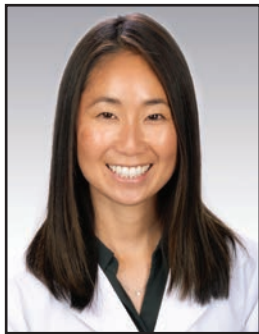
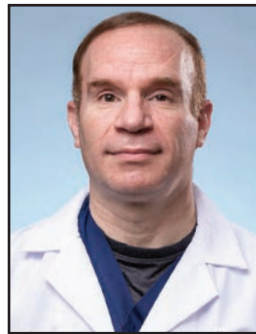


Douglas G. Adler MD, FACP, AGAF, FASGE, Series Editor

## Ergonomics in Endoscopy



Christina M. Minami



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### INTRODUCTION

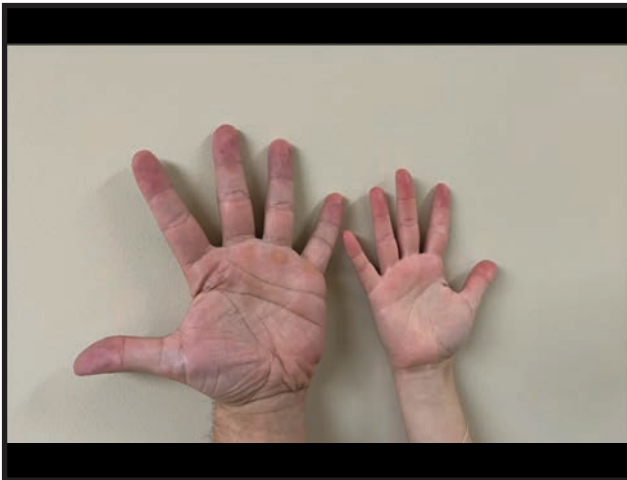
**M**usculoskeletal injuries are prevalent among healthcare workers. Proceduralists, such as gastroenterology (GI) endoscopists, require repetitive and often unnatural movements while maneuvering endoscopes and colonoscopes. The frequent stress and forces naturally lead to injuries and pain. Currently the one-size-fits-all endoscopes do not accommodate for the various hand sizes and body types of endoscopists. Proper ergonomics during procedures are recommended to both prevent and ameliorate endoscopy related injuries. The purpose of this article is to review the current literature on published studies and recommendations for gastroenterologists regarding ergonomics in endoscopy.

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### Injuries in Endoscopy

The most common sites of pain among endoscopists varied between studies. The most frequent sites of pain were low back, hand and wrist, fingers, neck, right shoulder, and left thumb.<sup>1 2 3</sup> The left thumb is particularly exerted during both colonoscopy and ERCP, of note. In an electronic survey sent to 72 GI physicians and 104 non-GI physicians employed by Mayo Clinic, frequency of overall musculoskeletal (MSK) pain was not significant between the two groups, but frequency of pain in left thumb, hand, and wrist were significantly higher in the GI group.<sup>2</sup> Endoscopists in practice less than 39 months experienced more left thumb and finger pain, while endoscopists practicing longer most commonly experienced left shoulder pain.<sup>1</sup> In a Canadian survey of 133 physicians practicing ERCP in Ontario, 74% of endoscopists attributed their pain to procedure work, and yet only 18% of participants modified their work based on their pain or injuries.<sup>3</sup>



**Figure 1a.** Side by side view of representative male and female hands showing size disparity.



**Figure 1b.** Overlapping view of representative male and female hands showing size disparity.



**Figure 2a.** Endoscope umbilical positioned on the outside of the forearm.



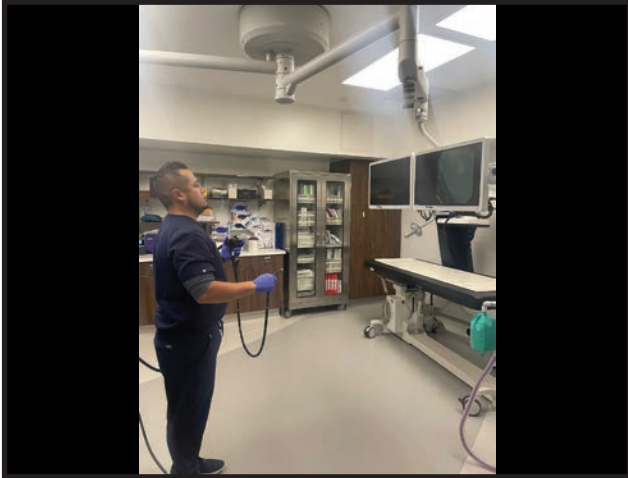
**Figure 2b.** Endoscope umbilical positioned on the inside of the forearm.

Injuries from endoscopy can be serious and debilitating. In a survey of 171 endoscopists of the Portuguese Society of Gastroenterology, missing work due to musculoskeletal injury was reported by 10.1% of respondents and 33.6% required a reduction in physical activity outside of work.<sup>4</sup>

### Risk Factors

The literature suggests a higher risk for injury in females compared to males, although studies seem to differ on statistical significance. This may be due to physical differences in hand sizes between males and females, as the endoscope is of constant size regardless of the user. (Figure 1) With the

increasing number of women entering the field of gastroenterology, in 2020, Bhatt et al. distributed an electronic survey which sought to evaluate the subtle gender differences in endoscopy ergonomics. They found a statistically higher incidence of injury in females compared to males ( $p = 0.02$ ) and a higher incidence of wrist pain in females compared to males ( $p = 0.02$ ). This was the first study to show, with statistical significance, differences in injury by gender. It was attributed to disproportionately smaller hand/glove size, and lesser muscle mass and upper body strength compared to males.<sup>5</sup> On the other hand, in a large electronic survey of 1,698 members of the American College of



**Figure 3a. Endoscope monitor is placed too high and produces cervical neck extension during endoscopy.**



**Figure 3b. Endoscope monitor is placed below the eye level allowing the endoscopist to hold a more neutral posture.**

Gastroenterology, the authors found no significant differences in prevalence of endoscopy related injury in men compared to women ( $p = 0.77$ ). The authors did find that females were more likely to have upper extremity and upper back pain.<sup>6</sup>

During endoscopy, the proceduralist must often hold and repeat difficult movements again and again, frequently in awkward positions, alternately pinching, gripping, pushing, pulling, and torquing the endoscope and its accessories for the entirety of the procedure. Bhatt et al. also found that females, compared to their male counterparts, tended to hold the endoscope umbilical cord outside the forearm ( $p = 0.00$ ), use the right hand to turn the small wheel ( $p = 0.03$ ), and were more likely to use a pediatric colonoscope in smaller patients ( $p = 0.01$ ). (Figure 2) This was likely attributed to females with smaller body and hand sizes needing to bear the weight and diameters of the endoscope and apply adequate force during the procedure. Regarding turning and stabilizing the endoscope shaft itself, they found no significant difference in technique between men and women ( $p = 0.26$ ). To turn the scope, most endoscopists (94.5%) favored torquing or twisting the shaft. Other less frequently used techniques included turning the left

forearm which holds the endoscope control head (47.4%), using the small wheel for left or right deflection (45.8%), and turning their entire body (41.1%). To stabilize the endoscope shaft, most endoscopists chose to either place the shaft on the bed (67.3%) or stabilize the shaft with their body (65.4%). Other less common techniques to stabilize the shaft included holding it between the fingers of the left hand (49.5%) and asking for assistance from a technician or nurse (28%).<sup>5</sup>

These maneuvers place significant strain on the endoscopist's musculoskeletal system. Shergill et al. quantified this strain by measuring the thumb force and forearm muscle loads of the extensor carpi radialis and flexor digitorum superficialis during colonoscopy insertion versus withdrawal. Tactile thumb pads were used to measure thumb force and bilateral muscle electromyography (EMGs) were used to measure muscle loads. They evaluated 12 attending gastroenterologists from the University of California, San Francisco and found that forearm loads were significantly greater during insertion even though more time was spent during withdrawal ( $p < 0.05$ ). Highest thumb forces also occurred during colonoscopy insertion compared to withdrawal.<sup>7</sup>

Injury may start as early as gastroenterology fellowship and becomes more likely over time. These early stages of training and introduction to endoscopy are crucial for learning proper posturing



**Figure 4. A loop in the endoscope umbilical behind the endoscopist creates both tension and traction on the endoscope, which can affect body positioning and ergonomic strain.**

and techniques to reduce physical strain.<sup>8</sup> In a study attempting to assess the prevalence of MSK injuries among GI fellows across the United States, 47% of 156 survey participants experienced new endoscopy-related MSK injury during fellowship and 85% occurred within the first 12 months.<sup>9</sup> In a similar survey analyzing the prevalence of endoscopy-related overuse injuries in GI fellows ( $n = 165$ ), 20% reported a musculoskeletal injury with female gender as the only factor associated with a higher rate of injury.<sup>10</sup> These injuries may be subsequent results of improper positioning of the patient and/or the monitor, and/or improper endoscopic technique.

Working as an attending in a fellowship program may be a protective factor, as Bhatt et al. found that working with GI fellows decreased the risk of injury significantly, suggesting a decreased endoscopy workload may be beneficial.<sup>5</sup>

In a Japanese web-based survey focusing on sites of injuries and risk factors among 352 Japanese endoscopists, they found that greater than or equal to 28 endoscopy procedures per week and age older than 36 years old were associated with endoscopy related injury. Endoscopist height taller than or equal to 172 cm was associated with neck injuries in males. Specifically, for hand injuries, risk factors included glove size greater than or equal to 7 in males and age above 36 in females. Authors suggested that in males, hand size does

not always match the standard size of endoscope. Additionally, their study showed that most females were also dissatisfied with the size and shape of the endoscopes. As age increases in females, arthritis is precipitated or worsened by frequent pinching and gripping. They concluded that changing the endoscope design and operability may be essential in preventing endoscopy-related injury.<sup>11</sup>

### Proper Ergonomics

To follow proper endoscopy ergonomics, the American Society of Gastroenterology Endoscopy (ASGE) suggests ergonomic education to reduce risk of endoscopy related injury.<sup>12</sup> Hansel et al. recommends aiming to reduce twisting and bending during procedures, having adjustable table heights to allow the endoscopist's elbows to be gently flexed at approximately 90 degrees, video monitors side by side with the endoscopist's eyes at three-quarters the way up the screen, using two-piece lead aprons (as opposed to one-piece aprons), scheduled breaks between procedures, and floor padding.<sup>2</sup> Similarly, Khan et al. recommended that the video monitor should be directly in front of the endoscopist, 15-25 degrees below eye level, the bed height between elbow height and 10 cm below elbow height, keeping foot pedals in front of the endoscopist's body, cushioned floor mats, two-piece lead aprons, endoscopists keeping in neutral position and square to monitor with feet hip-width apart, and finger grip 15-30 cm from anorectum when colonoscopy was being performed.<sup>13</sup> (Figures 3 and 4) Markwell et al. created individualized wellness plans for eight Duke University gastroenterologists at an ambulatory surgical center. They recommend a monitor height 15 degrees below the horizontal visual field, monitor placement directly in front of the physician to reduce cervical strain while maintaining clarity, bed at a height to allow the right hand to be at elbow height to 10 cm below elbow height, ergonomic floor mats, and closed toe footwear with arch support.<sup>14</sup>

### Prevention

#### Making Modifications

Modifications can, and should, be made to prevent and treat endoscopic injuries. Comparing the 109 endoscopists to the 120 non-endoscopists in

Kuwabara et al.'s study, the endoscopists chose to make fewer modifications to their daily practices to prevent musculoskeletal pain. The reasons for this were unclear, but it was speculated to be due to limited time, busier schedules, or a lack of willingness. In this study, the endoscopists' most common request to improve endoscope design was making parts of the endoscope lighter and smaller.<sup>1</sup> In a survey by Bhatt et al. more female participants, as compared to male participants, were willing to try a pre-procedure posture checklist, wear a posture sensor to signal the endoscopists to stand up straight, and use braces at sites of pain. This may be attributed to the significantly higher rate of injury in the females included in this study.<sup>5</sup>

Hansel et al. found that although gastroenterologists and hepatologists employed by Mayo Clinic experienced musculoskeletal injury, nearly a third made no modifications to their practice despite these injuries. Of those who chose to make modifications, the most common choices were stretching, using adjustable height beds, standing on rubber mats, and reducing the overall time spent performing endoscopies.<sup>2</sup> The ASGE's website includes links to the videoGIE journal for stretching suggestions.<sup>15</sup>

It has been suggested that endoscopists do not take enough breaks in prevention of injury. In O'Sullivan et al.'s survey of ERCP endoscopists, more than half of respondents did not take any breaks between procedures.<sup>3</sup>

The endoscopists in the study by Shergill et al. were invited to perform simulated colonoscopy using a novel antigravity support arm (zeroG system, Equipois, Manchester, NH, USA). They found that during simulation the support arm decreased muscle activity of the left wrist extensors when evaluated with EMG.<sup>7</sup> Another small study of three experienced endoscopists in Bologna, Italy evaluated the advantages of using a lighter, single-use duodenoscope compared with standard reusable ones. They measured upper limb postures and muscle activity, which found that a lighter endoscope could decrease static and dynamic load during ERCP procedures and lower muscle activity.<sup>16</sup>

Multiple studies have attempted to start ergonomics education as early as possible in training. In Pawa et al., gastroenterology fellows who reported

no musculoskeletal injuries were significantly more likely to have had previous ergonomics training.<sup>8</sup> Khan et al. created a simulation-based ergonomics curriculum studying general surgery, internal medicine, and gastroenterology trainees rotating at St. Michael's Hospital in Toronto, Canada. This cohort of trainees were compared to a similar group without ergonomics training. In order to quantify musculoskeletal injury, the authors used the "Rapid Entire Body Assessment" (REBA) and "Rapid Upper Limb Assessment" (RULA). These are ergonomic worksheet assessment tools developed to evaluate whole body (REBA) and upper extremity (RULA) ergonomic musculoskeletal injuries.<sup>17,18</sup> They saw significantly higher REBA scores in clinical colonoscopy ( $p < 0.001$ ) but not significant in simulated colonoscopy. Those without ergonomic training had worse REBA and RULA scores six weeks after training ( $p < 0.001$ ).<sup>19</sup> Similarly, Gala et al. created a six-month curriculum for 37 general GI and fourth year advanced GI fellows. This curriculum included a didactics session based on the ASGE guidelines on ergonomics for prevention of musculoskeletal injury, followed by a session practicing stretches, resistance bands, and ideal postures with a physical therapist. Participants were provided with a lifelong subscription code to the website with home exercises and stretching. They were evaluated with a pre and post curriculum survey. From those who completed post-curriculum surveys, those individuals felt that the interactive session with the physical therapist was the most impactful part of the curriculum.<sup>20</sup> Although there are many studies with a positive response to ergonomics training during fellowship, Villa et al. found differing results. Their 168-participant electronic survey to GI trainees found that 85% of respondents received ergonomics training but found no relation between training and endoscopic related injury.<sup>9</sup>

### Treatment of Endoscopic Injury

In the study by O'Sullivan et al., the most commonly used treatment for pain and injury from endoscopy included medication (36%), physiotherapy (15%), and massage therapy (13%).<sup>3</sup> The University of Miami also created an ergonomics training curriculum for GI fellows incorporating a physical

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therapist for active practice of exercises and an introduction to a “microbreaks” model. The “microbreaks” model was taken from studies for general surgeons trialing scheduled 1.5-minute breaks at appropriate 20–40 minutes intervals throughout surgical cases. During these breaks, the physician completes exercises and stretches targeting the neck, shoulders, upper back, lower back, wrists, hands, knees, and ankles. This study found that 100% of fellows reported reduction of pain immediately after implementing the “microbreaks” model.<sup>21, 22</sup>

## CONCLUSION

Improper ergonomics in GI endoscopy has left many proceduralists with injuries, most commonly in the upper extremity. The literature is mixed on whether females are disproportionately affected by endoscopy related injury, potentially due to smaller statures and hands. Many females report a desire for alternative techniques to accommodate such maneuvers. Injuries from endoscopy start as early as in fellowship training and should be addressed early on. An ergonomic curriculum during training is likely beneficial. During procedures, the patient beds should be at a height allowing the endoscopists elbows bent to approximately 90 degrees, positioning the screen to reduce cervical strain, using floor mats and using two-piece lead aprons when possible. Although there is widespread recognition of ergonomic injury, many gastroenterologists do not make any adjustments to their practice. Proper ergonomics may include making those adjustments before and during procedure, but also planning for microbreaks with stretching and exercises during and after the procedure. In conclusion, GI endoscopists are at risk of experiencing endoscopy-related injuries, and the literature suggests the solution may be multifactorial. The endoscope itself should be modified to accommodate the unique hand and body shapes of endoscopists. Body positioning and equipment positioning should minimize strain or extra force. Breaks and stretching should be incorporated into the proceduralist’s schedule. Finally, formal education on ergonomics should be implemented early in training. ■

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