

Endoscopy-related injury among gastroenterology trainees



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ABSTRACT

Background and study aims Endoscopy-related injury (ERI) is widespread among practicing gastroenterologists. However, less is known about the incidence among trainees. This study assesses the rate of self-reported ERI occurrence, patterns of injury, and knowledge of preventive strategies in a nationally representative sample of gastroenterology fellows.

Methods A 38-item electronic survey was sent to members of the American College of Gastroenterology. One hundred and sixty-eight gastroenterology fellows were included in analyses. Descriptive and univariate analyses evaluated the likelihood of ERI by workload parameters and gender.

Results ERI was reported by 54.8% of respondents. ERI was most common in the thumb (58.7%), hand/finger (56.5%), and wrist (47.8%). There was no significant difference in the reported occurrence of ERI between male and female gastroenterology fellows. However, female fellows were significantly more likely to report a greater number of body areas affected by ERI, and male fellows were more likely to report elbow pain. Most respondents (85.1%) reported discussion about, or training in, ergonomic strategies during gastroenterology fellowship.

Conclusions ERI is reported to occur as early as gastroenterology fellowship. Results of this study support this finding and highlight the need for ongoing implementation and monitoring of a formal ergonomics training program as well as development of ergonomically appropriate instruments. Implications of these findings likely extend to trainees in other procedural related specialties like orthopedics and general surgery, though further research is required. Ergonomics training in gastroenterology fellowship and monitoring of its impact on trainees reported ERI is important due to negative effects on productivity and career longevity.

Introduction

The prevalence of endoscopy-related injury (ERI) in practicing gastroenterologists is reported to be as high as 89% and is commonly attributed to repetitive movements, awkward postures, procedure volume, number of years in practice, and standing for long periods while performing endoscopy [1]. Little is known about the time of onset of ERI in gastroenterologists, as the prevalence of ERI and risk factors for ERI in physicians in gastroenterology fellowship training are not well established. Recent evidence suggests that ERI affects up to 49% of gastroenterology fellows [2, 3]. However, these studies are limited by sample size, gender representation, and provide minimal data about specific types of injury. Regardless of these limitations, the staggering proportion of gastroenterology fellows reporting ERI indicates a critical need for additional detailed information on ERI that serves as a foundation for the development of optimal methods and timing of ergonomics training.

Endoscopy is physically demanding and requires considerable training and dexterity to effectively perform procedures. Endoscopic ergonomics is the study of safe interaction between the endoscopists and their work environment, namely the endoscope and the endoscopy unit, to minimize the risk of ERI [4]. Endoscopes are only available in one size regardless of operator hand size and strength, which requires many gastroenterologists to work out of their neutral positions, predisposing them to ERI [5]. Though this manuscript focuses on gastroenterology, challenges with endoscopic ergonomics is applicable to laparoscopic surgery broadly, which in turn informs endoscopic ergonomics research and training. Literature on ergonomics in laparoscopic surgery suggests that monitors placed at eye-level reduce neck and shoulder muscle strain [6], optimal table height should position the laparoscopic instrument handles close to the surgeons elbows to minimize upper arm and shoulder discomfort [7], and intraoperative targeted stretching microbreaks lasting 1.5 to 2 minutes at 20- to 40-minute intervals throughout the case can mitigate work-related fatigue, pain, and injury [8]. Furthermore, the use of anti-fatigue floor mats and a two-piece, rather than one-piece, lead apron during prolonged standing for complex endoscopic procedures has shown to decrease the risk of back and neck injuries [9].

Despite the knowledge that ergonomic strategies reduce the risk of ERI and the occurrence of ERI in gastroenterology fellows, more than 70% of trainees report no structured curriculum in endoscopic ergonomics and ERI prevention [2]. The Accreditation Council for Graduate Medical Education does not require formal training in prevention of overuse injuries during gastroenterology fellowship. Because the health and practice longevity of gastroenterologists is paramount to providing high-quality care to patients, it is critical that gastroenterology training programs institute curricula to mitigate ERI, supported by training institutions and organizations, such as gastroenterology societies.

The primary aim of this study was to identify the occurrence, contributing factors, and types of self-reported ERI of gastroenterology fellows and compare reported injuries between male

and female trainees. Knowing which injuries are most common and the risk factors for the injuries (e.g., gender, hand size, equipment) will inform the development of ERI prevention curricula. The secondary aim was to evaluate the reported knowledge and use of ergonomic strategies in the prevention of ERI in a nationally representative sample of gastroenterology fellows.

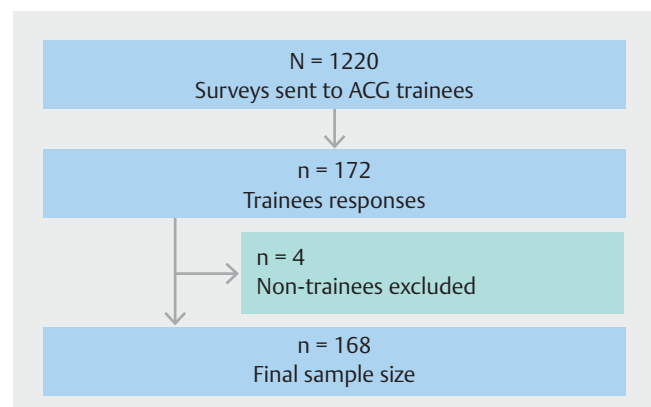
Methods

Participants

A 38-item electronic survey was sent to 15,868 members of the American College of Gastroenterology (ACG) as previously described [1]. We sent an additional introductory email describing the study and including a web link to the online survey instrument (Survey Monkey, San Mateo, California, United States) to 1,220 gastroenterology trainees who were part of the larger group. Members who self-reported current or previous performance of endoscopy were eligible to participate. Only respondents who identified as trainees ($N = 172$) were included in the reported analyses (response rate 14.1%). We removed additional respondents from analyses if they reported performing endoscopy for greater than 4 years ($n = 4$), which indicates they are unlikely to be trainees. The final sample size for analyses was $N = 168$ (► Fig. 1). No financial compensation was provided for participation. Informed consent was implied by response to the survey. All study procedures were approved by the ACG and the Institutional Review Board at Wake Forest University School of Medicine.

Survey

The survey included both write-in and multiple-choice responses. Questions consisted of demographics, practice information (e.g., workload), as well as ERI characteristics, use of preventive strategies, and injury prevention training. (Supplemental file content 1). Because the survey was designed to be relevant for all ACG members, postgraduate year (PGY) was not queried.



► Fig. 1 Flow diagram depicting participant selection. Survey invitations were sent to 1,220 trainee members of the American College of Gastroenterology. A total of 172 trainees responded. Respondents who were unlikely to be trainees (i.e., reported performing endoscopy for greater than 4 years) were removed from the sample, $n = 4$. The final sample size for analyses was $N = 168$.

Year in fellowship was estimated by reported years practicing endoscopy.

Statistical analysis

The data were analyzed using SAS Enterprise Guide 7.0 (SAS Institute Inc., Cary, North Carolina, United States). Independent samples *t*-tests compared continuous outcomes between groups. Logistic regression evaluated relationships between incidence of ERI and ordinal or continuous data, *P* values for chi-square (χ^2) and odds ratios (OR) are reported. Chi-square analyses evaluated differences when both variables of interest were categorical. Fisher's exact test was used when chi-square cell frequencies were too low to calculate chi-square. 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. We have reported sample sizes for all analyses with respective data.

Results

Sample characteristics

The gender of respondents was equally represented in this sample: Male (50.5%) and female (49.4%), with a mean age of 32.27 (± 2.77) years (► **Table 1**). Participants in this sample had

performed endoscopy an average of 2.09 (± 0.86) years, and 98.8% reported currently performing endoscopy. The average body mass index (BMI) for female fellows was significantly lower than for male fellows ($22.68 \pm 2.94 \text{ kg/m}^2$ vs $25.64 \pm 3.34 \text{ kg/m}^2$, *P*<0.001). Female fellows reported significantly smaller glove size than male fellows (mode=6.0 vs 7.5, respectively, *P*<0.001). We found no differences between trainees in the number of procedures (*P*=0.15) or hours spent performing procedures (*P*=0.20) per week. Male fellows were more likely to report experience with interventional endoscopy than female fellows (*P*=0.04) (► **Table 2**).

ER occurrence and characteristics

More than half (54.8%) of fellows in this sample reported ERI (► **Table 1**). Of those who reported ERI, the average number of injury sites was 4.26 ± 2.4 (► **Table 1**). Trainees who performed endoscopy for more years were more likely to report ERI (*P* = .04) but not a greater number of ERI (*P* = .77). Logistic regression indicated no association between number of ERI and age (*P* = .48, OR = 0.960, CI[0.51, 0.48]), BMI (*P* = .34, OR = 1.044, CI [0.96, 1.14]), glove size (*P* = .20, OR = 1.368, CI[0.85, 2.21]), number of procedures per week (*P* = .16, OR = 0.981, CI[0.95, 1.01]), time spent in procedures per week (*P* = .14, OR = 0.977, CI[0.95, 1.01]), or frequency of performing specific procedures

► **Table 1** Demographic characteristics of respondents (N = 168).

Demographics	Total Sample (N = 168)		Male (n = 85)		Female (n = 83)		P
	Mean \pm SD or N	Range or %	Mean \pm SD or N	Range or %	Mean \pm SD or N	Range or %	
Age, years	32.27 \pm 2.77	28–48	32.61 \pm 3.12	28–48	31.93 \pm 2.33	28–40	.109
▪ 28–29	20	11.9%	9	10.6%	11	13.3%	–
▪ 30–35	132	78.6%	67	78.8%	65	78.3%	–
▪ 36+	16	9.5%	9	10.6%	7	8.4%	–
Height, inches	67.45 \pm 4.02	59–80	70.24 \pm 2.80	65–80	64.56 \pm 2.89	59–74	<.001
Weight, lb	154.45 \pm 32.13	100–290	175.59 \pm 24.04	134–290	132.80 \pm 23.92	100–240	<.001
BMI in kg/m ²	24.49 \pm 3.47	17.64–45.16	25.64 \pm 3.34	18.56–45.16	22.68 \pm 2.94	17.64–30.16	<.001
Years performing endoscopy	2.09 \pm 0.86	0.5–4.0	2.09 \pm 0.92	0.5–4.0	2.08 \pm 0.80	0.5–4.0	.920
▪ .5–1	35	20.8%	19	22.3%	16	19.2%	–
▪ 1.1–2	70	41.7%	37	43.5%	33	39.8%	–
▪ 2.1–3	56	33.3%	23	27.0%	33	39.8%	–
▪ 3.1–4	7	4.2%	6	7.2%	1	1.2%	–
Reported occurrence of ERI	92	54.8%	42	49.4%	50	60.2%	.159
Number of reported ERIs (n = 92)	4.26 \pm 2.38	1–11	3.93 \pm 2.56	1–11	4.50 \pm 2.25	1–9	.041

SD, standard deviation; N, full sample size; n, subsample size; ERI, endoscopy-related injury; number of reported ERI, number of injury areas reported. Percent is calculated by column. *P* values are provided from *t*-tests (continuous data) and chi-square (categorical) analyses comparing outcomes by gender.

► **Table 2** Reported procedure volume by fellow gender (N = 168).

Procedures/ week	Men (n = 85)															
	EGD		Colonoscopy		ERCP		EUS		Enteroscopy		EMR/ESD/ POEM		Bariatric		Luminal Stenting	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
0	0	0.0	1	1.2	44	51.8	54	63.5	55	64.7	60	70.6	64	75.3	56	65.9
1–10	39	45.9	38	44.7	37	43.5	29	34.1	30	35.3	25	29.4	21	24.7	29	34.1
11–20	37	43.5	32	37.6	3	3.5	2	2.4	0	0.0	0	0.0	0	0.0	0	0.0
21+	9	1.6	14	16.5	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
	Women (n = 83)															
	EGD		Colonoscopy		ERCP		EUS		Enteroscopy		EMR/ESD/ POEM		Bariatric		Luminal Stenting	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
0	0	0.0	0	0.0	39	47.0	45	54.2	51	61.4	47	56.6	56	67.5	50	60.2
1–10	27	32.5	28	33.7	42	50.6	37	44.6	32	38.6	35	42.2	27	32.5	33	39.8
11–20	50	60.2	50	60.2	1	1.2	1	1.2	0	0.0	1	1.2	0	0.0	0	0.0
21+	6	7.2	5	6.0	1	1.2	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0

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

(i.e., colonoscopy, endoscopic mucosal resection, endoscopic retrograde cholangiopancreatography [data not shown]).

The most common sites of reported ERI were thumb (n = 54, 58.7%), hand/finger (n = 52, 56.5%), and wrist (n = 44, 47.8%). However, a relatively large proportion of respondents also experienced ERI in neck (n = 36, 39.1%) and lower back (n = 45, 43.5%) (► **Table 3**). The only difference in laterality of affected body area by gender was in the left thumb, such that there was a trend for female trainees to be more likely to report pain in the left thumb ($P = .05$). Notably, 65.2% (n = 60) of respondents reported being bothered by pain from one or more ERI outside of the work environment, though there were no gender differences. Only 5.4% (n = 5) of respondents with ERI reported taking time off due to ERI, and only 2.2% (n = 2) reported taking disability leave (► **Table 4**). We report treatments used for management of ERI in ► **Table 5**.

We found that the male and female fellows were equally likely to report the occurrence and severity of ERI. Female fellows were more likely to report a greater number of injury areas (4.50 ± 2.25) than male fellows (3.93 ± 2.56) ($P = .04$) (► **Table 1**), and elbow pain was significantly more likely to be reported by male (28.6%) than female fellows (10.0%) ($P = .02$) (► **Table 3**).

ERI during pregnancy

Only five trainee respondents reported pregnancy during their fellowship. Of these five trainees, four (80%) reported ERI that began during pregnancy, and three reported worsening ERI during pregnancy. All four respondents who were pregnant during fellowship reported performing endoscopy while preg-

nant with no reduced caseload, and only one reported additional allotted time for procedures during pregnancy.

Mechanisms reported to contribute to ERI

Among fellows who reported ERI, the leading causes were attributed to torquing with the right hand (n = 68, 73.9%), standing in awkward positions while supporting an endoscope (n = 57, 62%), and standing for prolonged periods (n = 45, 48.9%). There were no gender differences in contributing action of ERI (► **Table 6**).

Exposure to ERI prevention and ergonomics

In our cohort, 14.9% reported no current or previous training in ERI prevention (► **Table 7**). The most common ERI prevention training reported was on the importance of adjusting the bed height (n = 114, 67.9%), posture (n = 101, 60.1%), and adjusting monitor height (n = 86, 51.2%). In our cohort, ERI was not less likely in respondents with ERI prevention training ($P = 0.35$). Though less than half of the sample (n = 48, 28.6%) reported taking breaks (of any length), they were not associated with lower likelihood of injury ($P = 0.26$). The most common reported break lengths were micro breaks (n = 47, 28%), followed by 15- and 30-minute breaks (n = 17, 10.1% for each) (► **Table 7**).

Discussion

In this national sample of gastroenterology trainees, over half of respondents reported at least one area affected by ERI. There were no significant gender differences in the reported occurrence or severity of ERI, though our data indicate emergence of ERI with an onset as early as less than one year performing

► **Table 3** Location of self-reported ERI (N = 92).

ERI Location	ERI-only subsample (N=92)		Male (n=42)		Female (n=50)		P
	n	%	n	%	n	%	
Upper extremity							
▪ Thumb pain	54	58.7	20	47.6	34	68.0	.259
▪ Hand/finger pain	52	56.5	23	54.8	29	58.0	.906
▪ Hand/arm numbness	20	21.7	11	26.2	9	18.0	.247
▪ Carpal tunnel syndrome	9	9.8	3	7.1	6	12.0	.522
▪ De Quervain's tendonitis	8	8.7	4	9.5	4	8.0	.773
▪ Wrist pain	44	47.8	18	42.9	26	52.0	.630
▪ Elbow pain	17	18.5	12	28.6	5	10.0	.015
▪ Shoulder pain	28	30.4	9	21.4	19	38.0	.110
Back/neck							
▪ Neck pain	36	39.1	14	33.3	22	44.0	.383
▪ Upper back pain	37	40.2	12	28.6	25	50.0	.178
▪ Lower back pain	40	43.5	14	33.3	26	52.0	.216
Lower extremity							
▪ Hip pain	8	8.7	5	11.9	3	6.0	.224
▪ Knee pain	15	16.3	6	14.3	9	18.0	.828
▪ Foot pain	23	25.0	10	23.8	13	26.0	.978
P values are reported from chi-square analyses. ERI, endoscopy-related injury; N, full sample size; n, subsample size.							

endoscopy, with increasing occurrence over time. A recent survey in practicing Japanese endoscopists showed longer upper and lower endoscopic submucosal dissections and lower gastrointestinal treatment were significantly associated with low back musculoskeletal disorders [10]. However, there were gender differences on specific ERI outcomes, such that females reported a greater number of injury areas, and males were more likely to report elbow pain, which mirrors the findings in a recently published large, non-trainee sample of practicing gastroenterologists [1]. Overall, our results suggest that specific vulnerabilities to ERI emerge as early as training and should be both monitored and prevented.

Our findings differ from a study published in 2008 that indicated early career gastroenterologists (in practice <39 months) reported different locations of pain compared to more experienced practitioners [11]. These differences may be due to variability in measurement, sample, or reflect differences in skill already apparent post-fellowship, but not developed to the extent of more experienced practitioners.

In contrast, the proportion of reported ERI location in our study are similar to a recent survey in practicing gastroenterology [1]. In this study of practicing gastroenterology, the most common sites of ERI were thumb (59%), hand/finger (56.5%), and wrist (48%), which are reflected in the present sample and

suggests early vulnerability to injury in certain locations due to overuse causing strain and soft tissue microtrauma.

Ergonomically inappropriate instruments are a major ERI consideration among gastroenterology physician researchers as well as laparoscopic researchers generally. A prevalent hypothesis is that practitioners with smaller hand size, specifically women, may have more difficulty using the instruments, which will then lead to ERI. In addition to smaller hand size, this could also be attributed to suboptimal grip strength, reduced force generating mass [12–14], as well as ergonomically inappropriate instruments [5]. Though not statistically significant, we found greater proportions of female trainees reporting upper extremity ERI, and there was a significant trend indicating that females were more likely to report left thumb pain compared to male fellows. This may not have reached significance in our sample due to sample size and the overwhelming reports of ERI generally. This is congruent with a study that indicated that female gastroenterology fellows were more likely to report that their hand size (97.4% of whom had glove size of 6.5 or less) was too small for a standard endoscope [14]. Despite this, only 34.2% of respondents indicated that they would opt to use smaller instruments if given the option [14]. Regardless of the research focus to evaluate differences between men and women, this suggests that development of ergonomics curricu-

► **Table 4** Impact of ERI on pain outside of work place, time off work, and disability (N=92).

ERI	N	Pain outside of work environment		Time off		Disability	
		n	%	n	%	n	%
Total ERI-only sample	92	60	65.2	5	5.4	2	2.2
Upper extremity							
▪ Thumb pain	54	20	37.0	2	3.7	1	1.9
▪ Hand/finger pain	52	18	34.6	1	1.9	0	0.0
▪ Hand/arm numbness	20	14	70.0	0	0.0	1	5.0
▪ Carpal tunnel	9	8	88.9	0	0.0	0	0.0
▪ Tendonitis	8	6	75.0	1	12.5	0	0.0
▪ Wrist pain	44	19	43.2	1	2.3	0	0.0
▪ Elbow pain	17	9	52.9	0	0.0	0	0.0
▪ Shoulder pain	28	14	50.0	1	3.6	1	3.6
Back/neck							
▪ Neck pain	36	23	63.9	1	2.8	0	0.0
▪ Upper back pain	37	24	64.9	0	0.0	0	0.0
▪ Lower back pain	40	20	50.0	1	2.5	0	0.0
Lower extremity							
▪ Hip pain	8	4	50.0	0	0.0	0	0.0
▪ Knee pain	15	8	53.3	0	0.0	0	0.0
▪ Foot pain	23	11	47.8	0	0.0	1	4.3

ERI, endoscopy-related injury.

Total ERI-only sample is the total number of respondents reporting.

Pain outside is reported pain outside of the work environment.

Disability is reporting using short- or long-term disability.

la, instruments, or other innovations that consider and accommodate variability in characteristics such as hand size and grip strength is critical to preventing ERI among gastroenterology.

Our finding that male gastroenterologists were more likely to report elbow pain due to ERI is noteworthy because this outcome was not affected by pre-existing (non-ERI) injury and has been reported in a larger non-trainee sample [1]. Male endoscopists should be cognizant that elbow pain appears to be a specific vulnerability and determine forces contributing to it and ensure measures are instituted to avoid it. Specific to female gastroenterology fellows in this sample, 80% who had a pregnancy during training reported ERI, with most (75%) reporting worsening pain. Though our sample size is small, these proportions are congruent with recent findings in non-trainee female gastroenterology [1]. As the number of female physicians entering gastroenterology grows, the impact of endoscopy during pregnancy and determining ways to prevent injury will be important issues to address.

Our results diverge from a recent survey [2] of 165 trainees (35.2% females) in which female gastroenterology fellows reported a higher rate of ERI. There are several explanations for this discrepancy, including differences in the number of fe-

males in each cohort and question verbiage. In addition, previously described risk factors for ERI [15] including procedure volume (>20 cases/week) and greater number of hours spent performing endoscopy (>16 hours/week) were not associated with ERI in our sample. However, congruent with this research, we found the occurrence of reported ERI increased after the first year of training. It is likely that younger age and less cumulative procedure burden explains the disparities.

The need for more substantial training in ergonomics for trainees is apparent in the high rate of reported ERI as early as fellowship. Comparisons have been made between gastroenterology trainees and novice endurance runners. Like these runners, gastroenterology trainees repeatedly employ postures and repetitive and kinetic muscle forces for holding and advancing an endoscope in ways that are largely unfamiliar. One study evaluating the rate of injuries in novice runners found that those who increased their weekly running distance by more than 30% over a 2-week period sustained more overuse injuries compared to those who increased their distance by less than 10% [16]. Though data suggest that gradually increasing physical activity by 10% or less per week may reduce injury risk, this has not been evaluated in gastroenterology trainees

► **Table 5** Reported ERI treatment by ERI location (N=92).

ERI	N	Acupuncture/ chiropractor		Massage		Medications		Physical therapy		Rest		Splinting		Steroid		Surgery	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Thumb pain	54	0	0.0	4	7.4	2	3.7	4	7.4	10	18.5	4	7.4	1	1.9	0	0.0
Hand/ finger pain	52	0	0.0	8	15.4	3	5.8	3	5.8	11	21.2	3	5.8	0	0.0	0	0.0
Hand/arm numbness	20	0	0.0	4	20.0	1	5.0	2	10.0	6	30.0	3	15.0	0	0.0	0	0.0
Carpal tunnel	9	0	0.0	1	11.1	2	22.2	1	11.1	3	33.3	3	33.3	0	0.0	1	11.1
Tendonitis	8	0	0.0	0	0.0	1	12.5	1	12.5	2	25.0	2	25.0	1	12.5	0	0.0
Wrist pain	44	0	0.0	4	9.1	4	9.1	3	6.8	6	13.6	2	4.5	0	0.0	0	0.0
Elbow pain	17	0	0.0	0	0.0	2	11.8	2	11.8	4	23.5	2	11.8	0	0.0	0	0.0
Shoulder pain	28	0	0.0	8	28.6	4	14.3	4	14.3	3	10.7	0	0.0	0	0.0	0	0.0
Neck pain	36	0	0.0	14	38.9	5	13.9	4	11.1	5	13.9	0	0.0	0	0.0	0	0.0
Upper back pain	37	0	0.0	14	37.8	4	10.8	2	5.4	5	13.5	0	0.0	0	0.0	0	0.0
Lower back pain	40	1	2.5	9	22.5	4	10.0	3	7.5	4	10.0	0	0.0	1	2.5	1	2.5
Hip pain	8	0	0.0	0	0.0	0	0.0	0	0.0	1	12.5	0	0.0	0	0.0	0	0.0
Knee pain	15	0	0.0	0	0.0	0	0.0	0	0.0	3	20.0	0	0.0	0	0.0	0	0.0
Foot pain	23	0	0.0	2	8.7	3	13.0	0	0.0	5	21.7	0	0.0	0	0.0	0	0.0

N is the number of respondents reporting injury.
n is the number of respondents reporting specific therapy by injury.
Pain outside is experiencing pain outside of the work environment.
Percentages are calculated within rows.

► **Table 6** Mechanism of ERI (N=92).

ERI contributing action	ERI-only subsample (N=92)		Male (n=42)		Female (n=50)		P
	N	%	n	%	n	%	
Adjusting tip angulation with left hand	32	34.8	12	28.6	20	40.0	.252
Torquing with right hand	68	73.9	29	69.0	39	78.0	.330
Use of lead aprons	16	17.4	9	21.4	7	14.0	.349
Use of the elevator on the duodenoscope	7	7.6	4	9.5	3	6.0	.525
Standing for prolonged periods of time	45	48.9	19	45.2	26	52.0	.518
Standing in awkward positions supporting an endo- scope	57	62.0	27	64.3	30	60.0	.673
Non-adjustable bed/monitor	24	26.1	12	28.6	12	24.0	.619

P values are provided from chi-square analyses.
ERI, endoscopy-related injuries.
N is the full sample size.
n is the subsample size.

► **Table 7** Reported training in ERI prevention and use of breaks (N = 168).

ERI prevention training	Total sample (N = 168)	
	n	%
Prevention training		
▪ Posture	101	60.1
▪ Bed height	114	67.9
▪ Monitor height	86	51.2
▪ Techniques to reduce injury	44	26.2
▪ Exercise	15	8.9
▪ None	25	14.9
Scheduled breaks		
▪ 1 per half day	11	6.6
▪ 1 per full day	28	16.7
▪ 2 or more per half day	5	3.0
▪ 2 or more per full day	5	3.0
▪ No scheduled breaks	97	57.7
Break length		
▪ Microbreaks	47	27.9
▪ 15 minutes	17	10.1
▪ 30 minutes	17	10.1
▪ 45 minutes	7	4.2
▪ 60 minutes	7	4.2
N is the full sample size ERI, endoscopy-related injury. n is the number reporting.		

regarding endoscopy volume [17]. Identifying the optimal increase in physical activity will be key as the field moves toward competency-based assessment. It will also be critical to have competent trainers that teach proper ergonomic principles of scope handling techniques [18]. This training is further important because endoscopy is highly repetitive, which can develop into muscle memory that is difficult to correct. Adopting

proper technique is crucial in early training phases and may protect against ERI and potential disability.

Despite the high rate of occurrence of ERI among fellows, the exposure to and benefit of ergonomics training is mixed. Most (85.1%) gastroenterology fellows in our sample reported receiving some form ergonomic training, but no relation was found between ergonomics training and occurrence of ERI. However, these results differ from a 2019 survey [3] in which 36% of gastroenterology fellows had ergonomics training. Further, ERI was less prevalent in fellows who had attended ergonomics training than in those who had not, suggesting a beneficial effect. When comparing the present trainee sample to a recent non-trainee sample [1], it appears that ergonomics training has become more common, which is encouraging (61.5% of gastroenterologists vs 85.1% of trainees). This may be due to increasing awareness of risks for ERI coupled with a call from gastroenterology societies for an increased focus on ergonomics [18, 19]. Nonetheless, the large number of gastroenterology trainees reporting ERI indicates an opportunity for improvement in ergonomic training and instrument design. To that end, ASGE has recently published a core curriculum for ergonomics in endoscopy for trainers and trainees that outlines cognitive, technical, and non-technical skills that should be obtained for endoscopy [20].

Recent research has started to shed light on pathophysiology mechanisms of ERI and best practices in ergonomic education. In a study evaluating biomechanical risk factors during colonoscopy, the activity of the left-wrist extensors, left thumb extensors, and right-wrist extensors exceeded the hand activity level action limit established by the American Conference of Industrial Hygienists during routine colonoscopy resulting in injury [21]. Another study assessed the impact of simulation-based ergonomic training curriculum (i.e., didactic lectures, watching videos of expert performance, ergonomic-specific feedback, and an ergonomics checklist to augment feedback) and found it to be associated with a lower rate of ERI [22]. However, despite this training, the intervention group was still at moderate risk for ERI, which highlights the need for multimodal ergonomic training and intervention, such as the creation of adjustable or ergonomically appropriate instruments [22, 23]. A pilot study involving individual assessment and instruction by a physical therapist resulted in improvement of musculoskeletal complaints among endoscopists reporting ERI [24].

► **Table 8** Published reported occurrence of ERI in gastroenterology fellows.

Study	Year of survey	Year of publication	Sample size	% male	% female	% reporting ERI
Villa et al. [3]	6/2016; 5/2017	2019	156	65	35	47
Austin et al. [2]	3/2016–7/2016	2019	165	65	35	20
Morais et al. [26]	5/2019	2020	38	Not reported	Not reported	21
Pawa et al. (current study)	10/2018–4/2019	2022	168	51	49	55

ERI, endoscopy-related injury.

There are several strengths and limitations to consider in this study. Though the sample size is small, it is one of the largest gastroenterology trainee samples with a near-equal distribution between male and female gastroenterology (► **Table 8**), which allows for meaningful gender comparisons. Notably, there is a potential for response bias, as only 14.1% of gastroenterology trainees completed the survey. However, this is comparable to other published samples [2, 3]. Other limitations are inherently related to the self-reported survey design, including selection and recall bias [25].

The survey was also developed for the purpose of determining general occurrence of ERI within this population and this study did not include a validated measure of musculoskeletal injury. Finally, this sample of fellows was drawn from a larger sample of practicing gastroenterologists [1]. Because of this, some fellow-specific information was not asked (e.g., post-graduate year); therefore, this variable was estimated by number of years performing endoscopy, which is ultimately a more precise measure of time contributing to overuse injuries.

Conclusions

Overall, our results contribute additional evidence that ERI is common in gastroenterologists as early as fellowship training. Our outcomes provide support for three specific actions. First, we need granularity regarding what contributes to ERI in endoscopists, during training and beyond. Research will be required to inform what should be targeted (e.g., specific ergonomic techniques, other safety measures) and the optimal time for implementation (e.g., during fellowship, throughout career). Second, it is highly likely that a nationwide ergonomic-specific training curriculum would be highly beneficial to trainees. However, knowledge about the most effective teaching strategies to ensure compliance and injury prevention is needed. We suggest these should include self-assessment, formal assessment, setting metrics and potential graded observations during endoscopy. Finally, improvements in endoscopic instrument design safe for both male and female gastroenterologists is paramount. This will require collaborative efforts to both evaluate ergonomics and kinematics and design instruments around these findings.

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Competing interests

The authors declare that they have no conflict of interest.

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