# Are All Endoscopy-Related Musculoskeletal Injuries Created Equal? Results of a National Gender-Based Survey

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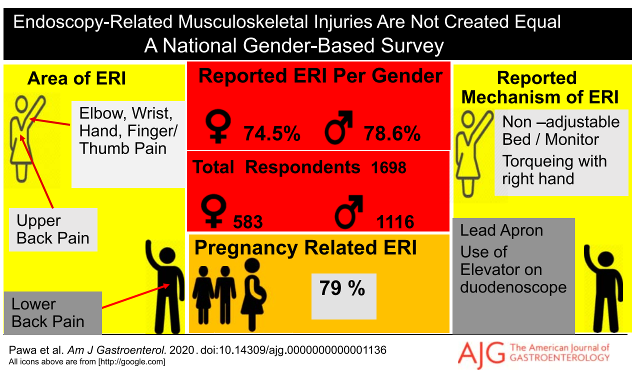
INTRODUCTION: **Endoscopy-related injury (ERI) is common in gastroenterologists (GI). The study aim was to assess the prevalence of self-reported ERI, patterns of injury, and endoscopist knowledge of preventative strategies in a nationally representative sample.**

METHODS: **A 38-item electronic survey was sent to 15,868 American College of Gastroenterology physician members. The survey was completed by 1,698 members and was included in analyses. Descriptive, univariate, and multivariate analyses were conducted to evaluate the likelihood of ERI based on workload parameters and gender.**

RESULTS: **ERI was reported by 75% of respondents. ERI was most common in the thumb (63.3%), neck (59%), hand/finger (56.5%), lower back (52.6%), shoulder (47%), and wrist (45%). There was no significant difference in the prevalence of ERI between men and women GI. However, women GI were significantly more likely to report upper extremity ERI while men were more likely to report lower-back pain-related ERI. Significant gender differences were noted in the reported mechanisms attributed to ERI. Most respondents did not discuss ergonomic strategies in their current practice (63%). ERI was less likely to be reported in GI who took breaks during endoscopy (*P* = 0.002).**

DISCUSSION: **ERI is highly prevalent in GI physicians. Significant gender differences regarding specific sites affected by ERI and the contributing mechanisms were observed. Results strongly support institution of training in ergonomics for all GI as a strategy to prevent its impact on providers of endoscopy.**

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## INTRODUCTION

Gastroenterologists (GI) are at high risk of endoscopy-related injuries (ERIs), with previous studies indicating occurrence in up to 89% (1–9). ERI is primarily caused by repetitive use of muscles, joints, and tendons; contorting into awkward positions to traverse difficult turns; and standing for long periods while performing endoscopy. A significant portion of available literature was conducted when procedure volumes were lower, endoscopic therapies were less complex, and fewer interventional procedures were conducted (10,11). Therefore, a contemporary assessment of ERI is needed.

In addition to increases in procedural volumes, the gender composition of GI has changed considerably. The proportion of women in GI training has more than doubled, to 30%, over 2 decades (12). This is important because women GI face unique challenges in endoscopy. For example, endoscopes are manufactured in 1 size that does not accommodate smaller hands. Furthermore, smaller muscle mass (13) and high levels of progesterone during pregnancy cause laxity of joints and ligaments, which can potentially lead to ERI. No studies have assessed the impact of pregnancy on ERI.

One survey in 2015 reported ERI in 53% of GI who spent >16 hours per week performing endoscopy, with an average of 12 upper endoscopies and 22 colonoscopies per week (6). The current procedural endoscopy volumes have increased since then with more patients undergoing colonoscopy for colorectal cancer screening (14), postpolypectomy surveillance, and advanced endoscopic procedures which often are supplanting surgery. With the increased volumes of procedures, ERIs are likely to increase along with long-term consequences, including physical restrictions, inability to painlessly perform procedures, and disability, all potentially leading to provider dissatisfaction and loss of workforce (15). It is therefore crucial to recognize that ergonomic knowledge and strategies play a critical role in injury prevention and methods for mitigation of ERI are needed.

Ergonomic training for endoscopy is a relatively new concept and could have important impact on decreasing ERI. For ergonomic training to be effective, it needs to be available to currently practicing GI as well as incorporated into GI training programs when optimal endoscopic technique and injury prevention strategies may be most impactful. It is unclear whether currently practicing GI are aware of any available ergonomics training programs and whether those who have incorporated this training have a lower incidence of ERI.

The primary aim of this study was to identify the prevalence, contributing factors, and types of self-reported ERI between men and women and to assess the prevalence of ERI during pregnancy. The secondary aim was to evaluate the reported knowledge and use of ergonomic strategies in the prevention of ERI.

## METHODS

### Survey sampling/participants

An electronic survey was sent to members of the American College of Gastroenterology (ACG) by e-mail between October 2018 and April 2019. Members who self-reported current or previous performance of endoscopy were eligible to participate. Informed consent was implied by response to the survey. No financial compensation was given for participation. All study procedures were approved by the ACG and the Institutional Review Board at Wake Forest University School of Medicine.

### Survey instrument

The 38-item anonymous, electronic survey (see Table, Supplemental Digital Content 1, http://links.lww.com/AJG/B862) began as a project from the Women in GI Committee and was developed by a core group of ACG members. Responses were elicited as either multiple choice or quantitative (e.g., age and weight). Nonidentifiable demographic information including age, sex, height, and weight was obtained. Workload parameters including type of current practice and practice years, type and time spent performing procedures were obtained. Questions related to ERI included injury characteristics (i.e., cause, location, pain severity and duration, treatment, and adjustment to practice in response to injury), the presumed motion that caused the injury (referred to as the mechanism of injury), and treatments used for ERI. Questions about preventative strategies included information about training in ergonomics for endoscopy, including bed height, monitor height, the use of scheduled breaks (defined as 15–30 minutes) and microbreaks (defined as a biologically meaningful movement break lasting 30 seconds to 2 minutes), and interest in further ergonomic training.

### Survey data collection

Five e-mails were sent, with 15,868 successful deliveries between October 2018 and April 2019. The introductory e-mail described the study and included a web link to the online survey instrument (Survey Monkey, San Mateo, CA). Six thousand one hundred nineteen recipients opened the e-mails, and the number of unique respondents was 2,164. Of the 2,164 recipients who began the survey, 86% (n = 1,870) completed the survey. Trainees (n = 172) were excluded from the present analyses, bringing the final sample size to N = 1,698.

### Statistical analysis

Data analysis was performed using SAS Enterprise Guide 7.0 (SAS Institute, Cary, NC). Logistic regression evaluated relationships between ERI and ordinal data. Multiple logistic regression evaluated independence of these variables. Chi-square tests evaluated differences when both variables of interest were categorical. Independent-samples *t* tests evaluated differences in groups with continuous outcomes. Correlations were conducted between continuous variables. Outcomes with $P < 0.05$ were considered statistically significant. Any missing data were deleted listwise in analyses. Sample sizes for all analyses are reported with respective data. Because of possible selection bias and expansive age range in the sample, all ERI subsample analyses were conducted with 2 additional focused subsamples: (i) only including physicians who reported currently performing endoscopy and (ii) focusing the former sample to ages 30–65 years. Outcomes using these samples did not alter the outcomes seen in the larger subsample, and therefore, the larger ERI subsample was retained for analyses.

ENDOSCOPY

**Table 1. Characteristics of respondents**

| Demographics | Total sample (N = 1,698) M ± SD | Total sample Range | Male (n = 1,115) M ± SD | Male Range | Female (n = 583) M ± SD | Female Range | P |
|---|---|---|---|---|---|---|---|
| Age, yr | 51.9 ± 12.3 | 24–93 | 55.3 ± 12.1 | 29–93 | 45.4 ± 9.9 | 24–76 | <0.001 |
| Height, inches | 68.2 ± 3.8 | 58–82 | 70.0 ± 2.8 | 58–82 | 64.6 ± 2.6 | 58–78 | <0.001 |
| Weight, pounds | 168.9 ± 34 | 90–330 | 183.5 ± 28.8 | 110–330 | 140.7 ± 25.4 | 90–260 | <0.001 |
| BMI, kg/m$^2$ | 26.0 ± 4.0 | 15.3–48.0 | 26.9 ± 3.7 | 15.3–48.0 | 24.2 ± 3.9 | 16–42.0 | <0.001 |
| Years performing endoscopy | 21.1 ± 12.0 | 0.5–58 | 24.4 ± 11.9 | 0.5–58 | 14.8 ± 9.7 | 0.5–47 | <0.001 |
| No. of reported ERIs | 5.5 ± 3.1 | — | 5.3 ± 3.1 | — | 5.9 ± 3.12 | — | 0.001 |

| Demographics | Total sample (N = 1,698) n | Total sample % | Male (n = 1,115) n | Male % | Female (n = 583) n | Female % | P |
|---|---|---|---|---|---|---|---|
| GI specialty[a] | | | | | | | |
| General | 1,466 | 86.3 | 967 | 86.7 | 499 | 85.6 | 0.518 |
| Hepatology | 304 | 17.9 | 204 | 18.3 | 100 | 17.2 | 0.560 |
| IBD | 407 | 24.0 | 240 | 21.5 | 167 | 28.6 | 0.001 |
| Interventional | 418 | 24.6 | 334 | 30.0 | 84 | 14.4 | <0.001 |
| Motility | 170 | 10.0 | 98 | 8.8 | 72 | 12.4 | 0.020 |
| Practice setting[a] | | | | | | | |
| Private | 905 | 46.7 | 676 | 60.6 | 229 | 39.3 | <0.001 |
| Academic | 571 | 33.6 | 308 | 27.6 | 263 | 45.1 | <0.001 |
| Hospital employee | 336 | 19.8 | 198 | 17.8 | 138 | 23.7 | 0.004 |
| Veterans affairs | 83 | 4.9 | 43 | 3.9 | 40 | 6.9 | 0.006 |
| Industry | 3 | 0.2 | 2 | 0.2 | 1 | 0.2 | 0.971 |
| Retired | 81 | 4.8 | 74 | 6.6 | 7 | 1.2 | <0.001 |
| Performing endoscopy currently | 1,554 | 91.5 | 985 | 88.3 | 569 | 97.6 | < 0.001 |
| Reported prevalence of ERI | 1,277 | 75.2 | 822 | 74.5 | 455 | 78.6 | 0.060 |
| Disability taken due to ERI | 55 | 3.24 | 38 | 3.4 | 17 | 2.9 | 0.587 |

BMI, body mass index; ERI, endoscopy-related injury; GI, gastroenterologist; IBD, inflammatory bowel disease; M, mean; N, full sample size; n, subsample size.
[a]Indicates categories are not mutually exclusive. Disability indicates the respondent reported previously using either short-term or long-term disability. Percent is calculated by column. *P* values are provided from *t* tests (continuous data) and $\chi^2$ (categorical) analyses comparing outcomes by gender.

## RESULTS

### Sample characteristics

The majority of respondents were men (65.7%), with a mean age of 52 (±12.3) years, in general GI practice (86.3%) and currently performing endoscopic procedures (91.5%) (Table 1). Most (52.2%) respondents reported performing 30–40 procedures per week. Approximately 57.5% reported spending between 20 and 30 hours per week performing endoscopy. Women respondents were younger (mean age 45.4 [±9.9] years vs 55.3 [±12.1] years, $P < 0.001$), shorter (mean height 64.6 [±2.6] inches vs 70.1 [±2.8] inches, $P < 0.001$), and weighed less (mean weight 140.7 [±25.4] lbs vs 183.5 [±28.8] lbs, $P < 0.001$) than men. Women were also more likely to wear smaller gloves than men (96.7% women reported extra-small to medium vs 73.0% men reported large to extra-large, $P < 0.001$).

### ERI prevalence and characteristics

ERI was reported in 75.2% (1,277/1,698) of the respondents. Of those with ERI, 90.3% reported more than 1 ERI (mean = 5.48 [±3.14], median = 5). In univariate analyses, age ($P = 0.004$), general GI practice ($P < 0.001$), years performing endoscopy ($P < 0.001$), number of procedures per week ($P < 0.001$), number of hours per week performing procedures ($P < 0.001$), and number of colonoscopies per week ($P < 0.001$) were significantly associated with a greater likelihood of ERI. No other type of practice setting (Table 2) or specific procedure was associated with ERI. Multivariate analyses indicated that years performing endoscopy ($P = 0.022$) and number of hours performing procedures per week ($P = 0.009$) were the only 2 variables independently associated with ERI. Table 3 reports the number of weekly procedures performed by physician gender and procedure type. Physicians performing endoscopies for more years had a significant higher rate of injury ($P = 0.019$).

Among physicians reporting ERI, the most common sites of injury were in the thumb (63.3%), neck (59%), hand/finger (56.5%), lower back (52.6%), shoulder (47%), and wrist (45%) (Figure 1a, b). There was no difference in likelihood of ERI between men and women ($P = 0.060$). However, men and women tended to report different sites of ERI. Specifically,

**Table 2. Likelihood of ERI by practice type and procedure hours per week**

| Practice | Percent reporting ERI | | |
|---|---|---|---|
| | N | % | *P* |
| Practice type | | | |
| General | 1,123 | 66.7 | 0.001 |
| Hepatology | 216 | 16.9 | 0.051 |
| IBD | 300 | 23.5 | 0.440 |
| Interventional | 308 | 24.1 | 0.313 |
| Motility | 124 | 9.7 | 0.346 |
| Procedure hours/wk[a] | | | 0.009 |
| 1–5 | 49 | 53.1 | |
| 6–10 | 167 | 64.1 | |
| 11–15 | 285 | 73.7 | |
| 16–20 | 407 | 78.4 | |
| 21–25 | 344 | 79.4 | |
| 26–30 | 220 | 82.7 | |
| 31–35 | 112 | 73.2 | |
| 36–40 | 51 | 76.5 | |
| 41+ | 48 | 81.3 | |

Categories are not mutually exclusive. Chi-square analyses compare the likelihood of injury between those within each practice vs those who are not.
ERI, endoscopy-related injury; IBD, inflammatory bowel disease; N, number of respondents reporting.
[a]Data missing for 15 respondents.

women were significantly more likely than men to report ERI in their upper back and upper extremities. Men were more likely to report lower-back pain ($P = 0.018$). In addition, women tended to report a greater mean number of ERI compared with men (5.9 [±3.1] vs 5.3 [±3.1], $P = 0.001$, respectively). No significant difference in the pain severity in specific locations was observed between women and men. Despite significant physical size differences between men and women, none of these factors were associated with ERI. History of non-ERI injury or pre-existing health condition was not associated with greater likelihood of ERI, ERI severity, or gender differences in ERI.

### Mechanisms reported to contribute to ERI

The most common actions reported to contribute to ERI were torqueing (65.5%), supporting the endoscope in awkward positions (62%), standing for prolonged periods (60.3%), and adjusting tip angulation (55.8%) (Table 4). Men were more likely to report ERI due to use of lead aprons ($P < 0.001$) and using the duodenoscope elevator ($P < 0.001$) than women. Women were more likely to report torqueing with the right hand ($P = 0.013$) and nonadjustable beds/monitors ($P = 0.008$) contributing to ERI.

### ERI during pregnancy

Of the women respondents (n = 583), 19.6% reported a history of pregnancy while in practice. During pregnancy, 78.9% of women reported noticing new-onset ERI and 70.2% noted worsening of existing ERI. Despite noticeable and/or worsening ERI, 93.0% continued performing endoscopy and only 20.8% of those performing endoscopy reduced their caseload during pregnancy (Table 5).

### Treatments used in ERI

Treatments used in response to ERI were typically nonsurgical (see Table, Supplemental Digital Content 2, http://links.lww.com/AJG/B863). Few (12.4%; n = 158) respondents reported surgery for ERI. Surgery was most commonly used for carpal tunnel syndrome (16.4%; n = 44/268), lower-back pain (4.5%; n = 30/671), shoulder pain (5.2%; n = 31/600), thumb pain (3.3%; n = 27/808), and hand or arm numbness (6%; n = 27/451). Although ERI-related surgery was reported across all age ranges, it was most common in respondents 50 years and older (67.1% of respondents who underwent surgery), congruent with more years of practice. A small number of respondents (20.5%) reported taking time off for any injury. Men (22.3%) were more likely than women to report taking time off (17.4%) ($P = 0.038$) which was significantly correlated with the number of injuries reported. Very few (3.2%; n = 55) respondents reported use of short- (55.7%) or long-term (44.3%) disability.

### Exposure to ERI prevention and ergonomics

Over half (61.5%) of the sample reported no training in ERI prevention (Table 6). Of the respondents who received ergonomics training, taking microbreaks (38.3%), adjusting bed height (19.7%), posture (15.8%), and adjusting monitor height (12.2%) were the most reported learned strategies. A lower likelihood of ERI was found in both those who take breaks ($P = 0.002$) and microbreaks ($P = 0.016$). The duration of breaks was not significantly associated with ERI ($P = 0.500$).

## DISCUSSION

In this nationally representative sample of previously and currently practicing GI physicians, ERI was reported in over three-quarters of the respondents. These results demonstrate an overwhelming prevalence of ERI in GI physicians, regardless of practice setting and endoscopy patterns. Our results expand on previous findings. We found no difference in reported prevalence of ERI between men and women; however, gender differences in specific types of ERI were noted. ERI in women was more likely in upper extremities and upper back, whereas in men, it was elbow and lower-back pain. Although there were gender differences in the likelihood of injury type, no differences in pain intensity by injury type were observed.

Our results diverge from a recent European survey including 171 GI (97 women) which showed female gender was a significant predictor of severity ($P = 0.03$) and number of ERI ($P = 0.02$) (8). However, we consistently found that women reported a greater number of ERI on average. Differences between the 2 studies that might explain this discrepancy include smaller sample size, inclusion of trainees, younger age of respondents, and a greater proportion of women respondents in that study. We recommend future studies oversample for women in GI within larger samples sizes to explore these discrepancies. In addition, longitudinal cohort studies that begin with training would be invaluable. Regardless, together these studies suggest that there are gender differences in ERI in GI, although highly prevalent in both men and women, which supports the development of ergonomically

**Table 3. Number of weekly procedures by procedure type and gender (N = 1,683)**

| | EGD | | Colonoscopy | | ERCP | | EUS | | Enteroscopy | | EMR/ESD/ POEM | | Bariatric | | Luminal stenting | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Men (n = 1,115)** | | | | | | | | | | | | | | | | |
| Procedures/wk | n | % | n | % | n | % | n | % | n | % | n | % | n | % | n | % |
| 0 | 2 | 0.2 | 3 | 0.3 | 400 | 35.9 | 647 | 58.0 | 645 | 57.8 | 581 | 52.1 | 764 | 68.5 | 515 | 46.2 |
| 1–10 | 403 | 36.1 | 144 | 12.9 | 652 | 58.5 | 410 | 36.8 | 464 | 41.6 | 510 | 45.7 | 349 | 31.3 | 586 | 52.6 |
| 11–20 | 567 | 50.9 | 394 | 35.3 | 53 | 4.8 | 48 | 4.3 | 3 | 0.3 | 22 | 2.0 | 1 | 0.1 | 8 | 0.7 |
| 21–30 | 107 | 9.6 | 363 | 32.6 | 7 | 0.6 | 9 | 0.8 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 2 | 0.2 |
| 31–40 | 12 | 1.1 | 148 | 13.3 | 1 | 0.1 | 1 | 0.1 | 0 | 0.0 | 1 | 0.1 | 0 | 0.0 | 0 | 0.0 |
| 41–50 | 8 | 0.7 | 41 | 3.7 | 1 | 0.1 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 1 | 0.1 | 2 | 0.2 |
| 51–60 | 16 | 1.4 | 22 | 2.0 | 1 | 0.1 | 0 | 0.0 | 3 | 0.3 | 1 | 0.1 | 0 | 0.0 | 2 | 0.2 |
| **Women (n = 583)** | | | | | | | | | | | | | | | | |
| | EGD | | Colonoscopy | | ERCP | | EUS | | Enteroscopy | | EMR/ESD/ POEM | | Bariatric | | Luminal stenting | |
| Procedures/wk | n | % | n | % | n | % | n | % | n | % | n | % | n | % | n | % |
| 0 | 1 | 0.2 | 6 | 1.0 | 346 | 59.3 | 374 | 64.2 | 379 | 65.0 | 331 | 56.8 | 407 | 69.8 | 359 | 61.6 |
| 1–10 | 296 | 50.8 | 89 | 15.3 | 227 | 38.9 | 197 | 33.8 | 202 | 34.6 | 242 | 41.5 | 175 | 30.0 | 224 | 38.4 |
| 11–20 | 260 | 44.6 | 282 | 48.4 | 6 | 1.0 | 10 | 1.7 | 1 | 0.2 | 9 | 1.5 | 0 | 0.0 | 0 | 0.0 |
| 21–30 | 17 | 2.9 | 149 | 25.6 | 3 | 0.5 | 2 | 0.3 | 0 | 0.0 | 0 | 0.0 | 1 | 0.2 | 0 | 0.0 |
| 31–40 | 7 | 1.2 | 41 | 7.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 41–50 | 1 | 0.2 | 12 | 2.1 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| 51–60 | 1 | 0.2 | 4 | 0.7 | 0 | 0.0 | 0 | 0.0 | 1 | 0.2 | 1 | 0.2 | 0 | 0.0 | 0 | 0.0 |

EGD, esophagogastroduodenoscopy; EMR/ESD/POEM, endoscopic mucosal resection/endoscopic submucosal dissection/peroral endoscopic myotomy; ERCP, endoscopic retrograde cholangiopancreatography; EUS, endoscopic ultrasonography; n, subsample total/number of respondents reporting.

appropriate devices and institution of a curriculum to educate GI on ERI preventive strategies (16).

Factors contributing to ERI in our study were largely congruent with what would be expected for the type of injury and gender of the GI. Women were more likely to attribute ERI to torqueing and nonadjustable bed monitors, whereas men were more likely to attribute ERI to use of lead aprons and use of the elevator on the duodenoscope. Women in our study had smaller glove size, and therefore smaller hands, which likely contributed to the greater likelihood of injury in upper extremities compared with men (17). However, it is important to consider these data in the context of the sample because there were fewer women than men performing endoscopic retrograde cholangiopancreatography represented in this study.

Similar to a survey published in 2015 (6), our study showed the likelihood of ERI increased as the number of years performing endoscopy and time spent per week performing endoscopy increased. We found an increase in reported ERI with as little as 6–10 hours of endoscopy per week. Recognition of early overuse injury is important. Understanding physiologic forces and prevention of repetitive microtrauma which leads to collagen breakdown, connective tissue damage, and weakness is imperative (18,19). Proper endoscopic technique and development of ergonomically appropriate endoscopes is critical.

Advanced endoscopic procedures including endoscopic ultrasonography, endoscopic retrograde cholangiopancreatography, and third space endoscopy are more time consuming and technically challenging, theoretically leading to higher rates of ERI (20,21), but our study showed no statistically significant difference in ERI among respondents who identified as advanced endoscopists. This finding could be attributed to the small sample size of advanced endoscopists in our study. In univariate but not multivariate analyses, colonoscopy was associated with a greater likelihood of ERI. The lack of association in the multivariate analysis is likely because colonoscopy was the most commonly performed procedure (and highly correlated with time per week spent performing endoscopy). Colonoscopy requires more instrument manipulation and torque, which may lead to thumb and wrist injury (22–25). A pilot study of musculoskeletal load during colonoscopy reported the injury threshold was exceeded for right-thumb peak pinch forces required during left and right colon insertion (26). Also, left-wrist extensors, left-thumb extensors, and right-wrist extensors exceeded the American Conference of Industrial Hygienists hand activity level action limit during routine colonoscopy (27). The American Conference of Industrial Hygienists recommended task modification to reduce the risk of repetitive injury if the activities exceed the hand activity level action limit (27).

This is the first survey reporting the impact of pregnancy on ERI. During pregnancy, almost 80% of women reported new-onset ERI and 70% reporting worsening of existing ERI. Only 1 in 5 pregnant women reduced their workload in

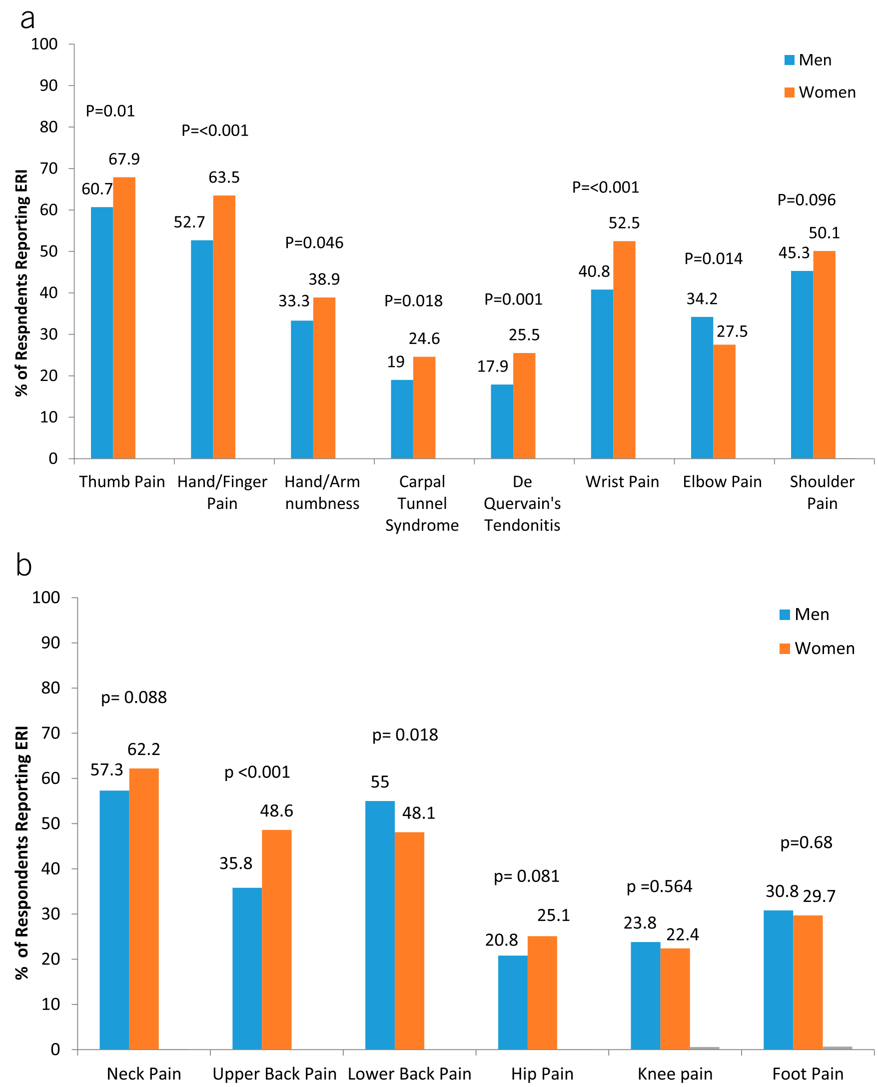


**Figure 1.** (**a**) Location of self-reported upper extremity ERI. (**b**) Location of self-reported back/neck and lower extremity ERI. ERI, endoscopy-related injury.

response to ERI. Paired with the results that women were less likely to report taking time off due to ERI, this may reflect a reluctance to acknowledge the occurrence of ERI due to associated fear of adverse effects on one's reputation and livelihood (28).

ERI prevention among endoscopists has been historically overlooked. We found over half of respondents had not received any training in ergonomics for endoscopy. We found that physicians had a lower likelihood of ERI after incorporating ERI prevention strategies, such as the use of breaks and microbreaks. No other studies have assessed the impact of incorporating preventative strategies on the likelihood of ERI. This poses a significant opportunity to potentially lower the risk of ERI among GI using simple strategies that can be incorporated into daily practice immediately with minimal changes to procedure flow. For example, an "ergonomic time out" could be quickly and easily performed before endoscopy (16,29). This would include assessing the bed height, patient position, monitor location, and cushion mats. In addition, intentionally including scheduled breaks and microbreaks is important to allow adequate time for rest and recovery to muscles, tendons, and ligaments. Lowering the incidence of ERI could decrease the detrimental effects on the provider (chronic pain, disability, confidence, and premature retirement), endoscopy service (missed days at work), and the patient (impaired performance).

In addition to ERI prevention, changes to endoscope design is essential. Our findings of increased ERI in the upper extremity in women is consistent with previous studies, suggesting that female endoscopists may be at greater risk of injury because of differences in hand size and grip strength. Multiple studies report women's grip strength to be between 57% and 65% and fingertip-pinch strength to be 73% of men (30–32). Therefore, women expend more strength and effort to perform the same endoscopic manipulations. This increases the risk of repetitive strain injury, which may be compounded if grip is suboptimal because of smaller hand size. It is crucial that future design of endoscopy tools include input of

 

**Table 4. Reported mechanism of ERI (N = 1,277)**

| ERI contributing action | ERI-only subsample (N = 1,277) | | Male (n = 822) | | Female (n = 455) | | |
|---|---|---|---|---|---|---|---|
| | N | % | n | % | n | % | *P* |
| Adjusting tip angulation with left hand | 713 | 55.8 | 469 | 57.1 | 244 | 53.6 | 0.237 |
| Torqueing with right hand | 836 | 65.5 | 518 | 63.0 | 318 | 69.9 | 0.013 |
| Use of lead aprons | 283 | 22.2 | 218 | 26.5 | 65 | 14.3 | <0.001 |
| Use of the elevator on the duodenoscope | 232 | 18.2 | 175 | 21.3 | 57 | 12.5 | <0.001 |
| Standing for prolonged periods | 770 | 60.3 | 497 | 60.5 | 273 | 60.0 | 0.872 |
| Standing in awkward positions supporting an endoscope | 792 | 62.0 | 505 | 61.4 | 287 | 63.1 | 0.563 |
| Nonadjustable bed/monitor | 382 | 29.9 | 225 | 27.4 | 157 | 34.5 | 0.008 |

*P* values are provided from $\chi^2$ analyses.
ERI, endoscopy-related injury; N, full sample size; n, subsample size.

endoscopists and accommodate for various hand sizes and differences in upper-body strength (33).

There are several strengths and limitations to consider in this study. The sample is one of the largest, is nationally representative, and comprises a variety of practice backgrounds and expertise (Table 7). In addition, the sample is one-third women, which provided adequate power to conduct analyses on gender differences and on ERI during pregnancy. Limitations of this study are related to the study design with use of self-reported survey data, response, and recall bias. It is also possible that GI with ERI were motivated to participate in this survey leading to some overestimation of the prevalence of ERI in this study and that our results be interpreted in the context of the methodology used. Although the response rate was relatively low (14%), this survey is currently the largest study sample to date on the ERI issue with 1,870 respondents. All respondents were members of the ACG, and therefore may not be representative of GI internationally, limiting generalizability.

The prevalence of ERI is an undue burden on the health and practices of GI performing endoscopy and mandates significant changes in the physical approach to endoscopy for both men and women. Our results highlight the importance of training and education of all GI in ergonomics from early career stages, as well as the critical need for endoscopes with better ergonomic design to help reduce ERI.

## CONFLICTS OF INTEREST

**Guarantor of the article:** Swati Pawa, MD.

**Specific author contributions:** S.P.: conception, planning, creating, reviewing, and editing the study survey, drafting of manuscript, review and revision of the manuscript, and response to reviewers. P.B.: conception, planning, creating, reviewing, and editing the study survey; review and revision of the manuscript. S.K. and S.L.D.: planning, creating, reviewing, and editing the study survey; review

**Table 5. Reported impact of pregnancy on ERI (N = 114)**

| ERI symptom or action | N | % |
|---|---|---|
| Pregnancy | 114 | 19.6 |
| Noticed symptoms during pregnancy | 90 | 78.9 |
| Symptoms worsened during pregnancy | 80 | 70.2 |
| ERI symptoms present postpartum | 65 | 57.0 |
| Performed endoscopy during pregnancy | 106 | 93.0 |
| Reduced endoscopy case load during pregnancy (N = 106) | 22 | 20.8 |
| Allotted longer procedure times during pregnancy (N = 106) | 9 | 8.5 |
| Used fluoroscopy during pregnancy (N = 106) | 21 | 19.8 |

Percentages are calculated by overall pregnancy sample size (N = 114) unless otherwise noted in parentheses.
ERI, endoscopy-related injury; N, full sample size.

**Table 6. Current and previous training in ERI prevention**

| Training query | Total sample N | Total sample % |
|---|---|---|
| Specific aspects of ERI training | | |
| Posture | 268 | 15.8 |
| Bed height | 334 | 19.7 |
| Monitor height | 208 | 12.2 |
| Techniques to reduce injury | 81 | 4.8 |
| Exercise | 47 | 2.8 |
| None | 1,044 | 61.5 |
| Specific ergonomic strategies used in current practice | | |
| Posture | 250 | 14.7 |
| Bed height | 363 | 21.4 |
| Monitor height | 321 | 18.9 |
| Techniques to reduce injury | 125 | 7.4 |
| Exercise | 98 | 5.8 |
| None | 984 | 58.0 |

N refers to the number of respondents reporting specific training.
ERI, endoscopy-related injury.

ENDOSCOPY

**Table 7. Prevalence estimates of endoscopy-related injury in current literature**

| Study | Sample size | % reporting injury |
|---|---|---|
| Buschbacher (1) | 265 | 57.0 |
| O'Sullivan et al. (7) | 114 | 67.0 |
| Liberman et al. (5) | 608 | 39.0 |
| Byun et al. (2) | 55 | 89.1 |
| Hansel et al. (4) | 72 | 73.6 |
| Battevi (34) | 88 | 40.0 |
| Kuwabara et al. (9) | 190 | 43.0 |
| Geraghty et al. (3) | 58 | 57.0 |
| Ridtitid et al. (6) | 684 | 53.0 |
| Morais et al. (8) | 171 | 69.6 |
| Pawa (current study) | 1,698 | 75.2 |

and revision of the manuscript. S.L.M.: analytic design, data preparation, data analysis, drafting of manuscript, and review and revision of the manuscript; response to reviewers. J.K.J.G. and A.S.O.: planning, reviewing, and editing the study survey; review and revision of the manuscript. C.A.B.: planning, creating, reviewing, and editing of study survey; review and revision of the manuscript, response to reviewers. All authors have reviewed and approved the final manuscript draft before submission.

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## Study Highlights

### WHAT IS KNOWN

- ✓ Endoscopy-related musculoskeletal injury is common.
- ✓ Controversy exists on the association between gender and ERI.
- ✓ The impact of pregnancy and ergonomic training on ERI is unknown.

### WHAT IS NEW HERE

- ✓ Women and men report equally high rates of ERI.
- ✓ Areas affected by ERI and mechanism driving ERI differ between women and men.
- ✓ Approximately 79% of women reported new-onset ERI related to pregnancy.

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