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Educational interventions to improve ergonomics in gastrointestinal endoscopy: a systematic review

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ABSTRACT

Background and study aims Endoscopists are at high risk of musculoskeletal pain and injuries (MSPI). Recently, ergonomics has emerged as an area of interest to reduce and prevent the incidence of MSPI in endoscopy. The aim of this systematic review was to determine educational interventions using ergonomic strategies that target reduction of endoscopist MSPI from gastrointestinal endoscopy.

Methods In December 2020, we conducted a systematic search in MEDLINE, EMBASE, PsycINFO, Web of Science, Scopus, the Cochrane Central Register of Controlled Trials and the Cochrane Database of Systematic Reviews for articles published from inception to December 16, 2020. Studies were included if they investigated educational interventions aimed at changing knowledge and/or behaviors related to ergonomics in gastrointestinal endoscopy. After screening and full-text review, we extracted data on study design, participants, type of training, and assessment of primary outcomes. We evaluated study quality with the Medical Education Research Study Quality Instrument (MERSQI).

Results Of the initial 575 records identified in the search, five met inclusion criteria for qualitative synthesis. We found that most studies (n = 4/5, 80 %) were single-arm interventional studies that were conducted in simulated and/or clinical settings. The most common types of interventions were didactic sessions and/or videos (n = 4/5, 80%). Two (40 %) studies used both standardized assessment studies and formal statistical analyses. The mean MERSQI score was 9.7.

Conclusions There is emerging literature demonstrating the effectiveness of interventions to improve ergonomics in gastrointestinal endoscopy.

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Introduction

Practicing medicine in a procedural or surgical specialty has long been associated with a high incidence of musculoskeletal pain and injuries (MSPI) with work-related etiologies. Many of

these disorders share risk factors including repetitive movements, static and awkward postures, long working hours, and challenging equipment designs [1–3].This places gastrointestinal endoscopists at a particularly high risk of MSPI, which commonly include disorders such as carpal tunnel syndrome, tendonitis, De Quervain's tenosynovitis, and postural/ spinal injuries [4, 5].

These injuries, once acquired, can have a profound impact on the wellness and productivity of physicians. In many cases, they require practice modification, decreased volume, leaves of absence, or early retirement [5, 6]. Given recent data that demonstrate a rising prevalence of MSPI among practicing endoscopists [2], educational interventions to teach ergonomic principles that mitigate MSPI are needed.

While existing training covers other important dimensions of endoscopic competency, minimal time, if any, is dedicated to ergonomic techniques [7, 8]. The aim of this paper was to perform a systematic review to determine educational interventions using ergonomic strategies that target the reduction of MSPI from gastrointestinal endoscopy.

Methods

This systematic review is registered in the PROSPERO international prospective register of systematic reviews (CRD42021265898). The reporting follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [9].

Search strategy and data sources

We conducted a systematic search in collaboration with a health sciences librarian. We searched the following databases from their inception to July 16, 2021: MEDLINE; EMBASE; PsycINFO; Web of Science; and Scopus. Additionally, we searched the Cochrane Central Register of Controlled Trials (1991–), and the Cochrane Database of Systematic Reviews (2005–) using the Cochrane Library platform. The search strategy concept blocks were built on the topics of: "Interventions" AND "Ergonomics" AND "Endoscopy". We elicited peer review of our search strategy following the Peer Review of Electronic Search Strategies (PRESS) guidelines [10]. The search strategy was translated into each database using that platform's command language, including text words, controlled vocabulary, and subject headings when applicable. Animal studies were excluded. No date, language, or study design limits were imposed on the search strategies. The complete detailed strategy is provided in **Appendix 1**. We also used hand searching of the reference lists of any review articles for any additional relevant articles.

We searched the gray literature using the following databases: the PROSPERO international prospective register of systematic reviews [11]; and the World Health Organization International Clinical Trials Registry Platform (WHO ICTRP) [12]. We also searched abstracts and proceedings of major meetings related to gastrointestinal endoscopy using the key words "ergonomics" and "education". Specifically, we searched the following meetings: the Canadian Digestive Diseases Week (CDDW) (2016–2021); and Digestive Disease Week (DDW) (2009–2021). We hand-searched the reference lists of the studies and review articles that were tentatively included for full-text review to identify further relevant studies.

Selection process and data extraction

Two authors (MAS, NG) screened the records independently and in duplicate to retrieve full-text publications, wherein any discrepancies were resolved via consensus. Articles were included if they were original full-text articles published in English that investigated the impact of an educational intervention that teaches ergonomic principles to mitigate the risk of developing MSPI from gastrointestinal endoscopy. Any studies that were non-primary, such as letters, commentaries, reviews or opinion publications, and/or lacked retrievable full-text manuscripts (e. g. conference abstract only) were excluded. For data extraction, two authors collected the following data from each of the included studies: study identifier (e. g. authors, year published); study design type (e. g. randomized controlled trial [RCT]); number and type of study participants; length of training and assessment; description of study arms with number of assigned participants; type of primary outcome used; and primary finding. We considered the primary finding to be the primary outcome measure. If there was no primary outcome identified or there were multiple primary outcomes, we considered the first reported measure in the Results section as the primary outcome.

Data synthesis and quality assessment

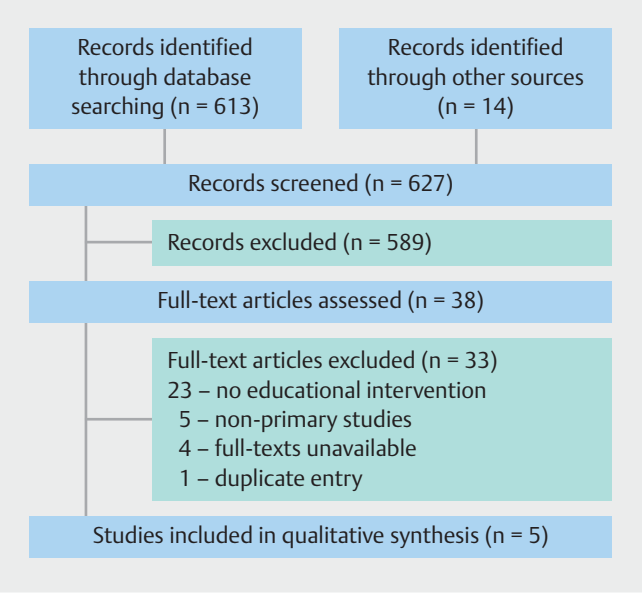
We conducted a qualitative narrative synthesis of the interventions aimed at improving ergonomics in endoscopy. Two authors (MAS, NG) assessed the quality of the included articles using the Medical Education Research Study Quality Instrument (MERSQI), which is a standardized tool used in the medical education literature [13]. Using this tool, the two authors assessed the following six domains of all included studies: study design; sampling; type of data; validity evidence for evaluation instrument scores; data analysis; and outcome. The overall score ranges between 5 and 18. Any discrepancies in scoring were resolved via consensus.

Results

Our search strategy identified 575 records and 14 from the gray literature. After full-text review, we included five studies for qualitative synthesis. The search flow is summarized in ▶ **Fig. 1**. The characteristics and relevant findings of the included studies are summarized in ▶ **Table 1**.

Study design and participants

Most studies (n = 4/5, 80 %) used single-arm designs that were conducted in clinical settings. The remaining study was a two-arm trial with a historical control that was conducted in both simulated and clinical settings [3]. All studies were prospective. Most studies investigated interventions that were not specified for any one endoscopic procedure (n = 3/5; 60 %); and the remaining two studies focused primarily on colonoscopy [3, 14].



▶ **Fig. 1** Summary of study flow.

Participants were most commonly endoscopists of varied levels of experience, though one study (20 %) also included non-endoscopist staff at an endoscopy unit [15].

Types of interventions and outcomes

Where specified (n = 3/5, 60 %), the length of both the training and assessment ranged from a 6-minute teaching video [16] to 6 weeks of training [3]. In terms of interventional content, didactic sessions and/or videos were the most common modalities (n = 4/5, 80 %). Additional intervention modes of delivery included individualized feedback (n = 2/5, 40 %), checklists (n = 2/5, 40 %), and simulated training (n = 1/5, 20 %).

The primary outcomes of most studies involved either self-reported measures (n = 2/5, 40 %) or knowledge tests (n = 2/5, 40 %). One study assessed ergonomics using blinded assessors [3]. Formal statistical analyses were used in two studies (40 %), while the remaining studies only provided descriptive data. One study used a standardized assessment tool, the rapid entire body assessment (REBA), which estimates the risk of entire body MSPI by assessing joint positioning, force loads, movement repetitiveness, and frequency of postural change [3, 17,18].

Impact of interventions on ergonomics

All studies reported a benefit of their respective interventions on the assessed dimension of ergonomics. Both studies (n = 2/5, 40%) that conducted formal statistical analyses found a statistically significant difference in either behavioral strategies in risk reduction of MSPI or knowledge of safe ergonomic practices due to the intervention. In one study, the combined approach of didactics, individualized feedback, and a checklist of the intervention group led to statistically significantly lower REBA scores (wherein higher scores indicate greater MSPI risk) compared to the control group in the setting of two clinical colonoscopies [3]. The other study found that staff at an endoscopy unit had improved knowledge of ergonomic principles in endoscopy after the intervention [15].

The studies using descriptive statistics evaluated the impact of their respective interventions using either reduction in a score given to a particular marker of ergonomics over time or improvement in knowledge. One study reported a 100 % pain reduction among participants who had initially indicated pain after completing an educational module on MSPI prevention [19]. The other study examining pain reduction found a 63 % decrease in the number of pain sites after participants completed an individualized wellness program with recommendations on exercise and posture [14]. The study examining knowledge of ergonomics in endoscopy found that the post-test showed a 20 % increase in correct responses [16].

Study quality

A summary of the study quality is provided in ▶ **Table 2**. The mean MERSQI score was 9.7 (ranged 8.5 to 12).

Discussion

In this systematic review of educational interventions to teach ergonomic principles to mitigate risk of developing MSPI from gastrointestinal endoscopy, we found a total of five studies [3, 14–16, 19]. Overall, each study reported a reduction in MSPI or improved knowledge of ergonomics following their respective interventions. These interventions, which included didactic teaching, individualized feedback, checklists, and simulation training, were typically investigated among practicing endoscopists using single-arm study designs. To our knowledge, this is the first systematic review summarizing the literature on educational interventions for ergonomics in gastrointestinal endoscopy.

There is an urgent need for effective ergonomic interventions. A recent review estimated that prevalence of MSPI in endoscopists can be as high as 89 % [20]. These injuries are typically attributable to forceful and repetitive hand motions with awkward wrist positioning, and sustained non-neutral postures of the neck, back, and shoulders. Moreover, many of the deleterious effects of endoscopic training and practice may go unrecognized due to a lack of formal observation and documentation, as highlighted by one editorial article suggesting that educators rarely teach ergonomic handling and skills to reduce MSPI in practice [7]. Taken together, endoscopic trainees and practitioners alike are at risk for compromising their wellness and productivity due to MSPI that occur in routine clinical work [6].

Our review, however, demonstrates that there is promise for effective interventions. In particular, all included studies found an improvement in endoscopy-associated MSPI, endoscopic REBA scores, or knowledge of ergonomic principles and technique. These outcomes, which exist on the spectrum of Miller's pyramid [21], represent varying degrees of adoption of good ergonomic practice in endoscopy. Furthermore, the included studies demonstrate a range of available intervention modalities. Several studies presented relatively simple, straightfor-

▶ **Table 1** Characteristics and quality assessment for included studies (n = 5).

First author [ref.]; year of publication	Article type	Study design	Study setting and procedure	Total number of participants with level of endoscopic training/ experience[1]	Length of training and assessment	Number of participants in intervention arm(s) with summary of intervention	Number of participants in comparator arm(s); summary of intervention	Type of assessment for primary outcome (s)	Type of statistical analysis for primary outcome (s)	Summary of primary outcome
Ahmed [12], 2016	Abstract only	One-arm trial; 5 training programs	Clinical, not procedure specific	58 gastroenterology fellows; 60.3 % performed > 150 EGDs and 56.9 % performed > 150 colonoscopies	6 minutes	58 participants received a teaching video demonstrating endoscopy ergonomics to minimize injury	N/A	Knowledge test	Descriptives only	Post-test data showed a 20 % increase in correct responses
Brennan [11], 2018	Abstract only	One-arm trial; single center	Clinical, not procedure specific	38 staff members of an endoscopy unit (10 fellows; 8 attendings; 12 nurses; 8 technicians); endoscopic experience not specified	Not specified	38 participants received ergonomic recommendation checklist and watched a video on ergonomics	N/A	Knowledge test	Used, but not specified	There was a significant change in ergonomic knowledge after the delivery of an intervention
Sussman [16]; 2020	Full article	One-arm trial; single center	Clinical, not procedure specific	13 intermediate endoscopists who were gastroenterology and hepatology fellows; endoscopic experienced not specified	Two 60–minute modules over one academic year	12 participants completed didactic module on MSK pain and exercises; 8 participants completed the second module on additional stretches	N/A	Self-reported reduction in pain and discomfort	Descriptives only	All participants reported an immediate decrease in pain and discomfort after completing both modules
Khan [13]; 2020	Full article	Two-arm trial single center	Simulated colonoscopy on AccuTouch VR simulator with clinical colonoscopies	30 novice endoscopists who were gastroenterology, general surgery, and internal medicine residents; completed < 25 real and/or simulated procedures	2 days of training followed by assessment 4 to 6 weeks later	15 participants received training with didactic lectures, training video, tailored feedback on ergonomics and checklist	15 participants from a historical cohort that did not receive ergonomics training	REBA, assessed by two experts blinded to participant identity and group assignment	Mann-Whitney U tests for between group differences	Ergonomics training led to improved ergonomics in two clinical colonoscopies
Markwell [10]; 2021	Full article	One-arm trial; single center	Clinical colonoscopy	8 expert endoscopists who were practicing physicians; endoscopic experienced not specified	Not specified	8 participants received comprehensive assessment of ergonomics and a detailed personalized wellness program	N/A	Self-reported number of pain sites, assessed by the Nordic Musculoskeletal Questionnaire	Descriptives only	Individualized wellness programs lead to a 63 % reduction in the number of pain sites

EGD, esophagoduodenoscopy; N/A, not applicable; REBA, rapid entire body assessment; RCT, randomized controlled trial; VR, virtual reality.
[1] Level of training/experience was defined by the authors of each paper.

▶ **Table 2** Quality assessment for included studies (n = 5).

First author [ref.]; year of publication	Study design (score [max 3])	Sampling: Number of institutions (score [max 1.5])	Sampling: follow-up (score [max 1.5])	Type of data: Outcome assessment (score [max 3])	Validity evidence for evaluation instrument scores (score [max 3])	Data analysis: appropriate (score [max 1])	Data analysis: sophistication (score [max 2])	Highest outcome type (score [max 3])	Total MERSQI
Ahmed [12], 2016	Single-group pretest and post-test (1.5)	3 or more institutions (1.5)	< 50 % or not reported (0.5)	Assessment by study participant (1)	Content (1)	Data analysis appropriate for study design and type of data (1)	Descriptive analysis only (1)	Knowledge, skills (1.5)	9
Brennan [11], 2018	Single-group pretest and post-test (1.5)	1 institution (0.5)	< 50 % or not reported (0.5)	Assessment by study participant (1)	Content (1)	Data analysis appropriate for study design and type of data (1)	Beyond descriptive analysis (2)	Satisfaction, attitudes, perceptions, opinions, general facts (1)	8.5
Sussman [16]; 2020	Single-group pretest and post-test (1.5)	1 institution (0.5)	≥ 75 % (1.5)	Assessment by study participant (1)	Content (1)	Data analysis appropriate for study design and type of data (1)	Descriptive analysis only (1)	Satisfaction, attitudes, perceptions, opinions, general facts (1)	8.5
Khan [13]; 2020	Nonrandomized, 2 group (2)	1 institution (0.5)	< 50 % or not reported (0.5)	Objective (3)	Internal structure (1)	Data analysis appropriate for study design and type of data (1)	Beyond descriptive analysis (2)	Behaviors (2)	12
Markwell [10]; 2021	Single-group pretest and post-test (1.5)	1 institution (0.5)	< 50 % or not reported (0.5)	Objective (3)	Content (1)	Data analysis appropriate for study design and type of data (1)	Descriptive analysis only (1)	Behaviors (2)	10.5

MERSQI, Medical Education Research Study Quality Instrument.

ward educational interventions, such as didactic sessions, training videos, and checklists [15, 16, 19]. The remaining two studies demonstrate approaches that can be integrated into existing systems. For example, the simulation-based training curriculum addressing poor ergonomic behaviors can be used in residency training programs [3, 8], and a tailored feedback model to maximize physician wellness with exercises is well-positioned for implementation as a quality improvement initiative in the endoscopy unit [14].

We note several important limitations of this study. First, we included studies with both physicians and non-physicians, which restrict the generalization of our findings to an endoscopist-only population. Second, we could not conduct a meta-analysis due to no comparable outcome measures used in the included studies, which led to a qualitative synthesis only. Furthermore, the lack of comparable outcome measures also impaired our ability to specifically target one objective parameter (e. g. risk of MSPI).

Based on these studies, we make several recommendations for future research in the area of endoscopic ergonomics to provide nuance when making future recommendations. First, higher-quality research is required, as the mean MERSQI score of 9.7 is reflective of suboptimal quality [13]. In particular, we suggest that studies use endoscopist-focused primary outcomes, such as research that evaluates the impact of interventions targeting both short-term (e. g. improvement of MSPI risk assessment) and long-term goals (e. g. prevalence of MSPI, lost productivity). Furthermore, these outcomes should be assessed using both robust statistical analyses, which will then enable subsequent robust inferences. Second, long-term evaluations of ergonomic interventions in endoscopy will prove invaluable to determine whether they are sustainable. Finally, studies across the spectrum of endoscopist training level (e. g. novice vs. experienced) and characteristics (e. g. age, sex) [22, 23] are needed to elucidate nuances that can affect implementation. For example, interventions may need to be tailored to endoscopist sex to better reflect mitigate differences in MSPI, such as the proclivity of women to develop upper extremity injuries [22].

Competing interests

Dr. Khan has received research grants from AbbVie and Ferring Pharmaceuticals and research funding from Pendopharm. Dr. Grover has received research grants and personal fees from AbbVie and Ferring Pharmaceuticals, personal fees from Takeda, education grants from Janssen, and has equity in Volo Healthcare.

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