Review

Musculoskeletal Injuries in the Endoscopy Practitioner Risk Factors, Ergonomic Challenges and Prevention—Narrative Review and Perspectives

Tadej Durič 1,*, Ivana Cibulková 1,2 and Jan Hajer 1,2

1 3rd Medical Faculty, Charles University, 100 00 Prague, Czech Republic; ivana.cibulkova@fnkv.cz (I.C.); jan.hajer@fnkv.cz (J.H.)
2 Department of Internal Medicine, Kralovske Vinohrady University Hospital, 100 00 Prague, Czech Republic
* Correspondence: tadej.duric@gmail.com

Abstract: GI endoscopy forms an important part in the daily practice of a gastroenterologist. Musculoskeletal injuries related to GI endoscopy are on the rise. Observational studies and surveys depict the importance of a proper ergonomic environment when performing GI endoscopy. Our aim is to describe the pathophysiology, risk factors and possible preventive measures to reduce the risk of musculoskeletal injuries during gastrointestinal (GI) endoscopy. We review the most relevant studies that outline the gravity of the problem. A detailed analysis of proposed ergonomic recommendations is performed, outlining crucial steps in injury prevention. Proper ergonomic education is a key step in preventing occupational injury. Robotics and other mechanical solutions offer a variety of approaches to tackling the ergonomic challenge. Implementing proper ergonomic education and mechanical solutions lowers the possibility of occupational injury. The strategies and appliances presented are beneficial to all GI endoscopy practitioners.

Keywords: GI endoscopy; occupational injury; musculoskeletal injury; ergonometry; endoscopic robots; hands-free endoscopy

1. Introduction

Gastrointestinal (GI) endoscopy forms an important part of the daily practice of a gastroenterologist. Its use and applicability nowadays shift from diagnostic to therapeutic fields, and it forms a significant part of the workload of the GI practitioner. Having in mind that the basic design of a flexible endoscope remained practically the same for the last couple of decades [1] and considering the complexity of modern endoscopic procedures, musculoskeletal injuries amongst endoscopists are on the rise. According to Young et al., a systematic review of 13 studies showed that 39–89% of surveyed endoscopists reported pain and/or injuries related to endoscopy. Common areas of pain were the back (15–57%), neck (9–46%), shoulders (9–19%), elbows (8–15%) and hands/fingers (14–82%). Risk factors included procedure volume, time spent performing endoscopy, cumulative time in practice and endoscopist age. Experimental studies showed that the forces and loads placed on endoscopists’ bodies during procedures place them at risk of occupational injury. Areas of pain differed between novice and experienced endoscopists, implying separate mechanisms of injury [2]. Villa et al. depicted the importance of proper endoscopy training in young fellows. Among the two researched groups, the one without formal ergonomic training reported a significantly higher percentage of musculoskeletal injuries related to endoscopy [3,4]. With this emerging and growing problem, a set of basic recommendations was published by Amandeep K. Shergill [5]. The author addressed the basic principles of ergonomics related to endoscopy and proposed organizational and spatial solutions with the intent of minimizing the possibility of occupational injury. In the following years, similar publications were published addressing the problem and offering similar
solutions [6–11]. However, a practical solution, in the form of an accessory or a machine, to the ergonomic problem is lacking. The focus of this literature review is to outline currently proposed measures regarding the prevention of musculoskeletal injuries in gastrointestinal endoscopy.

2. Ergonomic Challenges

To address proposed solutions to the muscle and body overload during endoscopic procedures, the basics of ergonomics in endoscopy must be outlined. Ergonomics, as applied to endoscopy, can be broadly defined as the study of endoscopists’ interactions with elements of their work environment, including the endoscope and endoscopy unit, and redesigning these to minimize the risk of endoscopy-related injury, optimize endoscopist well-being and maximize overall system performance [7]. With the development of new methods and procedures, endoscopy is becoming more and more physically demanding. According to surveys, gastroenterologists have been reported to spend at least 40% of their time practising endoscopic procedures [12]. Research indicates that if no ergonomic education is exercised, musculoskeletal injuries can already happen in young fellows [3]. Injuries related to practising endoscopy can shorten endoscopists’ careers, reduce personnel available for healthcare delivery and thereby negatively impact patient care [7]. Table 1 summarizes systematic reviews, surveys and cross-sectional studies outlining the weight of the ergonomic challenge.

Table 1. Summary of systematic reviews, surveys and cross-sectional cohort studies.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Ref. No.</th>
<th>Title</th>
<th>Methodology</th>
<th>Key Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvin</td>
<td>2014</td>
<td>[13]</td>
<td>Review of Musculoskeletal Injuries and Prevention in the Endoscopy Practitioner</td>
<td>Systematic review</td>
<td>Strategies for the management of the risk of musculoskeletal injuries related to the practice of endoscopy include compliance with currently recommended ergonomic practices, education of trainees in ergonomic technique when practising endoscopy, and research toward the modification and development of more ergonomic endoscopes and procedure spaces.</td>
</tr>
<tr>
<td>Ridtitid et al.</td>
<td>2015</td>
<td>[12]</td>
<td>Prevalence and risk factors for musculoskeletal injuries related to endoscopy</td>
<td>Survey</td>
<td>Among endoscopists, there is a high prevalence of injuries definitely or potentially related to endoscopy. Higher procedure volume, more time performing endoscopy per week and cumulative years performing endoscopy are associated with more work-related injuries.</td>
</tr>
<tr>
<td>Yung et al.</td>
<td>2017</td>
<td>[2]</td>
<td>Musculoskeletal injuries in gastrointestinal endoscopists: a systematic review</td>
<td>Systematic review</td>
<td>Comprehensive investigation into the prevalence, types, pathophysiology and methods to minimize endoscopy-related musculoskeletal injuries is vital to ensure the continued efficient provision of endoscopy services in the face of rising demands worldwide. A paradigm shift is required in endoscopic devices and techniques to improve safety and comfort.</td>
</tr>
<tr>
<td>Villa et al.</td>
<td>2019</td>
<td>[3]</td>
<td>Endoscopy-related musculoskeletal injuries in gastroenterology fellows</td>
<td>Survey, cross-sectional study</td>
<td>Injuries were more common in fellows who did not receive proper ergonomic training and education.</td>
</tr>
</tbody>
</table>
Table 1. Cont.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Ref. No.</th>
<th>Title</th>
<th>Methodology</th>
<th>Key Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austin et al.</td>
<td>2019</td>
<td>[4]</td>
<td>Musculoskeletal Injuries Are Commonly Reported Among Gastroenterology Trainees: Results of a National Survey</td>
<td>Electronic survey</td>
<td>Musculoskeletal injuries may affect up to 20% of GI fellows. Female fellows more frequently report injuries and may be at particularly high risk, which has not been found in previously reported surveys of practising gastroenterologists. Standardized curricula on ergonomic considerations and injury prevention are needed to enhance GI fellowship training and reduce injury rates.</td>
</tr>
<tr>
<td>Han et al.</td>
<td>2020</td>
<td>[14]</td>
<td>High prevalence of musculoskeletal symptoms and injuries in third space endoscopists: an international multicenter survey</td>
<td>International multicenter survey</td>
<td>Over two-thirds of endoscopists performing TSE suffer from MSI, with many reporting onset of their symptoms after starting TSE in their practice. Further studies are needed to understand and reduce the risk of MSI in TSE given the growing demand for these procedures and the potential long-term impact of this occupational hazard.</td>
</tr>
<tr>
<td>Lubna Kamani, Hamid Kalwar</td>
<td>2021</td>
<td>[15]</td>
<td>Ergonomic Injuries in Endoscopists and Their Risk Factors</td>
<td>Survey, cross-sectional study</td>
<td>Endoscopists are at high risk of developing ergonomic injuries, representing the negative potential of the endoscopy-associated workload. To overcome these issues, an appropriate strategic framework needs to be designed to avoid occupational compromises.</td>
</tr>
<tr>
<td>Shah et al.</td>
<td>2022</td>
<td>[16]</td>
<td>Ergonomics of gastrointestinal endoscopies: Musculoskeletal injury among endoscopy physicians, nurses, and technicians</td>
<td>Observational cross-section study</td>
<td>Three-fourths of our endoscopists reported MSI, of whom more than half were not sure or attributed this problem to endoscopy. The prevalence of MSI warrants urgent attention.</td>
</tr>
</tbody>
</table>

When practising endoscopy, endoscopists uses both hands with the combination of proper body posture [7,17] (Figure 1).

Figure 1. Recommended layout and positioning of an endoscopist in an endoscopic room as recommended in guidelines by ASGE [7].
In his detailed review, Harvin addressed the risk of occupational injuries in endoscopists and outlined preventive measures, reviewing a total of 62 articles. He identified the most common joint syndromes and specific areas of the body affected when performing endoscopy. The correlation between longer procedure time and higher risk of injury was also presented. His review found that the management of the risk of musculoskeletal injuries related to endoscopy falls into three categories: compliance with currently recommended ergonomic practices, education of trainees in ergonomic technique when practising endoscopy, and research toward the modification and development of more ergonomic endoscopes and procedure spaces and toward the better accommodation of practitioners with smaller hand sizes [13].

Villa et al. demonstrated that musculoskeletal injuries related to endoscopy already happen in young fellows, predominantly in those who do not receive proper ergonomic training. In their survey-based study about ergonomics and work-related musculoskeletal injuries, a total of 156 participants were included. A total of 47% of them reported a new musculoskeletal injury related to endoscopy, most commonly in the first year of practice. Not surprisingly, the results stated that injuries were more common in fellows who did not receive proper ergonomic training and education. As a preventive measure, the authors state that there is an urgent need for ergonomic training among young endoscopy practitioners [3].

In a systematic review, Yung et al. included 13 studies evaluating prevalence, risk factors and mechanisms of musculoskeletal pain and/or injuries related to GI endoscopy. Their review identified the most common areas of pain in practising endoscopy and as risk factors identified procedure volume, time spent performing endoscopy, cumulative time in practice and endoscopist age, and concluded that there is a hazard among GI endoscopists for developing occupational injury. In the final note, their expert commentary stated the need for further research to minimize the possibility of injury and that a paradigm shift is needed in order to develop more comfortable and safe endoscopic devices [2].

The American Society for Gastrointestinal Endoscopy (Walsh et al.) approached the problem with a set of instructions and guidelines addressing key elements of ergonomics when performing endoscopy and outlining common mistakes. Their approach recommends that everyone should receive basic training in ergonomics, which is divided into cognitive, technical and non-technical skills. The cognitive area covers the definition of ergonomics in endoscopy, the most common signs and injuries related to endoscopy, protective equipment, etc. The technical area includes knowledge of proper body posture and movement, room and equipment organization, different strategies of handling the procedure and thereby minimizing muscle overload on the body and hands. The non-technical part includes time management, planning of the procedures, awareness of occupational health hazards, etc. Also, details about the basic layout of the endoscopy room and the physician’s position and movement are provided [7]. However, even by strict following of these principles, injuries still happen, mostly due to the high volume of procedures [2,7] and bad endoscope design [1].

Siau and Anderson provided an interesting comparison between athletes and endoscopists [6]. In general, endoscopy is very similar to certain sports, e.g., archery. Like endoscopists, archers require a stable core and correct placement of the feet, hip, spine and neck to provide proper posture and balance. In sports, it is general practice to exercise proper training from the beginning to prevent wrong technique and consequently injuries. In the field of endoscopy, a structured approach to training is insufficient. In their article, the authors provide a reasonable parallel that the endoscopist should be treated in a similar way to professional athletes [11], the key points being proper training, cooperation with the manufacturers of endoscopic materials, rehabilitation programs and education. Introducing a structured approach would decrease the possibility of musculoskeletal injuries and would provide a safe procedure for the patient and endoscopist.

Shergill and McQuaid addressed the ergonomic challenge in a similar fashion to the above-listed authors. However, a term “Hierarchy of controls” was introduced as a rec-
ommendation from the Occupational Health and Safety Administration [18]. The most and least effective methods for controlling exposures and mitigating the risk of work-related injury are elimination and substitution, meaning preventing injuries through scope design and collaboration with endoscope companies, followed by engineering controls, which would result in endoscopy unit outline and endoscope assist measures (support stands, caps, dial assist, etc.). In fourth place, there are administrative controls consisting of endoscopy training, ergonomics “time out”, endoscopy schedules and endoscope maintenance. Personal protective equipment was described as the least effective measure among endoscopist technique, microbreaks and stretches, and maintaining physical fitness [19]. A clear statement can be deduced from the article: “If you have an endoscopy related injury, it’s not your fault” [8]. An urge to include the endoscopist in the endoscope design process by companies is strongly advocated, as well as a holistic approach to resolve the ergonomic crisis.

3. General Problem of the Endoscope Layout

“The current endoscope design lacks a consideration of human factors, and due to the high risk of injury, represents a failure of an engineered system [1]”. The development of the first endoscopic ideas reaches back to the early 1900s, when new discoveries regarding light transformation made an introduction for further discoveries [20,21]. The modern endoscope, as known today, was designed in the 1980s and it stayed basically the same until today. It applies the principle “one size fits all”, disregarding differences in size, sex and physical abilities. The endoscope handle is held and manoeuvred with the physician’s left hand; the shaft is held and manoeuvred with the right hand. To tackle the ergonomic problem from the technical point of view, the first solution that is obvious is to redesign the endoscope handle or the whole concept. All the major endoscopic companies are manufacturing endoscopes with almost the same unanimous layout and size. People come in different sizes, sexes and abilities; ergo, the need for different sizes of endoscopes is present. However, progress and development in this area is insufficient due to various reasons (economic, organizational, etc.). A statement from A.K. Shergill perfectly describes the cause of endoscopy-related injuries: “An endoscopist receives an injury not because they are weak or poorly trained, but because the endoscope was poorly designed [8]”.

4. New Possibilities in Endoscopy with Regard to Reducing and Preventing Musculoskeletal Injuries

4.1. Robotics

When talking about ergonomic challenges in GI endoscopy, robotics offers many solutions and possibilities [22,23]. Robotics is a unique and special technology in the field of gastrointestinal endoscopy that offers new diagnostic and therapeutic possibilities. However, it is also a method that can improve ergonomics and thus reduce the burden on the musculoskeletal systems of physicians during endoscopic procedures. Visconti et al. [24] divides the area of robotics in GI endoscopy into two basic approaches: that which aims to improve forceps handling and stability and that which aims to provide active movement. Furthermore, a more detailed stratification can be made in the three following directions:

- Platforms capable of high degrees of freedom in forceps manipulation for ESD (endoscopic submucosal dissection) and NOTES (natural orifice transluminal endoscopic surgery).
- Active introduction of the endoscopes to reduce the influence of the operator’s ability and to reduce the discomfort and pain referred by the patients.
- Endoscopic capsule evolution for use in screening for GI pathologies and as a therapeutic method [24].

Looking from the perspective of ergonomic change, platforms capable of high degrees of freedom in forceps manipulation for ESD and NOTES demand two-people manipulation. In each platform with high degrees of freedom in forceps manipulation for ESD and NOTES,
there are slight variations; however, this layout totally changes the approach in therapeutic endoscopy, ergonomically and organizationally. It unburdens the endoscopist from the classical stance and has practically no resemblance to the GI endoscopy performed with standard endoscopes. The approach demands two-people manipulation. The first physician manipulates the robot, usually in seating position, and the second physician manipulates the endoscope (Figure 2).

![Figure 2. Layout of an endoscopic robotic platform.](image)

Pioneer platforms with high degrees of freedom in forceps manipulation are the MASTER platform (developed by the Nanyang Technological University and the National University of Singapore), STRAS/Anubiscope (developed by the Research Institute against Digestive Cancer (IRCAD) with Karl-Storz) and Endo-Samurai (developed by Olympus Medical Systems) [24]. However, its applicability in everyday practice is limited due to the high cost, complexity and long learning curve. Nevertheless, the concept offers an idea worth pursuing in tackling the ergonomic issue.

Systems which are designed for active introduction of the endoscope incorporate devices which propel or introduce the endoscope mechanically. This can be achieved with mechanisms that are attached to the classical endoscope, or the endoscope design can be altered or redesigned. In his review article, Lim divides flexible robotic systems into four categories: robot-assisted flexible endoscopy for manoeuvring, robotic flexible endoscopy with therapeutic functions, active flexible colonoscopy and active capsule endoscopy [25]. A summary of available robotic endoscopic systems is provided, including the need for further development and clinical applicability.

Li and Chiu provide a stratification of the field in a similar fashion: the first category is robot-assisted rigid endoscopy for minimally invasive surgery, i.e., the rigid endoscope is held and manipulated by a robot arm. The second category is robot-assisted flexible endoscopy for GI tract inspection, i.e., the flexible endoscope is held and manipulated by a robotic device. The third category is active GI endoscopy, which includes active flexible colonoscopy and active capsule endoscopy [26]. A clear trend of introducing robotics in everyday practice is outlined, offering solutions in the technical and ergonomic area.

In the most recent publication on robotics in gastrointestinal endoscopy by Kim et al., a similar approach was used. However, certain robotic projects from the previous articles were discontinued; the latest robotic systems were divided into the three following categories: The first category includes robot-assisted therapeutic devices that assist advanced endoscopic procedures. This category includes robotic endoscopic multitasking platforms and robotic add-on devices. The second category is the robot-assisted colonoscopy system—a robotic-driven colonoscope that automatically navigates in the colon and an auxiliary
device that assists the conventional colonoscope. The last category is robotic capsule endoscopy. In Tables 2 and 3, outlined by Kim et al., a summary of the latest robotic platforms and robot-assisted systems are presented. Robotic platforms represent independent platforms, whereas robot-assisted systems are a combination of new inventions mimicking the traditional endoscope.

Table 2. Summary table of independent robotic endoscopic multitasking platforms [27].

<table>
<thead>
<tr>
<th>NAME</th>
<th>APPROVAL STATUS</th>
<th>CLINICAL TRIAL</th>
<th>PURPOSE OF USE</th>
<th>TECHNICAL FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENDOMASTER EASE SYSTEM (ENDOMASTER PTE., SINGAPORE)</td>
<td>No</td>
<td>Animal</td>
<td>Stomach ESD</td>
<td>Console for remote control of the robotic arms, independent endoscopic platform</td>
</tr>
<tr>
<td>ENDOLUMINAL ASSISTANT FOR SURGICAL ENDOSCOPY (ICUBE LABORATORY, STRASBOURG, FRANCE)</td>
<td>No</td>
<td>Animal</td>
<td>Colon ESD</td>
<td>Master console and a detachable flexible endoscope with three working channels</td>
</tr>
<tr>
<td>FLEX ROBOTIC SYSTEM (MEDROBOTICS, RAYNHAM, MA, USA)</td>
<td>FDA</td>
<td>Animal</td>
<td>Colon ESD</td>
<td>Robotic endoscope, mechanical single-use flexible instruments and a master console with a touchscreen, HD visual display and a joystick</td>
</tr>
<tr>
<td>K-FLEX (EASYENDO SURGICAL, DAEJEON, KOREA)</td>
<td>No</td>
<td>Explanted animal organs</td>
<td>Colon ESD</td>
<td>Bendable overtube, two exchangeable surgical instrument modules, a driving robot arm and a master console</td>
</tr>
</tbody>
</table>

Table 3. Summary of the operating principles and technical features of the most recently developed robotic flexible colonoscopy systems [27].

<table>
<thead>
<tr>
<th>NAME</th>
<th>SINGLE-USE</th>
<th>APPROVAL STATUS</th>
<th>ACTUATION PRINCIPLE</th>
<th>TECHNICAL FEATURES</th>
</tr>
</thead>
<tbody>
<tr>
<td>THE AER-O-SCOPETM COLONOSCOPE SYSTEM (GI VIEW LTD., TEL AVIV, ISRAEL)</td>
<td>Yes</td>
<td>FDA, CE</td>
<td>Electro-pneumatic mechanisms</td>
<td>Self-propelled, disposable colonoscope</td>
</tr>
<tr>
<td>ENDOTICS (ERA ENDOSCOPY SRL, CASCINA, ITALY)</td>
<td>Yes</td>
<td>CE</td>
<td>Electro-pneumatic mechanisms</td>
<td>Self-propelled, joystick-controlled endoscope</td>
</tr>
<tr>
<td>COLONOSIGHT (STRYKER GI, HAIFA, ISRAEL)</td>
<td>Yes</td>
<td>FDA</td>
<td>Electro-pneumatic mechanisms</td>
<td>Self-advancing system composed of a reusable colonoscope and a wrapped disposable multilumen sheath</td>
</tr>
<tr>
<td>NEOGUIDE ENDOSCOPY SYSTEM (INTUITIVE SURGICAL INC., SUNNYVALE, CA, USA)</td>
<td>Yes</td>
<td>FDA</td>
<td>Electro-mechanical actuation</td>
<td>16-segment insertion tube that controls the snake-like movement of the endoscope</td>
</tr>
<tr>
<td>ENDOCULUS (UNIVERSITY OF COLORADO, BOULDER, CO, USA)</td>
<td>No</td>
<td>No</td>
<td>Electrically actuated mechanisms</td>
<td>Small tank-like robot that can navigate the colon</td>
</tr>
<tr>
<td>MAGNETIC FLEXIBLE ENDOSCOPE (VANDERBILT UNIVERSITY, NASHVILLE, TN, USA)</td>
<td>No</td>
<td>No</td>
<td>Magnetic-actuated tethered robotic colonoscopes</td>
<td>Magnet-embedded endoscope, an actuated permanent magnet external to the patient and control software</td>
</tr>
</tbody>
</table>

The idea of capsule endoscopy changes the approach to endoscopy in comparison to conventional or robotic endoscopy. The process of capsule endoscopy eliminates the previously outlined musculoskeletal injuries connected to repetitive strain injuries. However, currently available endoscopic capsules lack the possibility of therapeutic interventions and serve mainly as diagnostic tools [28].
An almost unanimous division of the robotics area is provided by all of the abovementioned authors. Their work mainly focuses on technical issues with subtle insinuations to change the endoscope design and layout and therefore also addresses the ergonomic challenge. All of the abovementioned robotic systems are a novelty in GI endoscopy. One might argue that solutions are sought only in colonoscopy [29,30]. However most occupational injuries in GI endoscopy arise from repetitive actions with high-force manoeuvres [1,12]. From an ergonomic standpoint, the systems presented practically eliminate repetitive strain injuries due to their robotic-joystick properties. The downside is the high cost of the equipment, its uniqueness and its applicability in everyday practice. If one is to imagine the number of endoscopy units in the world and the number of procedures performed daily, implementing a system with disposable colonoscopes with robotic guidance systems poses an incomprehensible challenge.

The redesign of the endoscope is a crucial step in achieving better ergonomic conditions for endoscopists. However, an easier way is to implement robotic assistance with the existing traditional endoscope. In their review, Kim et al. present solutions using add-on platforms and the master–slave concept in conventional endoscopes. It is a lot easier and conventional to combine robotic assistance; however, the limitations in comparison with robotic platforms are greater. The add-ons used usually are less capable of triangulation of instruments and tissue manipulation compared to the robotic endoscopic multitasking platform. Their exchangeability, possibility of sterilization and low cost offer an interesting approach in preventing musculoskeletal injuries [27].

4.2. “Hands-Free” Endoscopy

As conceptualized by Dr. Binmoeller in 2004, the ScopeDoc (Figure 3) was the first device of its kind designed for “hands-free” endoscopy to reduce stress and fatigue from flexible endoscopy. The fatigue and stress result from having to carry the sheer weight of the endoscope and having to steer the endoscope with the hands. The ScopeDoc transfers the weight of the endoscope from the hand to the body. Subtle changes in body position are transferred to the endoscope shaft and the endoscope tip, enabling the endoscopist to steer the endoscope with the body rather than the hands. The concept of the device was developed further, and clinical trials with EMG of specific muscles of the left and right arms, torso and back are in progress [31–33]. The first results are confirming tension relief in left trapezoid and biceps muscles and a significant increase in microbreaks in the muscles when using the holder. This combination offers an alternative solution to robotics. Its simplistic design and idea allow widespread use. On the downside, it offers a solution only for the left arm and body posture, while the right arm still operates with conventional movements [31].

Figure 3. The ScopeDoc (COOK Medical).
4.3. Personal Care Strategies—Floor Mats and Cushioned Insoles

Prolonged standing on a hard surface is a known trigger for discomfort, resulting in suboptimal performance, leg pain, etc. In their research, Wiggerman and Keyserling demonstrated the positive effect of cushioned floor mats and their effect on discomfort relief and better work performance [34]. Their use in endoscopy can be beneficial to all endoscopists, despite not being a “true” endoscopic accessory connected to endoscope redesign or function [35]. Standing in cushioned insoles has been suggested to create subtle muscular movement, reducing musculoskeletal pain, improving blood flow and decreasing discomfort and fatigue [36]. The fundamental principle behind using anti-fatigue mats and insoles is to provide a supportive interface between the floor and the feet and to optimize bodyweight distribution [37]. When performing endoscopy, the body posture is predominantly in the upright standing position; hence, the use of cushioned insoles proves itself useful in the prevention of musculoskeletal injuries during endoscopy.

5. Conclusions

Ergonomics in GI endoscopy plays an important role in occupational injury prevention. Due to a higher volume of procedures, the problem with musculoskeletal injuries is becoming bigger and everyday more present among fellow gastroenterologists. A detailed set of recommendations addressing the ergonomic challenges with the intent of minimizing the possibility of occupational injury was issued by the American Society for Gastrointestinal Endoscopy (ASGE). It is our opinion that every young GI fellow should receive basic training in occupational injury prevention [38,39]. We believe providing recommendations will start the process of prevention by implementing active thinking about the problem from the start. This will allow for proper muscle memory to arise and long-term habits that prevent occupational injury to be built. As described in recommendations, there is no formal endoscopy-specific ergonomic assessment; therefore, we also promote the idea of formative assessment and feedback for all young fellows. However, a lack of technical solutions in ASGE guidelines is present. A detailed set of recommendations is given on how to educate a trainee without the possibility of implementing technological accessories that can help in injury prevention. Without a doubt, robotics will play a major role in tackling the ergonomic challenge in GI endoscopy. As with everything, its applicability and widespread use is closely related to the high financial and material costs. Many of the presented robotic solutions are still in an experimental phase. Therefore, their use in everyday clinical settings is extremely limited. It is of great importance for all the manufacturers of endoscopic equipment to comprehend the need for different sizes of endoscopes and maybe a totally different concept for endoscopic devices. The inclusion of endoscopists in the development process is crucial [40]. Nevertheless, progress in this area is slow. A “Hands-free endoscopy” concept with a belt add-on offers an alternative approach. Promising results in releasing the tension in key muscles that affect body posture and the workload of the upper limbs provide a step forward in addressing the ergonomic challenge. The concept of an endoscopic accessory that prevents occupational injury is a novelty in this area, and it offers a simplistic option in endoscopy-related injuries. On the downside, it offers a partial solution only for body posture and the left arm. Protective personal care strategies include floor mat and cushioned insole use. They offer a widespread solution to the modern challenges of ergonomic issues in GI endoscopy. Though not “true endoscopic accessorize”, they perform a very important part in injury prevention. A comfortable position and a cushioned floor in a prolonged standing situation play a crucial role in the well-being and performance of an endoscopist. The presented preventive measures decrease the possibility of endoscopy-related injury; however, they do not eliminate it. Implementing all the strategies should be a priority for all parties involved to minimize the possibility of occupational injury and promote safe endoscopy.
Author Contributions: Conceptualization, T.D. and J.H.; methodology, T.D.; writing—original draft preparation, T.D.; writing—review and editing, I.C. and J.H.; supervision, J.H.; project administration, I.C.; funding acquisition, T.D. and J.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Charles University Grant Agency (GAUK), grant number 412622.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were formed.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

ESGE European Society of Gastrointestinal Endoscopy
ASGE American Society for Gastrointestinal Endoscopy
GI Gastrointestinal
TSE Third-space endoscopy
MSI Musculoskeletal injuries
ESD Endoscopic submucosal dissection
NOTES Natural orifice transluminal endoscopic surgery
EMG Electromyography

References


25. Lim, S.G. The development of robotic flexible endoscopic platforms. *Int. J. Gastrointest. Interv.* 2020, 9, 9–12. [CrossRef]


Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.