measured with video analysis. • test 2 was to hold laparoscope for 15 minutes. EMG of BB was done. • laparoscopic surgery optimal table height was 70% to 80% of elbow height, • Allowed the joints to stay in neutral position over 90% of the procedure time. • Activity of EMG stays within 15 % of the maximum muscle activity	⨁◯◯◯ Very low	CRITICAL

Table 8: Evidence profile for PICO 5: use of floor mats vs no floor mats to reduce the risk of endoscopy related injuries

Certainty assessment							Impact	Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations			
volume									
1	randomised trials	not serious	not serious	serious	serious	none	**Haramis et al.** Prospectively randomized 50 patients each group (gel vs no gel)-18 providers • **Post-operative evaluation:** • Sitting time p< .001 • # stretched 1.28 vs 2.8 (p=.001) • #breaks 1 vs 2.8 (p=.001) • Pain: **Feet 1 v 2.26 (p=.003)** Ankle p=.281 **Knees 1.28 vs 2 (p=.001)** Hips 1.2 vs 1.3 (p=.108) **Back 1 vs 3.08 (p=.001)** Shoulders 1.6 vs 1.6 p=.731 Neck 1.56 vs 1.94 p=.069 **Overall discomfort 1 vs 2.4 (p=.001) Overall energy 8.7 vs 8 p=.049** • **24 hrs post gel vs non gel** • Pain Feet 1.24 vs 1.64 p=.004 Overall discomfort 1.24 vs 1.8 (p=.001) Overall energy 9.3 vs 8.88 (p=.044)	⊕⊕◯◯ Low	CRITICAL
New outcome									
1	observational studies	not serious	not serious	not serious	serious	none	**Graversen et al.** • 100 procedures/11 surgeons; 50 per group • **Procedures < 60 min.** no gel mat vs. gel mat: • Post op discomfort (p=.044) and post op energy (p=.0411) • **Procedures >60 min** no gel mat vs. gel mat • Post op discomfort (p=.048), post op energy (p=.049) • Posture changes (p=.039), Stretches (p=.024), Post op discomfort (p=.048), post op energy (p=.049)	⊕◯◯◯ Very low	CRITICAL

Acronyms:

ACG	American College of Gastroenterology
ASGE	American Society for Gastrointestinal Endoscopy
CI	Confidence interval
ERCP	Endoscopic retrograde cholangiopancreatography
ERI	Endoscopic Related Injury
GI	Gastrointestinal
GE	Gastroenterologists
GRADE	Grading of Recommendations Assessment, Development and Evaluation
IQR	Interquartile range
MA	Meta-analysis
MIS	Minimally invasive surgery
OR	Odds ratio
0SHA	Occupational Safety and Health Administration
PICO	Populations in question, intervention, comparator, outcomes of interest
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-analyses
RCT	Randomized controlled trial
RR	Relative risk
SOP	Standards of Practice
SR	Systematic review
SRMA	Systematic review and meta-analysis
TSE	Third space endoscopy

REBA	Rapid Entire Body Assessment
RULA	Rapid Upper Limb Assessment
TSMB	Targeted Stretching Microbreaks
NASA-TLX	National Aeronautics and Space Administration Task Load Index
SURG-TLX	Surgery Task Load Index