Communication from the ASGE Standards of Practice Committee

GUIDELINE

ASGE American Society for Gastrointestinal Endoscopy

American Society for Gastrointestinal Endoscopy guideline on the role of ergonomics for prevention of endoscopy-related injury: methodology and review of evidence

Prepared by: ASGE STANDARDS OF PRACTICE COMMITTEE

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This document was reviewed and approved by the Governing Board of the American Society for Gastrointestinal Endoscopy.

This guideline document was prepared by the Standards of Practice Committee of the American Society for Gastrointestinal Endoscopy using the best available scientific evidence and considering a multitude of variables including but not limited to adverse events, patient 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 because of 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.

Endoscopists are at high risk for endoscopy-related injuries (ERIs) with an occurrence approaching 89%.[1-19] ERI is a work-related musculoskeletal disorder caused by 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, with 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 has developed evidence-based guidelines on the role of ergonomics for prevention of ERI in gastroenterology based on GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) methodology.[23,24]

The aim of this article 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 article includes outcomes of interest and evidence considered by the panel in making final recommendations. The accompanying article, subtitled "Summary and Recommendations," provides a summary of the main findings and final recommendations of the ASGE Standards of Practice Committee for strategies to prevent ERI.

TABLE 1. List of population, intervention, comparator, outcomes questions addressed

Population	Intervention	Comparator	Outcomes*	Rating
1. Individuals who perform GI endoscopy	Ergonomics training	No training	Prevalence of ERI Type of ERI	Critical Critical
2. Individuals who perform GI endoscopy	Microbreaks Targeted stretching microbreaks Macrobreaks	No breaks	Prevalence of ERI Type of ERI	Critical Critical
3. Individuals who perform GI endoscopy	Neutral monitor position	Non-neutral monitor position	Prevalence of ERI Type of ERI	Critical Important
4. Individuals who perform GI endoscopy	Neutral bed position	Non-neutral bed position	Prevalence of ERI Type of ERI	Critical Important
5. Individuals who perform GI endoscopy	Floor mats	No floor mats	Prevalence of ERI Type of ERI	Critical Important

ERI, Endoscopy-related injury.

METHODS

Formulation of clinical questions

The panel addressed 5 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 reviews and meta-analyses to address the pertinent questions. A health sciences librarian developed the search strategy and searched the following databases on April 20, 2020 for all PICO questions: PubMed (coverage 1946 to present), Embase and Embase Classic (coverage 1947 to present), Cochrane Library (coverage 1898 to present), and Web of Science (coverage 1900 to present) (Fig. 1). 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 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 (eg, laparoscopic surgery) were also included.

A combination of subject headings (when available) and key words was used, and results are provided in Appendix 1 (available online at www.giejournal.org). 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, Penn, USA), duplicates were removed using the Bramer et al[25] method, and results were uploaded into Covidence (Melbourne, Australia) for screening.

Data extraction and statistical analysis

Three independent reviewers (S.P., R.S.K., and D.S.F.) performed data extraction for all systematic reviews and cross-sectional studies for PICO questions 1 through 5. Studies were first screened by title, abstract, and then by full text by 2 independent reviewers (S.P. and D.S.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. An additional data extraction was performed by 2 authors (S.P. and N.C.T.) for the meta-analyses to assess the prevalence of ERI and risk factors using Covidence.

The summary statistics included the odds ratio (OR), risk ratio, 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 (StataCorp, College Station, Tex, USA).

Panel composition and conflict of interest management

On November 15, 2021, we assembled a panel of stakeholders to review evidence and make recommendations. The panel consisted of lead authors (S.P., R.S.K., and D.S.F.); content experts independent of the Standards of Practice Committee (A.S. and S.C.G.); a GRADE methodologist (N.C.T.); Standards of Practice Committee members with expertise in methodology, systematic reviews, and

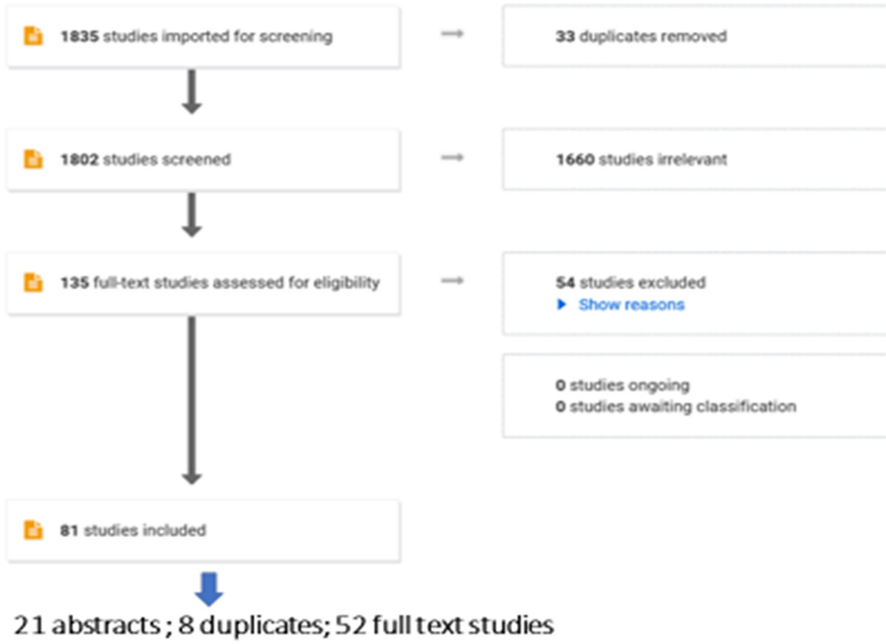

Figure 1. Preferred Reporting Items for Systematic reviews and Meta-Analyses diagram showing studies included in the systematic review evaluating the rates of endsocopic related injury , predictors, of endosopic related injury, and role of ergonomics for prevention of endoscopic related injury.

meta-analyses; and the Standards of Practice Chair (B.J. Q.). A patient representative was not included because 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 PICO questions 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.C.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 macrobreaks, neutral monitor positions, neutral bed heights, antifatigue mats, and use of ancillary devices. Other outcomes reported were scores on ergonomics tests, joint pain, 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 *Gastrointestinal Endoscopy* Editorial Board and Governing Board and was made available for public comment on the ASGE website.

RESULTS

Rates and sites of ERIs

For this question, we performed a systematic review and meta-analysis. Our search identified 17 survey studies assessing the prevalence of ERIs among 5227 GI endoscopists responding to the surveys. Fourteen of 17 included studies evaluated practicing gastroenterologists,[1,2,4-14,29] 1 study evaluated colorectal surgeons,[3] and 2 studies evaluated GI trainees.[30,31] Outcomes of interest were overall rate of ERI among endoscopists and most common sites for ERI. We found that the overall rate of ERI was 57.7% (95% confidence interval [CI], 48.8-66.1; $I^2 = 93\%$). The most common sites of ERIs were hands and fingers, back, and neck.

Predictors of ERI

Our systematic review identified 24 survey studies in the gastroenterology literature.[1-14,16-19,30-35] Eleven studies were conducted in the United States, 2 in Canada, 1 in Italy, 2 in Germany, 2 in the United Kingdom, 2 in Japan, 1 in South Korea, 1 in Portugal, and 2 in Pakistan. Fifteen

TABLE 2. GRADE categories of quality of evidence and corresponding meaning and interpretation and implications of the strength of GRADE recommendations on various stakeholders[26]

Quality of evidence	Meaning	Interpretation
High	We are confident 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.
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 the guideline could be used as a quality criterion or performance indicator.	Policymaking will require substantial debate and involvement of various stakeholders.

GRADE, Grading of Recommendations Assessment, Development, and Evaluation.

studies included endoscopists practicing all forms of GI endoscopy. One study included colonoscopists only, 2 included endoscopists who performed ERCP, and 2 included endoscopists who performed third-space endoscopy (TSE). Four studies surveyed GI trainees and 1 study pediatric gastroenterologists. A summary of all survey studies can be found in Table 3. We identified 2 major ERI predictors: endoscopist gender and procedure volume.

Gender of the endoscopist. Our systematic review identified 8 eligible studies that included 3355 GI respondents.[5,9,10,13,14,29] Two studies were specific to GI trainees.[30,31] The overall rate of ERI in female endoscopists was 62.4% (95% CI, 46.7-75.9), whereas the overall rate of ERI in male endoscopists was 45.5% (95% CI, 28.1-64.0). Harmonization of comparative studies revealed that female endoscopists had higher odds of developing ERIs than their male counterparts (OR, 1.79; 95% CI, 1.35-2.38; $P < .01$, $I^2 = 64\%$).

The panel also noted that injury mechanisms may differ between male and female endoscopists based on 1 study.[13] A recent study published in abstract form highlighted the different endoscopy styles between male and female endoscopists. Their results found that female GI endoscopists prefer holding the endoscope with the umbilical cord inside the forearm, using the right hand to turn the small wheel, and using a pediatric colonoscope to perform colonoscopy.[29]

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 a greater number of hours performing endoscopy and a greater number of years performing endoscopy.[1-6,8-10,13,16,17,19] Pawa et al[13] conducted a survey study of physician members of the American College of Gastroenterology with 1698 respondents. On multivariable analysis, the number of hours performing endoscopies per week ($P = .009$) and the number of years in practice ($P = .02$) were the predominant predictors of ERI. Morais et al[10] surveyed 171 endoscopists in Europe and reported that the number of years in practice (>15 years, $P = .03$) was an independent risk factor of ERI. Notably, an independent association was observed between female gender and musculoskeletal injury and severe pain.[10] Ridtitid et al[9] surveyed 684 ASGE members and found that higher procedure volume (>20 endoscopies a week, $P < .001$), longer scope hours per week (>16 hours a week, $P < .001$), and a higher total number of years performing endoscopy ($P = .004$) were associated with higher rates of ERI. Endoscopy volume as a risk factor appears to be consistent with other specialties and caregivers as well.[3] A recent international survey involving 82 physicians and 22 nurses who performed endoscopy showed that using the endoscope for more than 15 hours a week ($\chi^2 = 4.18$, $P = .04$) or performing more than 15 procedures a week ($\chi^2 = 5.42$, $P = .02$) were related to ERI.[19]

ERI in interventional endoscopists is also increasingly reported, although these studies are limited by their small sample size. Campbell et al[12] surveyed 203 ASGE members who performed ERCP (ranging from 1 to 500 per year) and found that 46% attributed their pain (neck pain, 24%; lower back pain, 17% [the most prevalent]) to performing ERCPs. This was particularly true for those who performed ≥100 ERCPs per year when compared with those who performed ≤50 ERCPs. Furthermore, 16% (n = 32) attributed musculoskeletal injuries such as De Quervain's tenosynovitis and 12% (n = 25) attributed cervical radiculopathy 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 TSE procedures. Twenty-two of 31 endoscopists who reported ERIs believed their symptoms began after starting TSE. Additionally, 48.9% of all endoscopists reported more symptoms after TSE compared with ERCP and EUS.[11] Matsuzaki et al[16] studied ERI in 110 endoscopists who performed TSE and found a positive correlation between endoscopic submucosal dissection (ESD) volume and risk for ERI. The authors found that longer upper ESD procedure times (total time, ≥81 minutes per month; OR, 5.7; 95% CI, 1.3-25.0), lower ESD (total time, 1-90 minutes a month; OR, 4.9; 95% CI, 1.1-22.0), and lower GI treatment (total time, ≥526 minutes a month; OR, 5.6; 95% CI, 2.3-13.3) were significantly associated with low-back symptoms. Moreover, lower ESD (total time, 91-180 minutes a month; OR, 5.0; 95% CI, 1.2-20.2) was a risk factor for symptoms in the left shoulder.[16] Our systematic review revealed 4 survey studies in gastroenterology trainees in which emergence of ERI was seen as early as <1 year of performing endoscopy, with increasing occurrence over time.[10,30-32]

Interventions to reduce risk of ERI

Our search identified very few randomized controlled trials and other high-quality prospective trials addressing any of the questions. Therefore, the quality of 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, joint pain, 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 varied and included informal short written guides or posters hanging in the endoscopy unit and ASGE videos[36] that resulted in improved awareness of ergonomics (based on improvement on post-training test scores). Another similar study looked at the outcomes on a written test taken by 58 fellows after a 6-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[38] compared REBA scores in 30 postgraduate trainees who underwent a formal ergonomics training curriculum with 25 historical control subjects who did not. The curriculum in this study consisted of a 1-hour lecture, 5-minute video, expert feedback, and an ergonomics checklist for reference. During 2 colonoscopies 6 weeks after training, the authors reported improved REBA scores in those who underwent ergonomics training compared with those 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 with the control group.

A few studies demonstrated that formalized ergonomics training given by physical therapists is beneficial. Markwell et al[40] studied pain and posture assessment in 8

TABLE 3. Summary of survey studies

Author and year	Country	Population	Sample size	ERI (%)	Age (y)	Risk factors
Buschbacher (1994)[1]	USA	ASGE members	265	57	47.8 ± 8.6	Amount of time spent per week spent doing endoscopy
O'Sullivan (2002)[2]	Canada	Endoscopists who perform ERCP	114	67	NA	Number of years performing ERCP (>150 ERCPs/y) Poor ergonomic room design
Liberman (2005)[3]	Canada	International members of American Society of Colon and Rectal Surgery	582	39	48 ± 9.5	Number of colonoscopies performed per week (>30 colonoscopies/wk)
Byun (2008)[5]	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 among experienced and beginners Standing and posture during endoscopy
Battevi (2009)[7]	Italy	International; endoscopists attending a gastroenterology conference in Italy	179	40	NA	Number of endoscopies performed per month
Hansel (2009)[4]	USA	USA; Mayo Clinic gastroenterology and nonprocedure-oriented internists and subspecialists	72 gastroenterology 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
Geraghty (2011)[8]	UK	GI endoscopists	58	57	NA	> 10 colonoscopies /wk
Kuwabara (2011)[6]	Japan	Endoscopists and nonendoscopists in Hiroshima University Hospital and its affiliates	190 gastroenterology vs 120 control	43	41.4 ± 6.7	Age >40 y
Riditid (2015)[9]	USA	ASGE members	684	53	50.8	>16 h/wk >20 procedures/wk Procedure volume Cumulative time spent in endoscopy
Austin (2019)[30]	USA	Gastroenterology fellows	165	20	67%: 31-35; 23%: 28-30; 10%: >36	Female gender was associated with higher rate of injury
Villa (2019)[31]	USA	Gastroenterology fellows	156	47	25-30: 9% 31-35: 48% 36-40: 16% 41+: 2%	More injuries were associated with lack of ergonomics training
Campbell (2020)[12]	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
Morais (2020)[10]	Portugal	Members of the Portuguese Society of Gastroenterology	171	75.4	36 (26-78)	Female gender (OR, 2.443; 95% CI, 1.166-5.121; P = .018) ≥15 y in practice (OR, 3.514; 95% CI, 1.490-8.284; P = .004) Proportion of time performing EGD (OR, .974; 95% CI, .951-.997; P = .026) independently associated with ERI

ERI, Endoscopy-related injury; *CRI*, colonoscopy-related musculoskeletal injury; *SD*, standard deviation; *ASGE*, American Society for Gastrointestinal Endoscopy; *NA*, not available; *OR*, odds ratio; *CI*, confidence interval.

TABLE 3. Continued

Affected area	Years in practice	Mean (SD) time spent in endoscopy	Percentage seeking intervention; percentage requiring surgery	Time off work (%)
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 >.5	12.4 h/wk	NA; 3.2	NA
Back pain (57%) Neck pain (46%) Hand pain (36%) Elbow (8%)	Mean (SD): injured, 14.7 (7); noninjured, 11.6 (5.9)	NA	55; 8	NA
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)	2.4 (1.9) days/wk	64; 2.6	1.3
Shoulder (52%), back (32%), neck (25%), right wrist (17%), left finger (14%), left wrist (12%)	Median duration 3.25	19.5 (7.7) h/wk	28.6 , 0	2
Shoulder (16.9%), elbow (9%), wrist and hand (25.8%)	NA	NA	NA; NA	NA
Back (18.8%), neck (10.4%), hands/fingers (16.7%), thumb (18.8%)	≥6	51.4%: 10 h/wk 13.9%: 21 h/wk	35.8; 0	13.2
Most common in back, neck, and left thumb. Carpal tunnel and De Quervain's syndromes (7%)	NA	NA	NA; 5 17% required reduced workload. Average 3 days of work lost per endoscopist	NA
Low back (26%), neck (9%), right shoulder (9%), left thumb (8%), hand and wrist (17%)	16.2 ± 8.1	11.9 ± 8.7 h/wk	26 ; NA 3% reduced workload	NA
Back and neck (29.3%), shoulder (10.2%), elbow (10.5%), hand (10.2%), thumb (27.6%), carpal tunnel syndrome (5.8%)	0-15: 42.8% 16-30: 36.6% >30: 20.6%	0-15 h/wk: 35.8%; 16-30 h/wk: 54.7%; >30 h/wk: 9.5%	68.5; 13.3	18.5
Hand-related pain (n = 28 [64%]), neck/upper back pain (n = 10 [23%]), shoulder pain (n = 8 [18%]), low-back pain (n = 8 [18%]), hand numbness/carpal tunnel syndrome (n = 7 [16%]), and elbow pain (n = 6 [14%])	≤4	NA	73; 2	11
Right wrist (53%) Left thumb (42%) Back (27%) Neck (22%)	≤4	NA	47; 0	4
Neck pain (24%), lower back pain (17%), De Quervain's tenosynovitis (16%), cervical radiculopathy (12%)	1 to >20	NA	NA; NA	NA
Neck pain (30.4 %) Thumb pain (29.2 %).	Median time 9 (range, .5-45.0)	25 h/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 reduced physical activity outside work	10.1

TABLE 3. Continued

Author and year	Country	Population	Sample size	ERI (%)	Age (y)	Risk factors
Han (2020)[11]	USA	Endoscopists practicing third-space endoscopy representing 10 countries across 4 continents	45	69	45.6 (SD, 7.2)	No variables were significantly associated with development of ERI on univariate logistic regression
Al-Rifale (2021)[14]	UK	Members of the British Society of Gastroenterology, European Society of Gastrointestinal Endoscopy, and National Nurse Endoscopy Group	319	79.6	31-60 (89.5%); 1.0% were less than 30 y and 9.5% were over age 60	Female endoscopists were found to have a significantly higher rate of CRI ($P = .004$) and to be more likely to require time off work ($P = .0001$) 42% believed that repetitive limb strain caused CRI 40% believed that torqueing the scope and challenging body position were precipitating CRIs
Pawa (2021)[13]	USA	American College of Gastroenterology members	1698	75.2	Men: mean age 52 ± 12.3; women: mean age 45.4 ± 9.9	Number of years performing endoscopy ($P = .022$) and number of hours performing procedures per week ($P = .009$) were independently associated with ERI Men and women tended to report different sites of ERI
Kamani (2021)[35]	Pakistan	National gastroenterology conferences	61 endoscopists and 31 nonendoscopists	95.08	44.02 ± 7.8	—
Matsuzaki (2022)[16]	Japan	Endoscopists at university hospital and affiliates	110	79.1	NA	Positive correlation between volume of endoscopic submucosal dissection and lower GI treatment and risk of ERI in back and left shoulder
Sturm (2022)[17]	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
Pawa (2022)[13]	USA	American College of Gastroenterology gastroenterologist trainee members	168	54.8	32.27 ± 2.77	ERI is reported to occur as early as gastroenterology fellowship
Miller (2022)[34]	USA	?	64	84	44.4 ± 10.8	Activity-limiting musculoskeletal symptoms/injuries affect over 50% of endoscopists with negative impact on procedural volume and efficiency
Wenley (2022)	USA	Pediatric gastroenterologists and trainees who attended NASPGHAN 2019 annual meeting	146 50/146 trainees	34.7	NA	Women were more likely to experience ERI compared with men (43.4% vs 23.4%; $P = .013$) Maneuvers contributing to ERI were standing in an awkward position (46.0%), application of torque (44.0%), prolonged standing (42.0%), tip angulation adjustment (38.0%), and patient positioning (20.0%) 20.9% of participants had formal training in ergonomics
Shah (2022)[18]	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
Bessone (2022)[19]	Germany	Worldwide online survey for doctors and nurses currently performing endoscopy	204	89% doctors 11% nurses	25-34: 19 35-44: 69 45-54: 75 55-64: 36 >65: 5	Female clinicians more prone to ERI ($P = .001$) >15 h/wk ($P = .041$) or performing more than 15 procedures/wk ($P = .020$) Taller physicians reported a higher incidence knee and ankle injury (both $P < .05$) Physicians performing a leisure activity involving the use of the fingers (eg, video games, playing a musical instrument) reported more ERI in the thumb ($P = .052$)

TABLE 3. Continued

Affected area	Years in practice	Mean (SD) time spent in endoscopy	Percentage seeking intervention; percentage requiring surgery	Time off work (%)
Shoulders (42.2%) Back (37.8%) Neck (33.3%) Wrist (24.4%) Foot (11.1%)	12.3 (SD 8.9) mean experience of 5.8 (SD 3.1) performing third-space endoscopy	33.8 (SD 14.6) procedures/wk Mean total third-space endoscopy 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
Lower back (36.5%), neck (35.2%), left thumb (33.9%).	0-5: 18.2% 6-10: 19.7%; >10: 62.1%	<6 h/wk: 14.4% >6 h/wk: 85.6%	NA; 4.3 30.7% made modifications in their practice	6.3
Thumb (63.3%) Neck (59%) Hand/finger (56.5%) Lower back (52.6%) Shoulder (47%) Wrist (45%)	21.11 ± 12.06	<15 h, n = 508, 29.92% 15-30 h, n = 976, 57.48% >30 h, n = 214, 12.60%	47.70; 9.3	20.5
Back (41%) Leg (23%) Hand (19.7%)	≤20: 58 >20: 3	≤5 h/wk:5 3 >5 h/wk: 8	48.4; NA	NA
Neck 47.3% Low back 41.8% Right shoulder 28.2% Left shoulder 27.3%	>4	Working hours (54.8 ± 11.4 h/wk)	NA; NA	17.3
Neck (53.6%) Back (50.3%) Shoulder (39.1%) Thumb (33.1%)	21.0 ± 10.1	6.2 ± 2.1 h/day	35.8; 3.3 (36.4%) impairment of leisure time activity (15.9%) reduced the number of endoscopic procedures	9.9
Thumb (58.7%) Hand/finger (56.5%) Wrist (47.8%)	≤4	<15 h, n = 93, 55.36% 15-30 h, n = 58, 34.52% >30 h, n = 17, 10.12%	20.83; 1.2	2.98 reported taking time off for any injury
Hand, wrist, finger (50%) Back (37.5%) Foot/plantar fasciitis (26.6%)	18.9 ± 10.8	185.5 ± 117.7/y	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
Neck/upper back (44.0%) Thumb (42.0%) Hand/finger (38.0%) Lower back (36.0%)	Fellow: 50 (34.2%) 1-5: 33 (22.6%) 6-10: 21 (14.4%) 11-15: 14 (9.6%) 16-20: 9 (6.2%) >20: 19 (13.0%)	0-5 h/wk: 82 (56.2%) 6-10 h/wk: 42 (28.8% 11-15 h/wk: 15 (10.3%) 16-20 h/wk: 4 (2.7%) >20 h/wk: 3 (2.1%)	24; NA	8% took time off 32% adjusted their practice
Neck (41.1%) Lower back (32.1%) Shoulder (21.4%) Thumb (12.5%) Hand (23.2%) Elbow (8.9%) Carpal tunnel syndrome (7.1%)	5: 48.9% >5: 51%	Mean number of endoscopies per week: 63.85	33.9; NA	21.4% of our respondents had to take time off from work because of endoscopy-related pain
Neck 45.7% Shoulder 36.4% Thumb 36.4% Wrist 31.8%	85% of responders had at least 5 y of experience and 73% had experience in ERCP	>10 h/wk	53; 2	NA

TABLE 4. Evidence profile for population, intervention, comparator, outcomes question 1: ergonomics training vs no training to reduce the risk of endoscopy-related injuries

Certainty assessment									
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Impact	Certainty	Importance
Knowledge of ergonomic techniques									
1	Observational studies	Not serious	Not serious	Not serious	Serious	None	Ahmed et al 2016[37] (abstract) • 58 gastroenterology fellows • Prospective nonrandomized value of video training • Pretraining test • 6-min teaching video • Post-test • 20% increase in right answers	⨁◯◯◯ Very low	CRITICAL
Decrease in REBA score									
1	Case control	Not serious	Not serious	Serious	Serious	None	Khan et al 2020[38] • 15 fellows vs 15 historical control subjects • Simulation + ergonomics training vs simulation training alone • REBA score was improved in the intervention group • Median REBA score was 6 vs 11; $P < .001$ • Ergonomics training: didactics, video-based teaching, ergonomics-specific feedback, ergonomics checklist	⨁⨁◯◯ Low	CRITICAL
Improvement in postintervention scores									
1	Observational studies	Not serious	Not serious	Not serious	Serious	None	Ali et al 2019[36] prospective nonrandomized nonblinded • Pre- and postintervention survey + questions on principles on endoscopic procedure ergonomics • 1-month intervention education: poster + 22-min American Society for Gastrointestinal Endoscopy video • 32 staff members (56% no prior training) • Average score preintervention 30%, increased to 69% (no *P* value provided); scores increased regarding 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[40] • Intervention: physical therapist assessment of 2 colonoscopies and creation of individualized wellness plan • Assessment: pain (Nordic Musculoskeletal Questionnaire), static posture assessment, dynamic posture assessment procedure suite, ergonomics assessment • Results: 63% of 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[39] (surgeons) • Standard da Vinci training (n = 13) vs standard training + ergonomics training (n = 13) (written guide, in-person instruction, and verbal coaching)	⨁⨁◯◯ Low	CRITICAL

(*continued on the next page*)

TABLE 4. Continued

Certainty assessment									
No. of studies	**Study design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Impact**	**Certainty**	**Importance**
							• Outcome increase in RULA score, intervention group with better RULA score for both right and left side of the body for exercises($P < .05$)		
Ergonomics curriculum									
1	Observational studies	Not serious	Not serious	Serious	Serious	None	Sussman et al 2020[42] *Retrospective study* • 2 modules, 60 min each led by physical therapists • Pre- and postsurvey (after modules) • 100% of participants believed this was a valuable topic, felt better, performed better • All reported immediate decrease in physical discomfort (mean, 4.8/5) after engaging in the exercises • 100% of fellows indicated they believed this ergonomics training would likely help them to perform better physically 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 2020[41] • 36 third-year medical students and surgical residents postgraduate years 1-7 • 3 modules lead by physical therapist; modules included didactics on ergonomics, posture, microbreak model, stretching exercises • Pre- and postlecture surveys • 93% believed ergonomics training would help them perform better in *or* • 85% believed reduction of physical discomfort after performing exercises and microbreaks model would help; pain decreased most in the neck (22%) and lower back (22%)	⨁⨁◯◯ Low	CRITICAL

REBA, Rapid Entire Body Assessment; *RULA*, Rapid Upper Limb Assessment.

endoscopists at various levels of experience (ranging from fellows to experienced attendings). 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 gastroenterology fellows.[42] When comparing pre- and post-therapy training surveys, a high percentage of the subjects reported the training as valuable (93%-100%). Furthermore, 85% to 100% reported immediate a 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 were mostly rated down for imprecision because of the small number of studies and for indirectness because of extrapolation from surgical studies.

Other considerations

No studies assessed the cost or cost-effectiveness of ergonomics training to reduce the risk of ERI. Although posters and 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 gastroenterologists, the panel made a strong recommendation despite the low quality of evidence. The panel noted that the specific forms of ergonomics training vary and can be achieved by didactic training and online teaching or can 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 has been demonstrated in assessments as far out as 6 weeks after training.[38] Available resources for ergonomics didactics are 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-minute stretching breaks at 20- to 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 that are 15 to 45 minutes long and built into a day's endoscopy schedule.[13]

We performed a systematic review of the published literature on this topic. Only 1 cross-sectional study was found in the gastroenterology literature that evaluated the role of microbreaks and macrobreaks in endoscopy.[13] Because of the paucity of gastroenterology literature, we extended our search to include laparoscopic surgery literature. Two additional studies were identified in the surgical literature.[50,51] All were full-text publications.

In a cross-sectional study of endoscopists with .5 to 58 years in practice (mean, 21.1; standard deviation, 12), the likelihood of developing ERIs was lower among endoscopists who took microbreaks (OR, .69; 95% CI, .54-.87; $P = .016$) and macrobreaks (OR, .72; 95% CI, .57-.92; $P = .002$) compared with those who did not take any breaks. The duration of macrobreaks by quartiles (1-15, 16-30, 31-45, and 46-60 minutes) was not significantly associated with ERI ($P = .50$). 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- to 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 and fatigue and physical and mental performance based on the validated Nordic Musculoskeletal Questionnaire, the National Aeronautics and Space Administration Task Load Index, and the Surgery Task Load Index. TSMBs improved physical postprocedure pain scores in all evaluated anatomic regions: neck ($P = .01$), right and left shoulder ($P < .001$), right and left hand ($P = .03$), and lower back ($P = .04$). Participants using TSMBs 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 nonrandomized crossover study of 56 surgeons in 4 academic centers showed that microbreaks were associated with improvement in shoulder pain ($P = .006$) and improved the overall physical performance in 57% of participants.[51] Mental focus improved in 34.4%, remained the same in 53.3%, and diminished in 12.4%. Additionally, 87% of surgeons wanted to incorporate microbreaks into their surgical routine. Importantly, the microbreaks did not prolong the duration of surgery.[51] A systematic review of ergonomics training and intraoperative microbreaks in the surgical literature identified 4 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 practitioners drew potential solutions from office and industry ergonomics. An evidence-based creation of a 1-minute targeted microbreak activity every 20 to 40 minutes during minimally invasive surgical procedures was developed that addressed posture correction, normalization of tissue tension, and relaxation/stress reduction by the Human Factors Engineering Laboratory at the Mayo Clinic. Printed files in pdf format to guide surgeons through a set of stretches are available.[53] A web-based 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 6 microbreaks a day per surgeon. Results showed improved physical performance and fatigue (91.7%), better mental focus (83.3%), and less pain and 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. Therefore, we made a conditional recommendation for both types of breaks.

TABLE 5. Evidence profile for population, intervention, comparator, outcomes question 2: microbreaks and scheduled macrobreaks compared with no breaks to reduce the risk of ERI

Certainty assessment									
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Impact	Certainty	Importance
Decrease in ERI									
1	Observational studies	Not serious	Not serious	Not serious	Not serious	None	Pawa et al 2021[13] • American College of Gastroenterology survey: 554 respondents took microbreaks (ERI, 69%) vs 894 respondents who did not take microbreaks (ERI, 75%) (odds ratio, .69; 95% confidence interval, .54-.87; $P = .016$) • 464 respondents took macro-breaks or had split schedules (ERI, 71%) vs 1219 who did not take breaks or had split schedules (ERI, 78%) (odds ratio, .72; 95% confidence interval, .57-.92; $P = .002$)	⊕⊕○○ Low	CRITICAL
Improvement in postprocedure pain score									
2	Observational studies	Not serious	Not serious	Serious	Serious	None	Park et al 2017[50] • 66 surgeons (academic and private) • Taught how to perform targeted stretching microbreaks • Microbreaks were associated with (1) improvement in post-procedure pain ($P > .05$), (2) physical performance of 57%, and (3) mental focus (38%); 87% planned to continue targeted stretching microbreaks; operative duration did not differ ($P > .05$) Hallbeck et al 2017[51] • 56 surgeons in 4 academic centers • Taught microbreak techniques • Microbreaks associated with (1) improvement in shoulder pain ($P = .006$), (2) overall improvement in physical performance (57% reported improvement), and (3) mental focus (34% improvement, 12% reported decline) • Did not negatively affect surgical time	⊕○○○ Very low	IMPORTANT

ERI, Endoscopy-related injury.

Certainty in the evidence

Details of outcomes and certainty of evidence are noted in the evidence profile (Table 5). While assessing the certainty of evidence, we rated down evidence for imprecision because of the 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 that 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 or 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 are 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 recommendations for prevention of musculoskeletal disorders in the workplace 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 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*)

Monitor placement is an important determinant of torso and head posture. An ergonomic stance during endoscopy involves neutral neck and back positions 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 3 published laparoscopic surgical studies assessing optimal monitor position.[56-58] The outcomes of interest were task performance, neck muscle strain, and electromyographyic 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 the monitor was directly in front (not to the right or left) of the laparoscopic surgeon.[57] The optimal distance between the monitor and surgeon was reported to be 90 to 182 cm, and the maximum distance at which the finest details of an image could still be seen was 139 to 303 cm.[58] Extrapolating from these studies, Shergill et al[20] concluded that monitors should be placed directly in front of the endoscopist just below 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. 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 the 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 believed 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 because of working in non-neutral positions.[10,17]

Discussion

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 recommendations suggested by Shergill et al[20] 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 endoscopist 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 a neutral bed position be used to reduce ERI?
>
> **Recommendation 4.** The ASGE recommends the use of a 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 the gastroenterology literature. Our search yielded 2 observational surgical studies on the optimal procedure table position in laparoscopic surgery.[61,62]

The first study involved 21 laparoscopic surgeons performing a 2-hand, one-fourth circle cutting task at 5 laparoscopic instrument handle heights relative to the surgeon's elbow height (–20, –10, 0, +10, +20 cm) relative to elbow height in a randomized sequence for 2 repetitions.[61] Each task was rated for difficulty and discomfort on a visual analog scale. In addition, electromyography measured the physical workload from the right deltoid and trapezius muscle. Statistically significant increases in subjective ratings of discomfort, deltoid, and trapezius electromyographic activity and arm elevation were seen if the bed was above elbow height or >10 cm below elbow height. Higher bed heights

TABLE 6. Evidence profile for population, intervention, comparator, outcomes question 3: use of neutral monitor position vs non-neutral monitor position to reduce the risk of endoscopy-related injuries

Certainty assessment									
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Impact	Certainty	Importance
Monitor distance									
1	Observational studies	Not serious	Not serious	Very serious	Very serious	None	El Shallaly et al 2006[58] • 14 laparoscopic surgeons • Found range of optimal working distance of standard 14-inch diagonal cathode-ray tube monitor for laparoscopic surgery • Both maximum and minimal distance variable between individuals • Surgeon should be within 3-10 feet distance from the monitor when performing surgery	⨁◯◯◯ Very low	CRITICAL
2	Observational studies	Not serious	Not serious	Not serious	Serious	None	Mattern et al 2005 • 18 subjects with no prior surgical experience • Simulated laparoscopic suturing by threading pearls with curved needle using 2 needle-holders • Influence of monitor position on task performance and neck muscle strain monitor positions were used: (1) frontal at eye level, (2) frontal at height of operating field, (3) 45 degrees to right side of eye level • Electromyographic activity of main neck muscle was significantly lower for position 1 compared with positions 2 and 3 ($P < .005$) • Task performance (measured by number of pearls threaded) was highest for position 2 and was statistically significant for position 2 compared with position 3 ($P = .0008$) but there was no statistical difference between positions 1 and 2 or 1 and 3 Haveran et al 2007[57] • 12 experienced surgical residents and 12 nonexperienced 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, or center and vice versa for 6 positions • Best performance when monitor was directly in front rather than on right or left side	⨁◯◯◯ Very low	CRITICAL

TABLE 7. Evidence profile for population, intervention, comparator, outcomes question 4: use of neutral bed height vs non-neutral bed height to reduce the risk of endoscopy-related injuries

Certainty assessment									
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Impact	Certainty	Importance
Procedure difficulty and postprocedure discomfort									
2	Observational studies	Not serious	Not serious	Serious	Serious	None	Berquer et al 2002[61] • 21 surgeons performed a one-fourth circle cutting task at 5 laparoscopic instrument handle heights (–20, –10, 0, 10, 20 inches) relative to elbow height • Difficulty and discomfort rated on visual analog scale • Skin conductance, electromyographic signal, and arm orientation • Statistically significant changes in subjective rating of discomfort, deltoid and trapezius electromyographic signal, and arm elevation • Laparoscopic surgery physicians had to flex their trunks during a task to accommodate a lower table height, with more discomfort and higher difficulty ratings • Optimal table height in this study was between elbow height and 10 cm below the elbow height van Veelen et al 2002[62] • Two pelvi-trainer tests were performed • Test 1 on 6 different operating surface heights; extreme joint excursions of the shoulder, elbow, and wrist were measured with video analysis • Test 2 was to hold a laparoscope for 15 min; electromyography of biceps brachii Electromyography of biceps brachii was done • Laparoscopic surgery optimal table height was 70%-80% of elbow height • Allowed the joints to stay in a neutral position over 90% of the procedure time • Activity of the electromyogram remained within 15% of the maximum muscle activity	⨁◯◯◯ Very low	CRITICAL

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, an increase in discomfort in procedures was found 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] in a 2-part study.

TABLE 8. Evidence profile for population, intervention, comparator, outcomes question 5: use of floor mats vs no floor mats to reduce the risk of endoscopy related injuries

Certainty assessment									
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	Impact	Certainty	Importance
Volume									
1	Randomized trials	Not serious	Not serious	Serious	Serious	None	Haramis et al 2010[67] • Prospectively randomized 50 patients to each group (gel vs no gel) for 18 providers • Postoperative evaluation • Sitting time ($P < .001$) • Number of stretches 1.28 vs 2.8 ($P = .001$) • Number of 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 h after using the gel mat vs not using • 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 2011[68] • 100 procedures and 11 surgeons; 50 per group • Procedures <60 min; no gel mat vs gel mat • Postoperative discomfort ($P = .044$) and postoperative energy ($P = .0411$) • Procedures >60 min; no gel mat vs gel mat • Postoperative discomfort ($P = .048$), postoperative energy ($P = .049$) • Posture changes ($P = .039$), stretches ($P = .024$), post op discomfort ($P = .048$), postoperative energy ($P = .049$)	⨁◯◯◯ Very low	CRITICAL

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 excursions of the shoulder, elbow, and wrist were 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 muscle activity.[63] Electromyography 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 a neutral position over 90% of the procedure time and allowed muscle activity to remain below 15% of the maximum.

Certainty in the evidence

While assessing the certainty of evidence, we rated down evidence for indirectness because of the lack of prospective studies in the gastroenterology literature and for imprecision because of the 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 neutral elbow, shoulder, and back positions, reducing the risk for ERI. We made a strong recommendation for a neutral table position.

> **Question 5:** In those performing GI endoscopies, should antifatigue floor mats be used to prevent ERI?
>
> **Recommendation 5.** The ASGE suggests the use of antifatigue mats to reduce the risk of ERI.
>
> (*Conditional recommendation, very low quality of evidence*)

For this question, we performed a systematic review. No studies were identified in the gastroenterology literature. Our search yielded 2 studies in surgical literature.[67,68]

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 attributed by 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 believed 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 electromyographic 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 (eg, antislip mats). Similarly, too much cushioning (eg, thick foam mats) is also not recommended because it can increase slipping. The Occupational Safety and Health Administration has provided some guidance in assessing various workplace injuries and assessment of ergonomics.[66] However, only limited data are available to assess the use of mats in GI endoscopy or potential role in decreasing ERI in GI endoscopy. Factors specific to the endoscopy suite are ease in cleaning mats and disposable mats given the types of procedures performed in gastroenterology.[22]

Certainty of the 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 are encouraging, evaluating medium- and long-term ERI in endoscopists is warranted. Further study of antifatigue mats in GI endoscopy should include cost-effectiveness and overall room efficiency.

Discussion

The initial question addressed was the use of gel floor mats in preventing ERI. The panel agreed that the intent was to evaluate antifatigue mats but without specification of type or material. One issue raised by the panel was the question of time efficiency: How do antifatigue mats, especially the use of multiple mats for nurses and technicians in the room, affect the time to clean rooms between cases and the 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[67] demonstrating an increase in errors with those not using a gel mat, mats may even improve patient safety. The panelists also queried whether shorter length procedures (eg, upper endoscopies) require antifatigue 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 antifatigue mats outweigh the potential risks. A conditional recommendation was made for using antifatigue mats during GI 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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Abbreviations: ASGE, American Society for Gastrointestinal Endoscopy; CI, confidence interval; ESD, endoscopic submucosal dissection; ERI, endoscopic-related injury; GRADE, Grading of Recommendations Assessment, Development and Evaluation; OR, odds ratio; PICO, population, intervention, comparator, outcomes; TSE, third-space endoscopy; REBA, Rapid Entire Body Assessment; RULA, Rapid Upper Limb Assessment; TSMB, targeted stretching microbreak.

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APPENDIX 1. SEARCH STRATEGIES FOR ALL POPULATION, INTERVENTION, COMPARATOR, OUTCOMES QUESTIONS

Revised search: ergonomics in endoscopy
Search date: April 22, 2020
Excluded: Case reports, editorials, letters, comments, notes
Limits: None

Ovid MEDLINE(R), Embase

Number Searches Results
1 exp Endoscopy, Digestive System/ use ppez 109,526
2 exp digestive tract endoscopy/ use emczd 215,204
3 exp endoscopes, gastrointestinal/ use ppez 5670
4 exp digestive endoscope/ use emczd 16664
5 (duodenoscop* or colonoscop* or enteroscop* or esophagoscop* or gastroscop* or proctoscop* or rectoscop* or sigmoidoscop* or esophagogastroduodenoscop* or ercp).ti,ab,kw. 167,913
6 exp gastroenterologist/ use emczd or exp Gastroenterologists/ use ppez 7225
7 exp gastroenterology/ 63,450
8 or/1-7 428,937
9 exp cumulative trauma disorder/ use emczd or exp Cumulative Trauma Disorders/ use ppez 35,431
10 ((Repetitive strain or repetition strain or overuse or carpal tunnel or cumulative trauma or ulnar nerve) adj2 (injur* or syndrome* or disorder*)).ti,ab,kw. 27,534
11 exp ergonomics/ 67,657
12 Ergonomic*.ti,ab,kw. 25,101
13 exp Occupational Injuries/ use ppez or exp Occupational Diseases/ use ppez or Accidents, Occupational/ use ppez 147,024
14 exp occupational disease/ use emczd 156,932
15 ((Injur* or disease* or accident*) adj2 (Occupation* or work or employment)).ti,ab,kw. 46,672
16 exp musculoskeletal injury/ use emczd or exp musculoskeletal pain/ 602,974
17 ((Musculoskeletal or msk) adj2 (pain* or disease* or injur*)).ti,ab,kw. 30,942
18 exp Equipment Design/ae [Adverse Effects] 578
19 exp “Hospital Design and Construction"/ use ppez 9815
20 exp hospital design/ use emczd 9681
21 exp Arm Injuries/ use ppez 30,744
22 exp arm injury/ use emczd 76,626
23 ((arm* or forearm* or elbow* or humeral or wrist*) adj2 (strain or pain or injur*)).ti,ab,kw. 16,820
24 exp Shoulder Injuries/ use ppez 16,652
25 ((Shoulder* or rotator cuff) adj2 (injur* or pain or strain or impingement)).ti,ab,kw. 23,479
26 exp Back Injuries/ use ppez 24,463
27 (back adj2 injur*).ti,ab,kw. 3730
28 exp Hand Injuries/ use ppez 18,091
29 ((Hand* or finger* or thumb*) adj2 injur*).ti,ab,kw. 10,103
30 exp neck injury/ use emczd or exp Neck Injuries/ use ppez 22,953
31 (neck adj2 injur*).ti,ab,kw. 4983
32 exp Tendon Injuries/ use ppez or exp Tendon Injury/ use emczd 47,985
33 exp tendinitis/ use emczd 17,971
34 (Tendinopathy or tendonitis).ti,ab,kw. 10,748
35 (Tendon* adj2 injur*).ti,ab,kw. 8387
36 exp hand strength/ 40,715
37 (hand* adj2 (size* or strength)).ti,ab,kw. 7512
38 pinch strength.ti,ab,kw. 2614
39 or/9-38 1,242,025
40 8 and 39 3812
41 remove duplicates from 40 3631
42 limit 41 to (case reports or comment or editorial or letter or note) [Limit not valid in Ovid MEDLINE(R),Ovid MEDLINE(R) Daily Update,Ovid MEDLINE(R) In-Process,Ovid MEDLINE(R) Publisher, Embase; records were retained] 375
43 Case Report/ 4,661,847
44 41 not (42 or 43) 1786