Exercise gap for endoscopists: implications for occupational musculoskeletal injuries

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Abstract

Background Endoscopy exposes operators to repetitive physical demands that may contribute to musculoskeletal (MSK) injury.

Methods A voluntary, anonymous questionnaire of active endoscopists assessed demographics, procedure type and volume, physical activity, prevalence of MSK injury, and ergonomic practices.

Results A total of 303 participants were included: gastroenterologists/trainees (67%; n=203), non-physician endoscopists (24.4%; n=74), and surgeons (8.6%; n=26). The median duration of practice was 10 years (IQR 15 years). Endoscopists performing complex procedures were more likely to report MSK injuries than those not performing complex procedures (56.8% vs. 42.8%; P=0.026). Nearly all complex procedures were performed by gastroenterologists (96.8%); however, specialty itself was not significantly associated with MSK injury (P=0.11). Injury prevalence increased with procedural lifetime volume, from 5.5% in those performing <1000 procedures to 40.4% in those exceeding 10,000 (P<0.001). Affected endoscopists had longer practice durations (median 20 years [IQR 11] vs. 10 years [IQR 15], P=0.003), and those requiring time off work had also practiced longer (median 20 years [IQR 11] vs. 10 years [IQR 15], P<0.001). Modifiable factors were also relevant: only 48.2% achieved ≥150 min of weekly exercise. Exercise frequency was significantly associated with time off work due to MSK injury (P=0.048), although the pattern across exercise categories was non-linear. (24.7% at ~150 min/week vs. 34.4% at <150 min/week).

Conclusions Longer endoscopy practice was independently associated with self-reported MSK injury. Complex-procedure performance was associated only on univariable analysis, while exercise-duration category showed an unadjusted, non-linear association with time off work.

Keywords Endoscopy, ergonomics, exercise, injuries, occupational health

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Introduction

Gastrointestinal endoscopy is routine practice for most practicing gastroenterologists. Over time, its role has evolved from primarily diagnostic procedures to increasingly longer and more technically challenging therapeutic procedures [1]. The rising complexity of modern endoscopic procedures may be contributing to a rise in musculoskeletal (MSK) injuries among endoscopists [2]. Understanding the prevalence and patterns of these injuries is crucial to help implement the right preventive strategies to improve endoscopists' occupational health.

Most published studies on MSK injuries in endoscopists have been center-specific, and do not necessarily reflect worldwide practice. As a result, the overall burden of injury and the range of risk factors may be underestimated or misrepresented. This international multicenter study aimed to assess the prevalence and risk factors for endoscopy-related MSK injuries, and to evaluate potential mitigating strategies.

Materials and methods

An anonymous, cross-sectional survey was conducted in 2024 among practicing endoscopists. The questionnaire was distributed and collected electronically. Self-reported information, including demographic characteristics (age, sex, years in practice), types and number of endoscopic procedures performed, physical activity levels, history and prevalence of MSK injuries, and adherence to established ergonomic practices during endoscopy were collected. Participants were eligible to participate in this study if they were actively performing endoscopic procedures at the time of the study.

The questionnaire included a mix of multiple-choice, Likert-scale, and short-answer questions designed to capture both quantitative and qualitative data. All responses were anonymized to maintain confidentiality and encourage honest reporting. Physical activity levels were assessed using questions adapted from the validated Godin Leisure-Time Exercise Questionnaire [3]. The standard weighted Godin leisure-time activity score was not calculated. Pre-existing osteoarthritis or inflammatory arthropathy was ascertained by self-report using a binary question asking whether participants had previously received such a diagnosis from a healthcare professional unrelated to work. Responses were categorized according to reported weekly exercise duration as: no regular exercise, less than 150 min/week, approximately 150 min/week, or more than 150 min/week. Respondents reporting approximately or more than 150 min/week were classified as meeting the recommended weekly exercise threshold.

The survey was distributed through professional networks and participating centers using a voluntary recruitment strategy. Consequently, the number of eligible endoscopists who received the questionnaire could not be established, precluding calculation of a response rate.

Three separate occupational outcomes were evaluated: (1) self-reported endoscopy-related MSK injury; (2) formal occupational health diagnosis or specialist assessment of an endoscopy-related MSK injury; and (3) time off work due to an endoscopy-related MSK injury. These outcomes were analyzed independently, as they represent different levels of injury recognition and occupational impact. Self-reported endoscopy-related MSK injury was defined as an affirmative response to the question, "Have you ever had an MSK injury related to endoscopies?" No minimum symptom duration, severity threshold, or formal diagnosis was required. Formal occupational health diagnosis or specialist assessment was defined as an affirmative response to whether the participant had received a formal occupational health diagnosis or had been reviewed by a physiotherapist or orthopedic surgeon. Time off work was defined as an affirmative response to whether the participant had required time away from work or endoscopy duties because of an endoscopy-related injury requiring physiotherapy, medical, or orthopedic assessment.

Statistical analysis

Statistical analysis was performed using SPSS version 28 (IBM Corp. Released 2015. IBM SPSS Statistics for Mac, Version 28.0. Armonk, NY: IBM Corp.). Descriptive statistics, including frequencies and percentages for categorical variables and medians with interquartile ranges or means with standard deviations for continuous variables, were calculated to characterize the study cohort. Non-parametric statistical methods were used given the nature of the data. The Mann-Whitney U test was applied to compare independent, continuous variables, while Fisher's exact test was used to assess associations between categorical variables. The 3 occupational outcomes - self-reported endoscopy-related MSK injury, formal occupational health diagnosis or specialist assessment, and time off work due to an endoscopy-related MSK injury—were analyzed separately. Univariable analyses were initially performed to assess associations between participant, procedural, ergonomic, and exercise-related characteristics and each outcome. Given their differing duration and physical demands, ERCP, EUS, ESD and enteroscopy were evaluated separately in relation to self-reported MSK injury. Separate multivariable binary logistic regression models were performed for formal occupational health diagnosis or specialist assessment and for time off work due to an endoscopy-related MSK injury. Adjusted odds ratios with 95% confidence intervals were calculated for each model. A P-value of less than 0.05 was considered statistically significant.

Results

Demographic data of the cohort studied

This study included 303 endoscopists (53.8%, n=163 male) from 38 worldwide centers (Supplementary Fig. 1).

Participants included 203 gastroenterologists/trainees (67%), 74 non-physician endoscopists (24.4%) and 26 surgeons (8.6%). Non-physician endoscopists included healthcare professionals, such as nurse endoscopists, nurse practitioners or physician assistants, trained to perform procedures. The median duration of endoscopy practice was 10 years (IQR 15 years).

The most common procedures performed were colonoscopies, followed by esophagogastroduodenoscopies (EGDs). Among advanced therapeutic endoscopic procedures, endoscopic mucosal resections (EMRs) were more common than endoscopic submucosal dissections (ESDs), which are performed as part of colonoscopies or EGDs. Enteroscopies were the least commonly performed procedures (Fig. 1).

The most common procedural combination was EGD and colonoscopy (n=84, 27.7%). A smaller number of endoscopists performed only colonoscopies (n=21, 6.9%) or only EGDs (n=12, 4.0%), suggesting that single-scope practice is relatively uncommon. A further n=36 (11.9%) reported performing EGD, colonoscopy and EMR. More advanced combinations,

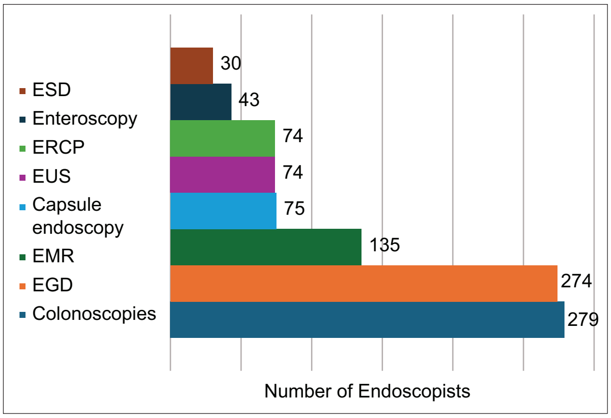

Figure 1 Types of procedures carried out by endoscopists
ESD, endoscopic submucosal dissection; ERCP, endoscopic retrograde cholangiopancreatography; EUS, endoscopic ultrasound; EMR, endoscopic mucosal resection; EGD, esophagogastroduodenoscopy

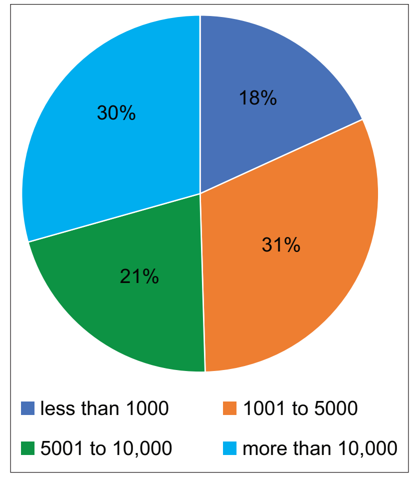

Figure 2 Number of lifetime endoscopy procedures performed by participants

such as EGD, colonoscopy, endoscopic ultrasound (EUS), EMR and endoscopic retrograde cholangiopancreatography (ERCP) (n=12, 4.0%) or EGD, colonoscopy, EMR and ESD (n=6, 2.0%) were less frequent, but still notable. The most complex multi-modality group, involving EGD, colonoscopy, EUS, EMR, ESD, enteroscopy, ERCP and capsules, was reported by n=3 (1.0%) respondents.

Overall, more than 60% of participants reported performing advanced or multi-procedure endoscopy in their routine practice, indicating that the sample largely represents endoscopists engaged in complex rather than basic diagnostic procedures.

The prevalence of self-reported endoscopy-related MSK injury increased significantly with cumulative lifetime procedural volume, from 5.5% among endoscopists who had performed fewer than 1000 procedures to 40.4% among those who had performed more than 10,000 procedures ($P<0.001$). The number of lifetime endoscopies performed is shown in Fig. 2.

Physical characteristics

The median height of respondents was 172 cm (IQR 15 cm), the median weight was 74 kg (IQR 19 kg), and the median body mass index was 24.9 kg/m^2 (IQR 5.0 kg/m^2). The majority of endoscopists (n=277, 91.4%) were right-hand dominant, whereas 26 (8.6%) were left hand-dominant. The most common glove size in endoscopists was medium (Supplementary Fig. 2), whilst the most common shoe size was EU size 42 (Supplementary Fig. 3).

Training in endoscopy ergonomics

Only 36.3% (n=110) of endoscopists were provided with formal training related to scope handling. Most endoscopists (n=285, 94.1%) ensured that the height of the bed was at the right level before starting a procedure, whilst 74.6% (n=226) ensured that the height of the screen was at the right level before starting the procedure. Most endoscopists (n=224, 73.9%) ensured that the monitor was at the appropriate distance away from their eyes. Sixty-nine percent of respondents (210/303) reported having been asked to help reposition heavily sedated patients during endoscopy. A draw sheet, defined as a sheet placed beneath the patient to facilitate repositioning or transfer, was available in only 118 of these 210 cases (56.2%).

Occurrence of MSK-related injuries

Formal ergonomic training prior to starting endoscopic practice was not significantly associated with the occurrence of self-reported endoscopy-related MSK injuries (47/110, 42.7% vs. 96/193, 49.7%; $P=0.24$), or requiring time off work due to injury (30/110, 27.3% vs. 50/193, 25.9%; $P=0.80$). In contrast, ergonomic training was associated with a higher formal reporting of injuries to occupational health ($P=0.013$). Among endoscopists without formal training, 20.7% (40 of 193) had a formal diagnosis of an occupational health injury, or were reviewed by a physiotherapist/orthopedic surgeon, compared with 33.6% (37 of 110) of those with formal training.

Female endoscopists were more likely than male endoscopists to report a formal diagnosis of an endoscopy-related MSK injury (44/140, 31.4% vs. 33/163, 20.2%; $P=0.034$). No significant sex-related difference was observed in time off work due to MSK injury ($P=0.19$).

There was no significant association between self-reported MSK injuries and height ($P=0.45$), weight ($P=0.18$), BMI ($P=0.25$), glove size ($P=0.25$), shoe size ($P=0.83$) or hand dominance ($P=0.41$). There was also no statistical difference observed between the hand dominance (right vs. left) and time required off work due to an endoscopy-related injury ($P=0.64$). Anatomical-site-specific pain patterns were also compared between right- and left-handed endoscopists using

Fisher's exact test. No significant associations were observed between hand dominance and neck, back, shoulder, elbow, hand, thumb, finger or hip pain (all P>0.05; Supplementary Table 1). There was no statistically significant association between self-reported MSK injuries and lifting of patients (P=0.26). Endoscopy-related self-reported MSK injuries did not correlate with the number of monitors in use in an endoscopy session (P=0.06) or with the location of those monitors (P=0.70).

The 3 most reported injuries were back, shoulder and neck pain (Fig. 3,4). Back pain was the most reported injury among endoscopists (n=82, 27%; Fig. 3). Shoulder injury was the most common injury associated with time off work, affecting 33 of 303 respondents (10.9%) and accounting for 41.3% (33/80) of all endoscopists who required time off work due to an endoscopy-related MSK injury. (Fig. 5) Of the 82 endoscopists with significant recurrent back pain, only 23 (28.0%) had ever taken time off work because of their injury.

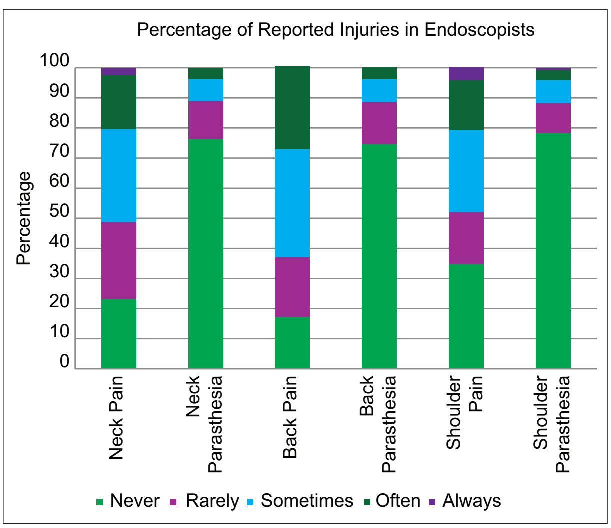

Figure 3 Injuries reported by endoscopists part 1

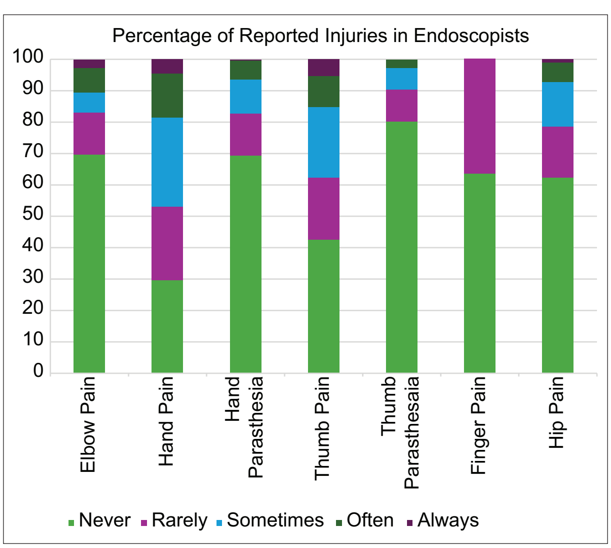

Figure 4 Injuries reported by endoscopists part 2

Endoscopists with preexisting non–work-related osteoarthritis (OA) or inflammatory arthropathy (IA) were more likely to report endoscopy-related MSK injuries (22/33, 66.7%) compared with those without a diagnosis of OA or IA. (121/270, 44.8%; P=0.018). However, preexisting non–work-related OA or IA did not significantly affect the likelihood of requiring time off work due to an endoscopy-related MSK injury (11/33, 33.3% vs. 69/270, 25.6%; P=0.34).

A statistically significant association was seen between self-reported endoscopy-related MSK injuries and endoscopists who carry out complex procedures (ERCP, EUS, ESD and enteroscopies) (n=54, 56.8% vs. n=41, 42.8%; P=0.026). However, the same endoscopists who performed complex procedures did not require more time off work than other endoscopists (P=0.48). There was also no statistical significance between the utilization of lead aprons and endoscopists suffering endoscopy-related MSK injuries (P=0.17). Gastroenterologists carried out more complex procedures (n=92, 96.8%) than the rest of the cohort studied. Gastroenterologists carrying out complex procedures also had a higher prevalence of self-reported MSK injuries (P<0.001), although no statistically significant association was observed between the specialty itself and the occurrence of MSK injuries (P=0.11).

The likelihood of having a formal occupational health diagnoses or specialist assessment differed by specialty (P=0.001). This was reported by 40 of 203 gastroenterologists/trainees (19.7%), 31 of 74 non-physician endoscopists (41.9%), and 6 of 26 surgeons (23.1%). Gastroenterologists performed complex procedures, such as ESD, ERCP and enteroscopies (92/203, 45.3%), whereas these were not performed by non-medical or nurse endoscopists. Of the 143 endoscopists reporting an endoscopy-related MSK injury, 80 (55.9%) required time off work. Shoulder injury was the most frequent cause, accounting for 33 of these 80 cases (41.3%).

Endoscopists with longer endoscopic experience had a higher risk of self-reported MSK-related injuries (P=0.003). Overall, 143 of 303 endoscopists (47.2%) reported having experienced an endoscopy-related MSK injury, whereas 160 (52.8%) reported no injury. Endoscopists reporting an MSK injury had been performing endoscopies for longer than those without injury (median 20 years [IQR 11] vs. 10 years [IQR 15]; P=0.003).

Endoscopists with longer endoscopic experience required more occupational health assessment or received a formal diagnosis of MSK injury (P=0.02). Endoscopists who had performed more

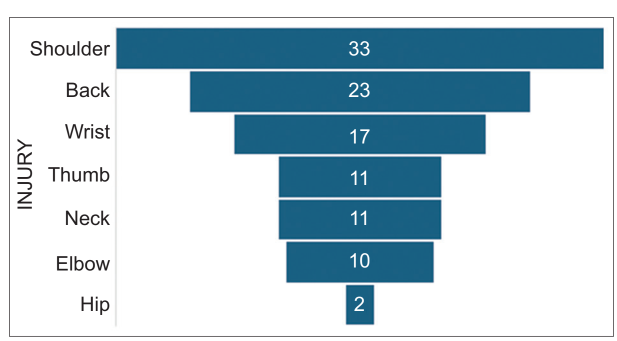

Figure 5 Number of endoscopists requiring time off work in view of a respective endoscopy-related musculoskeletal (MSK) injury

than 5000 procedures were more likely to have received a formal diagnosis or occupational health assessment (34.4% for 5001-10,000 procedures and 31.5% for >10,000 procedures) compared with 12.7% of those who had performed <1000 procedures).

Overall, 77 of 303 respondents (25.4%) reported a formal occupational health diagnosis or specialist assessment. This represented 53.8% of the 143 endoscopists who reported an MSK injury. One third (33.6%, n=48) sought occupational therapy, of whom 68.7% (n=33) felt supported by their institution.

Exercise routines in endoscopists

Less than half of the endoscopists (n=146, 48.2%) met the recommended 150 min of exercise per week (Fig. 6). An overall comparison across the four categories assessing weekly exercise-duration demonstrated a significant association with time off work due to an MSK injury (P=0.048).

Among those exercising more than 150 min per week, 11 of 65 (16.9%) required time off, compared with 20 of 81 (24.7%) in those exercising around 150 min per week, 42 of 122 (34.4%) in those exercising less than 150 min per week, and 7 of 35 (20.0%) in those who reported never exercising.

A history of participation in contact sport during adolescent years was not associated with endoscopy-related MSK injury (62/130, 47.7% vs. 81/173, 46.8%; OR 1.04; P=0.88) or time off work (40/130, 30.8% vs. 40/173, 23.1%; OR 1.48; P=0.14). Similarly, current participation in contact sport was not associated with MSK injury (5/15, 33.3% vs. 138/288, 47.9%; OR 0.54; P=0.27) or time off work (2/15, 13.3% vs. 78/288, 27.1%; OR 0.41; P=0.24).

In the multivariable binary logistic regression model evaluating formal occupational health diagnosis or specialist assessment, longer duration of endoscopy practice was independently associated with the outcome (aOR 1.077 per year, 95% CI 1.032–1.124; P<0.001). Pre-existing osteoarthritis or inflammatory arthropathy showed a borderline association (aOR 2.267, 95% CI 1.001–5.130; P=0.050). Formal training in scope handling and ergonomics was included in the model

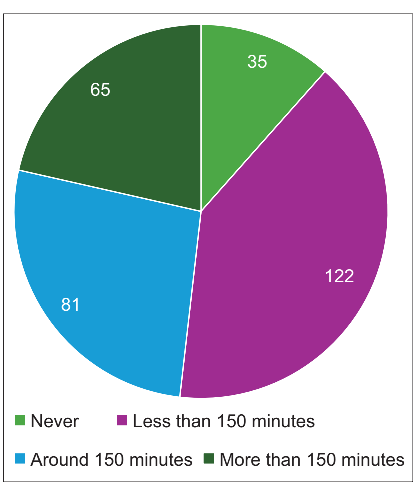

Figure 6 Exercise performed by endoscopists

but was not independently associated with formal diagnosis or specialist assessment (aOR 1.855, 95% CI 0.982–3.503; P=0.057). The overall model was statistically significant (χ^2[16]=39.180; P=0.001), with a −2 log likelihood of 303.726, a Cox and Snell R^2 of 0.122 and a Nagelkerke R^2 of 0.179. The complete model is presented in Supplementary Table 2.

In a separate multivariable model evaluating time off work due to an endoscopy-related MSK injury, longer duration of endoscopy practice was independently associated with the outcome (aOR 1.100 per year, 95% CI 1.052–1.150; P<0.001). Adolescent participation in contact sport was associated with greater adjusted odds of time off work (aOR 2.296, 95% CI 1.241–4.247; P=0.008), while greater exercise frequency was associated with lower adjusted odds (aOR 0.563, 95% CI 0.381–0.830; P=0.004). The overall model was statistically significant (χ^2[16]=45.571; P<0.001), with a −2 log likelihood of 303.614, a Cox and Snell R^2 of 0.140 and a Nagelkerke R^2 of 0.204. The complete model is presented in Supplementary Table 3.

Formal training in scope handling and ergonomics was included in the multivariable model but was not independently associated with self-reported endoscopy-related MSK injury (aOR 1.855, 95% CI 0.982–3.503; P=0.057). (Supplementary Table 3).

Discussion

Endoscopy is physically demanding, and poses a significant risk of MSK injury to endoscopists. Endoscopists are particularly prone to sustaining MSK injuries from their everyday practice. Published data has shown that 39-89% of practicing endoscopists have endoscopy-related pain and/or injuries [4]. The link to MSK injuries is potentially secondary to microtrauma resulting from repetitive motions, awkward postures and sustained high pinch force during endoscopic procedures. The current design of the endoscope was not developed with the variation in physicians' hand sizes and strength in mind, making endoscopy a physically demanding job for many endoscopists [5-10].

Endoscopists who perform the highest number of procedures tended to have a greater risk of developing MSK injuries, according to published research [11-13], and this was in concordance with our study, with a significant association reported between endoscopy years and MSK injuries related to endoscopies.

Female endoscopists were noted to have a higher risk of occupational health injury. This might be because females generally have on average smaller body frames, less muscle mass and less upper body strength compared to males. Also, females tend to have greater joint flexibility, which can be counterproductive, since it allows over-extension during long or complex procedures [14, 15]. Addressing these factors through better ergonomic designs, posture correction and workload can help mitigate risks of MSK injuries.

Overuse injuries have been recognized in athletes, secondary to excessive loading, insufficient recovery and under-preparedness [16].

MSK injuries are increasingly recognized among endoscopists. A recent large meta-analysis including more than 7600 endoscopists confirmed a high global prevalence of MSK injury and identified procedural volume, years in practice and sex as important non-modifiable risk factors [17]. Our findings support these associations while also highlighting potentially modifiable behaviors. The Physical Activity Guidelines for Americans recommend at least 150 min of moderate-intensity physical activity per week [18], with comparable recommendations issued by the NHS [19] and the World Health Organization [20]. In our cohort, fewer than half of the endoscopists (48.2%, n=146) achieved this threshold. A further 40.2% (n=122) reported some exercise but remained below 150 min per week, while 11.6% (n=35) reported no regular exercise.

On univariable analysis, weekly exercise duration category was associated with time off work due to MSK injury (P=0.048). However, the pattern across the four categories was non-linear and did not demonstrate a graded relationship. A non-linear pattern was observed across exercise categories, with the highest rate of work absence among endoscopists exercising for less than 150 min per week (34.4%), compared with 20.0% among those reporting no exercise. This may reflect reverse causation, as endoscopists with pre-existing MSK symptoms may have altered or reduced their physical activity after injury, meaning that current exercise habits may not reflect activity levels before injury onset. The relatively small no-exercise subgroup (n=35) may also have contributed to variability, and the cross-sectional design precludes inference of a causal or dose-response relationship.

In a separate multivariable binary logistic regression model evaluating self-reported endoscopy-related MSK injury, a previous diagnosis of OA or IA and a longer duration of endoscopy practice remained independently associated with higher odds of injury. Greater exercise frequency was associated with lower odds of injury (P=0.048). There was no significant association between lower exercise levels and a history of OA or rheumatoid arthritis (P=0.116).

On univariable analysis, neither adolescent nor current participation in contact sport was associated with self-reported MSK injury or time off work. However, adolescent contact-sport participation was associated with higher adjusted odds of time off work in the multivariable model.

This suggests that general physical conditioning rather than sport-specific exposure may be more relevant. Collectively, these findings highlight that, alongside cumulative procedural burden, modifiable lifestyle factors, particularly physical activity, may represent actionable targets for injury prevention strategies within endoscopic practice.

An association was observed between weekly exercise duration and the need for time off work due to MSK injury among endoscopists, although the pattern across exercise categories was non-linear. There remains a notable scarcity of data on targeted interventions, such as core-strengthening and pre-procedure stretching exercises, specifically tailored to endoscopy practice. Evidence from athletic settings suggests that dynamic stretching can improve flexibility and joint range of motion and may produce small short-term improvements in subsequent physical performance, although evidence that stretching alone prevents injury remains limited [21].

More directly relevant evidence is available from procedural practice. A small crossover trial involving endoscopic assistants found that a one-minute triple-stretch protocol reduced shoulder discomfort and improved neck posture during prolonged ESD and ERCP procedures. In addition, targeted stretching microbreaks reduced musculoskeletal discomfort among surgeons without significantly prolonging operating time [22,23]. Nevertheless, these findings cannot yet establish the effectiveness of such interventions specifically among endoscopists.

Adapting these athlete-inspired strategies, such as brief core exercises or stretching routines prior to procedures, to endoscopy could potentially address the ergonomic demands of prolonged scope manipulation and awkward postures, which contribute to high MSK injury rates in the field. However, the current literature on endoscopy ergonomics primarily focuses on equipment adjustments, microbreaks and general posture training [24,25], with limited empirical studies evaluating the efficacy of core-specific or pre-procedure stretching regimens. Future research should prioritize randomized trials to assess these interventions, potentially offering a low-cost, accessible means to reduce injury burden and improve endoscopist well-being.

Ergonomics in an endoscopy theatre are important for several reasons, focusing on both the health and safety of healthcare professionals, and the quality of patient care we provide. Proper ergonomics help reduce the risk of MSK injuries, ensuring staff can work efficiently and comfortably in the long term. Good ergonomics ensure that equipment is positioned optimally, allowing the endoscopy team to work more efficiently. An appropriate endoscopy setup reduces unnecessary strain, improves access to endoscopic equipment and allows for greater precision during procedures. Ergonomic practices can thus contribute to safer patient outcomes. For example, maintaining the right posture can help healthcare providers operate the endoscope more effectively, reducing the likelihood of accidental damage or injury to the patient. More complex endoscopy procedures can be lengthy, requiring healthcare professionals to remain in the same position for extended periods. Appropriate ergonomic measures, including adjustable monitors, optimally positioned equipment and an appropriate endoscopy-room setup, may reduce physical strain and the risk of endoscopy-related musculoskeletal injury [24]. Although most endoscopists were conscious of the surrounding ergonomics in theater, for example, ensuring that the bed is at the right height, our study highlighted the lack of training in ergonomics provided to endoscopists (only 36.3%) at the beginning of training in endoscopic procedures. Although 210/303 (69.3%) respondents had been asked to reposition heavily sedated patients, a draw sheet was available in only 118/210 (56.2%) of these cases. Routine availability of draw sheets represents a simple, low-cost and modifiable ergonomic measure that may reduce manual-handling strain. Receiving training related to ergonomics was associated with greater awareness and more reporting of MSK injuries related to endoscopies to occupational health (P=0.013).

Endoscopists with preexisting OA or IA appear more prone to develop endoscopy-related MSK injuries. However, this greater risk does not translate into more work disruption or time off.

One possible explanation is that these preexisting conditions may predispose to injury, but not to severe injury, so many affected endoscopists experience milder symptoms that do not require formal assessment or leave. Alternatively, endoscopists with chronic joint conditions may actively adapt their practice and technique, limit procedural volume, or employ ergonomic strategies to decrease their strain and manage their symptoms. These findings highlight the importance of both injury prevention and ergonomic strategies in maintaining work capacity among endoscopists with chronic MSK injuries.

Guidelines published by the American Society for Gastrointestinal Endoscopy (ASGE) define the correct layout of an endoscopic theatre and the positioning of the endoscopist (Supplementary Fig. 4). Monitors are to be placed in front of the endoscopist and should be at eye level. The guideline also recommends formal ergonomics education and neutral bed height, and suggests microbreaks, scheduled macrobreaks and antifatigue mats [25]. In our cohort, 94.1% reported using an appropriate bed height, whereas only 36.3% had received formal ergonomics training; breaks and antifatigue mats were not assessed. In our study, there was no statistically significant association between endoscopy-related MSK injuries and positioning of the monitor at the appropriate distance away from the eyes (P=0.51). This might be because of the significant number of endoscopists (~75%) who ensure that these guidelines are adhered to. Formal ergonomic training prior to starting endoscopic practice was not significantly associated with reporting an MSK injury (47/110, 42.7% vs. 96/193, 49.7%; P=0.24) or requiring time off work (30/110, 27.3% vs. 50/193, 25.9%; P=0.80); however, it was associated with a higher likelihood of reporting MSK injuries to occupational health (P=0.013).

The multicenter nature of the study, inclusion of different specialties and sample size are strengths; however, the predominance of gastroenterologists and trainees (203/303, 67.0%) and the relatively small number of surgeons (26/303, 8.6%) may limit the generalizability of the findings to other endoscopist groups.

A key limitation is the voluntary nature of recruitment, which may have introduced self-selection bias, as endoscopists with current or previous MSK symptoms may have been more likely to complete the questionnaire. The cross-sectional design prevents conclusions regarding causality or temporal relationships, particularly between current exercise habits and previous MSK injury or work absence. Reliance on retrospective self-report may also have introduced recall or misclassification bias regarding injury history, lifetime procedural exposure and time off work. Furthermore, ergonomic training, equipment, staffing, workload, access to occupational health services and injury-reporting practices may vary across the international centers included and were not standardized in this study. Finally, because the survey was circulated broadly through professional networks, the number of eligible endoscopists exposed to the questionnaire could not be determined and a formal response rate could not be calculated. The findings should therefore be interpreted as reflecting a self-selected international sample.

This may have led to overestimation of injury prevalence if endoscopists with current or previous MSK symptoms were more motivated to participate, while asymptomatic endoscopists may have been underrepresented. Consequently, the observed prevalence should not be interpreted as a population-level estimate, and the generalizability of the findings is limited. Although lifetime procedural volume was assessed, procedural exposure was recorded in broad cumulative categories. Exact annual procedural volume and the timing of individual injuries were not collected. Consequently, exposure-adjusted injury rates, such as injuries per endoscopist-year or per defined number of procedures, could not be calculated.

In conclusion, our study shows that reducing MSK injuries related to endoscopy requires a well-rounded approach addressing multiple factors. This should include raising awareness about the risks of MSK injuries among endoscopists, formal ergonomics training, ensuring an appropriate ergonomic endoscopic setup, as well as procedure-related observation by physiotherapists and/or occupational therapists. Routine availability of draw sheets for patient repositioning should also be considered as a simple, low-cost ergonomic measure. Endoscopists must be encouraged and supported to pursue healthier lifestyles, including promoting regular physical activity. Future prospective studies are required to help target MSK-related injuries, including enrollment of endoscopists in exercise programs, and to understand which specific exercises or quantification of exercise will help minimize MSK injuries. Addressing administrative factors, such procedure scheduling, caseloads per list and regular endoscope maintenance, might represent other significant variables [17,24-26].

Summary Box

What is already known:

- A large meta-analysis (>7600 endoscopists) confirmed that musculoskeletal (MSK) injuries have a high global prevalence worldwide
- Key non-modifiable risks, such as procedural volume, years in practice and sex, are established risk factors for MSK injuries
- Injuries contribute to occupational consequences such as work impairment, including time off practice

What the new findings are:

- Low exercise uptake was seen in endoscopists. Only 48.2% met the recommended ≥150 min/week physical activity levels
- Exercise frequency was associated with MSK-related time off work, although the pattern across exercise categories was non-linear
- Past or current contact sport participation showed no association with MSK injury or work absence, therefore general conditioning may be more relevant

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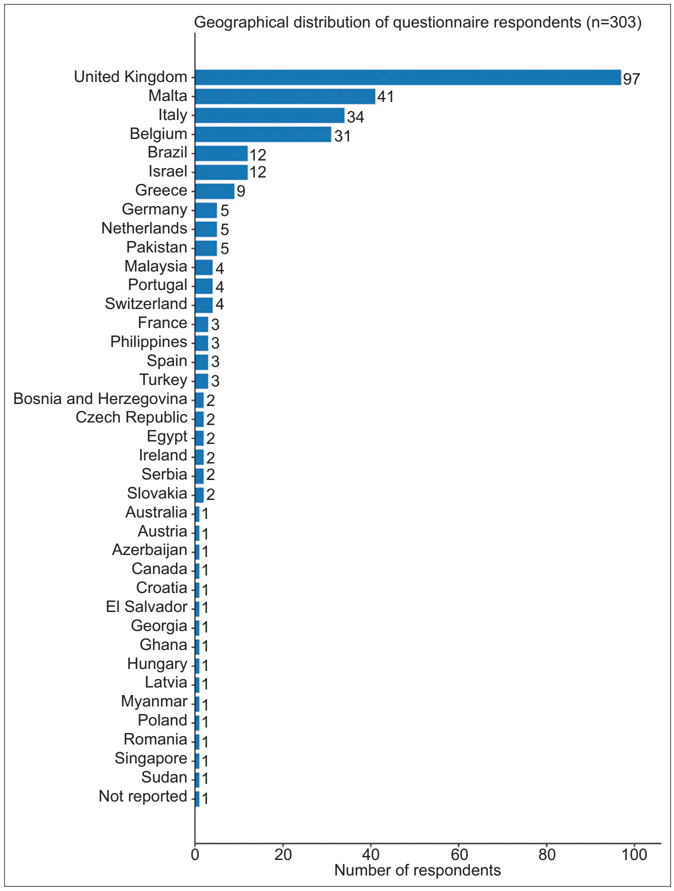
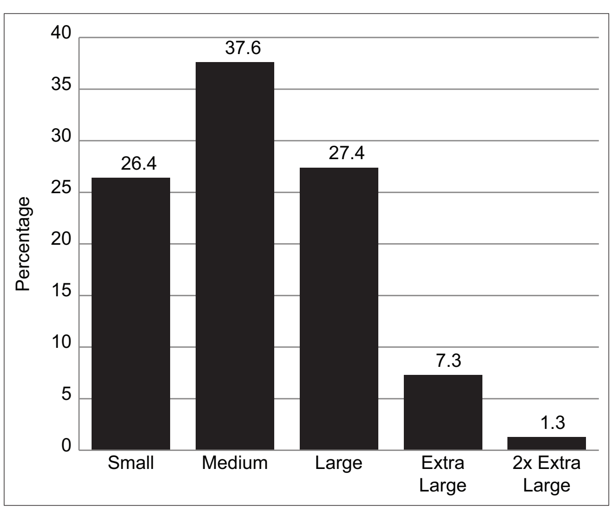
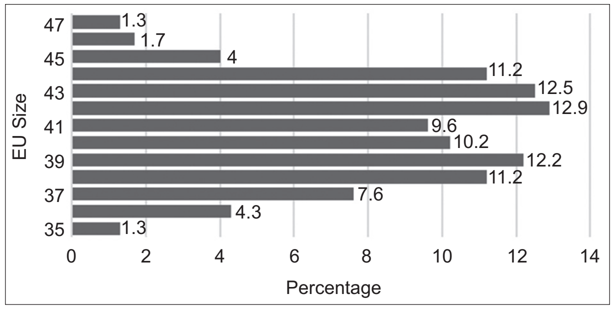
Supplementary material



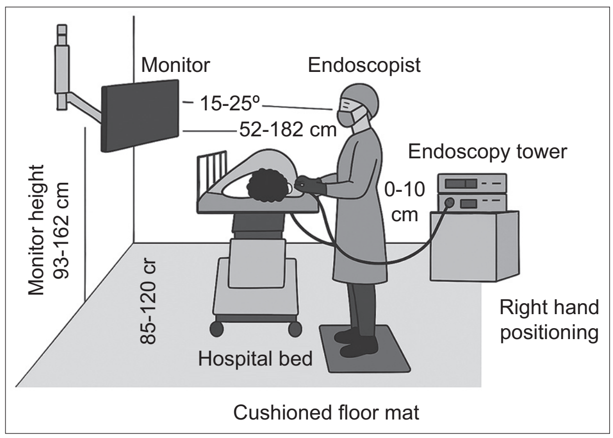
Supplementary Figure 1 Nationalities participating in the questionnaire



Supplementary Figure 2 Glove size of endoscopists



Supplementary Figure 3 Shoe size of endoscopists



Supplementary Figure 4 Recommended layout and positioning of an endoscopist in an endoscopic room (adapted from ASGE guidelines) [25]

Supplementary Table 1 Association between hand dominance and anatomical-site-specific pain among endoscopists

Anatomical site	Fisher's exact test P-value
Neck pain	0.338
Back pain	0.620
Shoulder pain	0.527
Elbow pain	0.132
Hand pain	0.146
Thumb pain	0.333
Finger pain	0.209
Hip pain	0.564

Paresthesia outcomes were excluded because paresthesia was not assessed consistently across all anatomical sites. Analyses were limited by the relatively small number of left-handed respondents

Supplementary Table 2 Multivariable binary logistic regression analysis of factors associated with self-reported endoscopy-related musculoskeletal injury

Predictor	Adjusted OR	95% CI	P-value
Sex	0.419	0.155–1.134	0.087
Endoscopic procedures performed	0.983	0.946–1.022	0.388
Duration of endoscopy practice, per year	1.077	1.032–1.124	<0.001
Specialty	1.284	0.799–2.064	0.302
Height, metres	8.507	0.046–1575.370	0.422
Weight, kilograms	0.986	0.960–1.012	0.286
Participation in contact sport during adolescence	0.989	0.536–1.824	0.972
Current participation in contact sport	1.168	0.262–5.201	0.839
Hand dominance	1.351	0.502–3.637	0.551
Screen positioned at eye level	1.268	0.618–2.601	0.517
Formal training in scope handling and ergonomics	1.855	0.982–3.503	0.057
Pre-existing osteoarthritis or inflammatory arthropathy	2.267	1.001–5.130	0.050
Weekly exercise category	0.704	0.484–1.024	0.066
Shoe size	1.050	0.821–1.343	0.697
Performance of complex procedures	2.989	0.968–9.232	0.057
Use of lead aprons	0.511	0.212–1.235	0.136

Supplementary Table 3 Multivariable binary logistic regression analysis of factors associated with time off work due to an endoscopy-related musculoskeletal injury

Predictor	Adjusted OR	95% CI	P-value
Sex	0.386	0.144–1.032	0.058
Endoscopic procedures performed	1.037	1.002–1.075	0.041
Duration of endoscopy practice, per year	1.100	1.052–1.150	<0.001
Specialty	0.886	0.543–1.447	0.629
Height, meters	2.339	0.013–413.239	0.748
Weight, kilograms	0.980	0.954–1.007	0.147
Participation in contact sport during adolescence	2.296	1.241–4.247	0.008
Current participation in contact sport	0.370	0.070–1.946	0.240
Hand dominance	1.368	0.509–3.678	0.535
Screen positioned at eye level	1.569	0.767–3.207	0.217
Formal training in scope handling and ergonomics	1.193	0.624-2.279	0.594