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Effects of endoscopy-related procedure time on musculoskeletal disorders in Japanese endoscopists: a cross-sectional study

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ABSTRACT

Background and study aims There has been little evidence assessing the prevalence of musculoskeletal disorders (MSDs) among endoscopists performing recent diagnostic and therapeutic endoscopic procedures requiring prolonged procedural times. We evaluated the prevalence and identified the risk factors for developing MSDs, focusing on procedural time.

Methods An electronic survey of endoscopists (n = 213) employed at the Nagoya University Hospital and its affiliated hospitals was developed by a multidisciplinary group.

Results Of the 110 endoscopists (51.6 %) who responded to the survey, eighty-seven endoscopists (79.1 %) had experienced endoscopy-related MSDs during the previous 1 year, and 49 endoscopists (44.5 %) had experienced these MSDs during the previous week. Nineteen endoscopists (17.3 %) reported absence from work due to severe MSDs. The most frequent sites of MSDs were neck, low back, and shoulders. Logistic regression analyses showed that longer upper endoscopic submucosal dissection ESD, (odds ratio: 5.7; 95 %CI: 1.3–25.0), lower ESD (odds ratio 4.9; 95 %CI: 1.1–22.0), and lower gastrointestinal treatment (odds ratio: 5.6; 95 %CI: 2.3–13.3) were significantly associated with the development of MSDs in the low back area. Moreover, longer lower ESD (odds ratio: 5.0; 95 % CI: 1.2–20.2) was a risk factor for symptoms in the left shoulder.

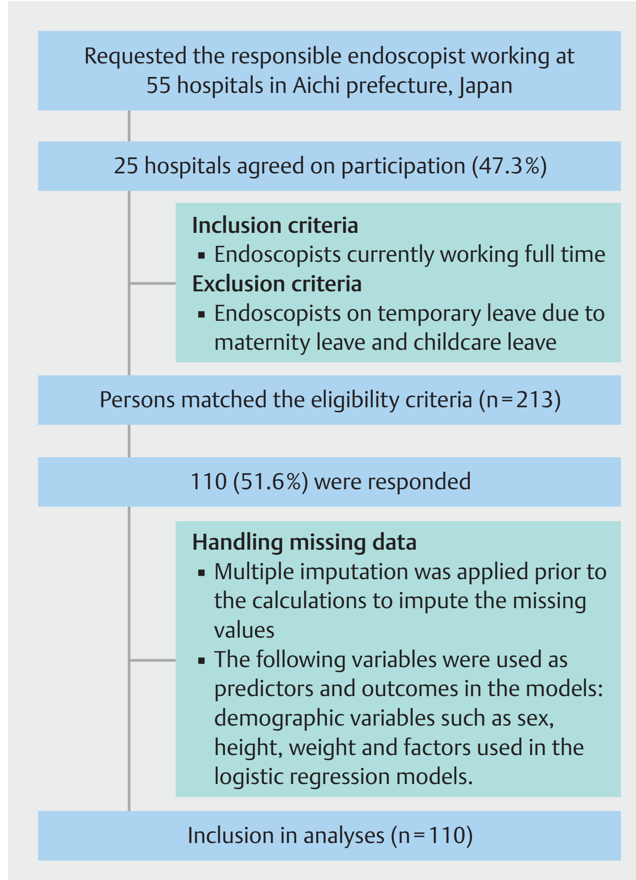
Conclusion This study suggests a correlation between the volume of therapeutic endoscopic procedures including ESD and the risk of MSDs mainly low back area and left shoulder. Managing monthly total endoscopic time, in light of organizational ergonomics, could contribute to minimizing such risks of endoscopy-related MSDs.

Introduction

Frequent, repetitive maneuvers and awkward body positions may lead to musculoskeletal disorders (MSDs) [1]. Work-related MSDs have been reported in individuals with various occupations, such as ultrasonographers, and surgeons [2, 3]. Endoscopists are also at high risk of developing MSDs. Several studies have reported the prevalence of endoscopy-related MSDs to range from 20 % to 89 %. Common sites of pain and injuries are the thumbs, wrists, neck, and low back [4–12]. The development of MSDs in endoscopists translates to cost for the hospital and society. Furthermore, this leads to longer waiting times for patients and poor endoscopic performance. Risk factors of endoscopy-related MSDs include sex, seniority, improper position during the procedure, and endoscopy-specific maneuvers (e. g., torqueing) during colonoscopy [4–12]. Other reported risk factors are high procedure volume and prolonged duration of endoscopy, which leads to overuse injury due to repetitive movements [4, 5, 9, 13].

Diagnostic and therapeutic endoscopic procedures requiring prolonged procedural times, such as endoscopic submucosal dissection (ESD), enteroscopy, and endoscopic ultrasound (EUS), are being performed with increased frequency in clinical practice. Due to the duration of these procedures, this may predispose endoscopists to higher rates of MSDs than previously reported. However, there have been a few studies proving the correlation between endoscopy volume and risk of MSD development including these recent developed procedures [9, 12, 14].

The aim of this study was to evaluate the prevalence of MSDs and identify the risk factors for developing MSDs, focusing on procedure time among endoscopists in Japan.



▶ **Fig. 1** Participant selection flowchart.

Methods

Survey sampling

We conducted an electronic cross-sectional survey of endoscopists employed at the Nagoya University Hospital and its affiliated hospitals with registered e-mail addresses (n = 55) between October 2019 and November 2019. Members who were currently performing endoscopy were eligible to participate. The institutional review board of Yamashita Hospital (YEC19–04) approved the study prior to the dissemination of the survey.

Survey instrument

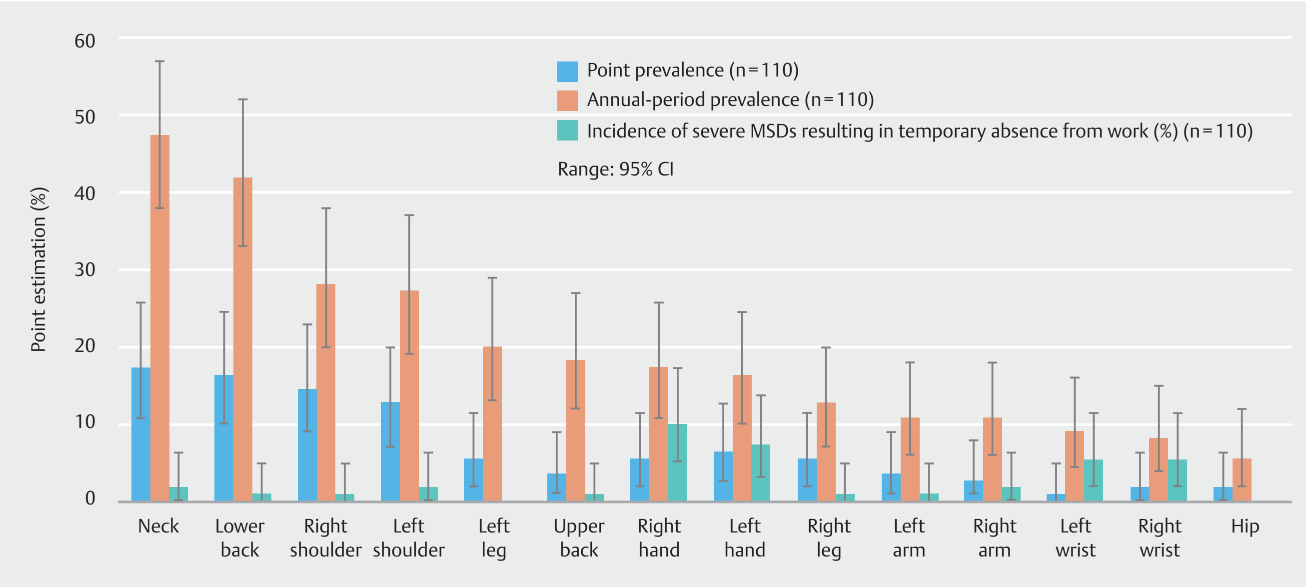
The survey was performed using a 50-item, self-administered, electronic questionnaire developed by a multidisciplinary group consisting of two endoscopists (I.M., M.F.), one endoscopy nurse (M.T.), one endoscopy technician (A.B.) and two ergonomists (T.E., K.Y.).

The items included in the survey measured the characteristics of endoscopists, workload parameters, and experience during and after the participants experienced an injury. The characteristics of endoscopists included age, sex, height, weight, hand dominance, main avocational activities, and practice setting. Workload parameters included the number of years in practice, hours and number and/or type of endoscopies conducted per month, length of time spent performing procedures, and working posture. Injury experiences included the location of pain or injury and the effects of the injury on the occupation of the participants.

The Standardized Nordic Musculoskeletal Questionnaire was used to assess the prevalence of MSDs experienced pain, numbness, and discomfort on local body parts as primary outcomes [15]. The duration of the survey was approximately 15 minutes.

Survey data collection

▶ **Fig. 1** shows the flowchart of selection of participants. We sent an invitation letter to 55 directors of hospitals, four academic centers, 14 large hospitals (≥ 5 specialists performing endoscopy), and 37 small hospitals in Japan. Of these, 25 hospitals, one academic center, nine large hospitals, and 15 small hospitals agreed to participate in this study. The director of each participating institution requested endoscopists working at each hospital to voluntarily participate in the online survey via e-mail. The e-mail described study objectives, identified the research team and provided a direct link to the online survey (prepared by Google form), which was valid for a period of two weeks. We did not send a second reminder email, even if the participants did not respond within 2 weeks after the initial email. Informed consent was obtained on the website, which



▶ **Fig. 2** Point/annual-period prevalence of MSDs and incidence of severe MSDs on local body site.

was required prior to filling out the questionnaire and served as respondent's agreement to participate in the study.

The Yamashita Hospital Research Group (I.M., M.T.) administered the survey and data were directly stored into a database. All data remained anonymous to prevent response bias. Responders were not remunerated for their participation.

Statistical analysis

Demographic characteristics of the respondents were summarized using the mean with standard deviation for continuous variables and count with proportion for discrete ones. Welch's t test adjusting degrees of freedom for unequal variances was adopted to estimate the significant difference of continuous data between two groups. Fisher's exact test was used to compare the distributions between nominal data. For estimating the point/annual prevalence of MSDs as primary outcomes, its 95 % confidence interval (CI) were calculated.

We adopted a binary logistic regression model to extract potential risk factors on each endoscopy-related procedure time affecting MSDs of neck, shoulders, and low back. Each procedure time was reclassified as categorical variables using quartile, or was distinguished them based on features of multimodal distribution. Our data had quite low missing values of only one or two cases in each estimation model though, we dared to apply the multiple imputation method to the cases to reduce the effect of potential biases in such a case of small sample size [16, 17].

Pooled adjusted odds ratios (ORs) were calculated after applying the multiple imputation to handle missing data. Such a multiple imputations method is widely recommended for correction of potential biases attributed to non-respondents and is considered more efficient in most settings. Adjustments against confounders were made for the following variables: sex, age, certified fellow of endoscopy, seniority (yrs), working hours (h/wk), and sedentary time (h/d).

All statistical analyses were carried out with statistical software package SPSS 24.0 (SPSS, Chicago, Illinois, United States).

Results

Point/annual-period prevalence of MSDs and incidence of severe MSDs among endoscopists

Of the 213 invited endoscopists in the 25 hospitals, 110 (51.6 %) responded. The majority of endoscopists (n = 87; 79.1 %) had experienced an endoscopy related-MSDs in at least one anatomic location during the previous 1 year (annual-period prevalence of MSD). The majority of endoscopists (n = 49; 44.5 %) also had experienced an endoscopy related-MSDs in at least one anatomic location during the previous week (point-period prevalence of MSD). Nineteen endoscopists (17.3 %) reported absence from work as a result of injury (severe MSD). In addition, 11 endoscopists (10.0 %) consulted doctors.

▶ **Fig. 2** shows the point/annual-period prevalence of MSDs and incidence of severe MSDs on local body site. The most frequent sites of annual-period prevalence of endoscopy related-MSD were the neck (n = 52; 47.3 %), low back (n = 46; 41.8 %), right shoulder (n = 31; 28.2 %), and left shoulder (n = 30; 27.3 %). For the point-period prevalence, the most frequent sites were the neck (n = 19; 17.3 %), low back (n = 18; 16.4 %), right shoulder (n = 16; 14.5 %), and left shoulder (n = 14; 12.7 %). In contrast, the most frequent sites of severe MSDs resulting in temporary absence from work were the right hand (n = 11; 10.0 %), left hand (n = 8; 7.3 %), left wrist (n = 6; 5.5 %), and right wrist (n = 6; 5.5 %).

Risk factors for developing endoscopy related MSDs

To investigate the risk factors for developing endoscopy-related MSDs, we focused on local body sites with high prevalence: neck, shoulders, and lower back. ▶ **Table 1** shows demographic characteristics of endoscopists between those who reported endoscopy-related MSDs currently perceived on the neck, shoulders, or low back (n = 37; 33.6 %) and those who had no reported endoscopy-related MSDs. The characteristics of respondents without MSDs were similar to ones with MSDs except in sex (P = 0.06) and body mass index (BMI, P = 0.05). On average, they spend 41.6 % of their working hours engaged in endoscopic work. Comparing endoscopists who reported MSDs and those who did not, there was no differences in procedure duration in either group when performing the same procedure.

Working posture under each type of procedure is shown in ▶ **Table 2**. More than 90 % of the endoscopists selected the standing position during the endoscopic examination and procedure.

Results of the multivariate analysis regarding potential predictors of endoscopy-related MSDs on the neck, shoulders, and low back area are shown in ▶ **Table 3**. Longer upper ESD (total time: ≥ 181 min/month, OR: 5.7; 95 %CI: 1.3–25.0) and lower ESD (total time: 1–90 min/month, OR 4.9; 95 %CI: 1.1–22.0), and lower gastrointestinal treatment (total time: ≥ 526 min/month, OR: 5.6; 95 % CI: 2.3–13.3) were significantly associated risk factors for symptoms in the low back area. Moreover, lower ESD was a significantly associated risk factor for symptoms in the left shoulder (total time: 91–180 min/month, OR: 5.0; 95 % CI: 1.2–20.2).

Discussion

Features of endoscopy-related MSDs

This study revealed a high prevalence of endoscopy-related MSDs (annual-period: 79.1 %, point-period: 44.5 %), including 17.3 % of respondents reporting absence from work. This study also corroborates the finding of other studies in correlating a higher number of procedural hours with the development of MSDs. The most frequent sites for the annual/point-period prevalence of endoscopy-related MSDs in our survey were the neck, low back, right shoulder, and left shoulder. On the other hand, endoscopy related-MSDs were not frequently observed in the hands and wrists. In contrast, a high prevalence of MSD on these sites was reported in several previous reports [4–12]. These sites of MSDs may be influenced by the definition of MSD prevalence, technical skill for operating the endoscope, and hand size.

Definition of MSD prevalence

Such discrepancy can be found in the definition of outcomes between studies. Some studies distinguished endoscopy-related MSDs and non-endoscopy-related MSDs [9, 12]. The current study did not determine the work-relatedness of MSDs to endoscopy because we thought respondents could not definitively report this association. However, the current study examined three outcomes: annual prevalence, point prevalence, and incidence of severe MSDs. These differences in definitions may influence the results related to the prevalence of MSDs in these sites. In our study, severe MSDs were often observed in the hands and wrists.

Technical skill for operating the endoscope

Villa et al. also reported that MSDs occurred mostly during the first 3 years of fellowship (85 %; P < 0.001) in the United States, suggesting that the most common sites of MSDs were the right wrist (53 %), left thumb (42 %), back (27 %), and neck (22 %). Only 26 % of those with endoscopy-related MSDs had received training in ergonomics versus 45 % of those without injuries (P = 0.012) [11]. Similarly, some studies reported differences in the sites of endoscopy-related MSDs between beginners and experienced endoscopists [6, 10].

Endoscopists have to perform endoscopy-specific maneuvers, such as adjusting the tip of angulation controls of the endoscope using the left thumb, and strongly torqueing using the right wrist in colonoscopy [5, 13]. Furthermore, the activity of the left-wrist extensors, left-thumb extensors, and right-wrist extensors exceeded the hand activity level action limit during routine colonoscopy established by the American Conference of Industrial Hygienists [13]. Trainees use markedly more clockwise torque using the right wrist compared with experts during the colonoscopy technique [18]. In contrast, in a recent European study, the prevalence of hand numbness and wrist pain was significantly higher in consultants than fellows. The sample size of fellows (n = 38) was smaller in comparison with that of consultants (n = 133) in the previous study, and this difference may be responsible for the observed discrepancy in the results [12].

In the current study, the seniority of responders was relatively high (> 4 years, 94 %) and 83 % of responders had completed a specialty (i. e., certified fellow of endoscopy). These characteristics of responders may have influenced the low frequency of the annual/point-period prevalence of MSD in the hands and wrists. Trainees may have to learn the neutral thumbs grip position, pinkie maneuver, and methods for the manipulation of the endoscope to avoid hand and wrist injuries [19].

Hand size

Hand size is a significant determinant of difficulty in using surgical instruments and affects the control of an endoscope [5, 20]. In a survey conducted in the USA, involving 1,295 gastroenterology fellows, 93 responders (41.0 %) considered the size of their hands to be inadequate for handling a standard endoscope. Of the 38 responders with a glove size ≤ 6.5 inches, 37 (97.4 %) were female, expressing a wish to use endoscopes with smaller handles, if available [21]. Previous reports and the current study on the prevalence of endoscopy-related MSDs did not evaluate the hand size of endoscopists [4–11]. A recent European study evaluated the relationship of glove size to MSDs: small (32.8 %), medium (47.1 %), large (17.6 %), and extra-large (2.5 %) (P = 0.734) [12]. There is a possibility that the hand size of endoscopists influences the sites of MSD prevalence. Several studies have reported that the prevalence of endoscopy-related MSD leading to absence from work ranges from 3 % to 18.5 %

▶ **Table 1** Demographic characteristics of respondents.

Variables		Those who have any endoscopy-related MSDs currently perceived on neck, shoulders or low back		
	Overall (n = 110)	No (n = 73)	Yes (n = 37)	*P*
Age (%)				0.93
▪ Less than 29	1 (0.9)	1 (1.4)	0 (0)	
▪ 30 to 39	61 (55.5)	40 (54.8)	21 (56.8)	
▪ 40 to 49	21 (19.1)	14 (19.2)	7 (18.9)	
▪ 50 to 59	23 (20.9)	16 (21.9)	7 (18.9)	
▪ 60 or older	4 (3.6)	2 (2.7)	2 (3.6)	
Sex(%)				
▪ Male	98 (89.1)	62 (84.9)	36 (97.3)	0.06
▪ Female	12 (10.9)	11 (15.1)	1 (2.7)	
BMI (kg/m^2, mean ± SD)	23.1 (2.9)	22.7 ± 2.5	23.8 ± 3.3	0.05
Seniority (years, %)				
▪ Less than 3	6 (5.5)	4 (5.6)	2 (5.4)	0.97
▪ 4 to 6	18 (16.4)	13 (18.1)	5 (13.5)	
▪ 7 to 9	20 (18.2)	12 (16.7)	8 (21.6)	
▪ 10 to 15	27 (24.5)	18 (25.0)	9 (24.3)	
▪ ≤ 16	38 (34.5)	25 (34.7)	13 (35.1)	
▪ Missing	1 (0.9)			
Dominant hand				
▪ Right	105 (95.5)	70 (95.9)	35 (94.6)	1.00
▪ Left	5 (4.5)	3 (4.1)	2 (5.4)	
Specialty (certified fellow of endoscopy)				
▪ No	27 (24.5)	19 (26.0)	8 (21.6)	0.65
▪ Yes	83 (75.5)	54 (74.0)	29 (78.4)	
Practice setting (%)				
▪ Academic center	34 (30.9)	25 (34.2)	9 (24.3)	0.36
▪ Large hospital	35 (31.8)	20 (27.4)	15 (40.5)	
▪ Small hospital	41 (37.3)	28 (38.4)	13 (35.1)	
Working hours (h/wk, mean ± SD)	54.8 (11.4)	55.3 (10.4)	53.7 (13.3)	0.51
Endoscopic work (%, mean ± SD)	41.6 (21.9)	40.6 (22.3)	43.5 (21.1)	0.51
Type of procedure (min/month)				
▪ Upper GI endoscopy	380.1 (229.0)	384.8 (225.8)	370.9 (238.0)	0.77
▪ Lower GI endoscopy	565.5 (476.9)	605.5 (537.1)	486.5 (319.4)	0.15
▪ Upper ESD	102.1 (128.5)	84.7 (93.6)	136.6 (175.1)	0.10
▪ Upper GI treatment	53.2 (71.2)	49.3 (66.3)	60.8 (80.3)	0.46
▪ Lower ESD	70.4 (102.6)	65.6 (95.6)	79.9 (115.9)	0.52
▪ Lower GI treatment	448.0 (465.4)	436.6 (492.0)	470.3 (413.3)	0.71
▪ Enteroscopy	93.6 (141.3)	82.0 (140.3)	116.4 (142.5)	0.23
▪ ERCP	206.9 (305.1)	217.6 (356.6)	185.7 (163.8)	0.52

▶ **Table 1** (Continuation)

Variables		Those who have any endoscopy-related MSDs currently perceived on neck, shoulders or low back		
	Overall (n = 110)	**No (n = 73)**	**Yes (n = 37)**	***P***
▪ EUS	99.7 (118.6)	101.5 (126.2)	96.1 (103.4)	0.81
Sedentary time (h/d, mean ± SD)	3.8 (2.7)	3.7 (2.5)	3.9 (3.0)	0.80

MSD, musculoskeletal disorders; BMI, body mass index; GI, gastrointestinal; ESD, endoscopic submucosal dissection; ERCP, Endoscopic Retrograde Cholangiopancreatography; EUS, endoscopic ultrasound; Fisher's exact test or Welch's *t* tests were used to test for differences between groups.

▶ **Table 2** Endoscopy-related work and working postures.

		%		
	n	**Standing**	**Sitting**	**sit-stand**
Upper GI endoscopy	110	108 (98.2)	2 (1.8)	–
Lower GI endoscopy	106	101 (95.3)	2 (1.9)	3 (2.8)
Upper ESD	67	64 (95.5)	3 (4.5)	–
Upper GI treatment	81	81 (100.0)	–	–
Lower ESD	52	47 (90.4)	1 (1.9)	4 (7.7)
Lower GI treatment	105	100 (95.2)	2 (1.9)	3 (2.9)
Enteroscopy	38	38 (100.0)	–	–
ERCP	75	75 (100.0)	–	–
EUS	73	73 (100.0)	–	–

GI, gastrointestinal; ESD, endoscopic submucosal dissection; ERCP, endoscopic retrograde cholangiopancreatography; EUS, endoscopic ultrasound; –: not applicable (no answer).

[6–9, 11, 12]. Notably, in the current study, 17.3 % of endoscopists had to be absent from work due to MSDs, and the most frequent sites of severe MSDs resulting in temporary absence from work were the hands and wrists. Regardless of the MSD prevalence, we should focus on hand and wrist injuries. Future surveys should investigate the hand size of endoscopists and manufacturers should develop safer and more user-friendly endoscopes [8, 22–24].

Endoscopy-related procedure time affecting MSDs

The risk of MSD development appears to be influenced by the increased volume of endoscopies. Higher procedure volume (> 20 cases/week, P < 0.001), a greater number of hours per week spent performing endoscopy (> 16 hours/week, P < 0.001), and the total number of years performing endoscopy (> 16 years, P = 0.004,) are associated with a higher rate of endoscopy-related MSDs [9]. Similarly, cardiac ultrasonographers experienced injuries at a significantly higher rate when the number of examinations performed per month exceeded 100 [2]. Workload-associated factors, such as the number of procedures or duration of work, were also related to the prevalence of MSDs in other occupations [25]. Alternatively, the ASGE survey did not show a meaningful relationship between the time spent performing several endoscopic procedures and the prevalence of endoscopy-related MSDs [9]. The endoscopic examination and procedure exhibit variability in procedure time, posture, and specifications of the endoscope in comparison with ultrasonography. Therefore, we confirmed the risk of endoscopy-related procedure time affecting MSDs through a multivariate analysis of endoscopy-related MSD in each site (i. e., neck, shoulders, and low back).

Neck MSDs

The endoscopy-related procedure time was not a significant risk factor for developing symptoms in the neck. Generally, the importance of proper setup of the monitor that allows for neutral postures has been established in surgery. In the horizontal plane, the monitor should be placed straight in front of the operator to avoid axial rotation of the spine. In the sagittal plane, the monitor should be positioned lower than the eye level to avoid neck extension [3, 26]. To date, verification experiments regarding the appropriate position of the monitor in an endoscopic unit have not been performed. According to ergonomics, several reports suggested the appropriate position to prevent neck strain [22–24, 27–29]. It is, however, out of the scope of this study. Hence, our survey could not deal with information regarding the monitor setting in each endoscopic pro-

▶ **Table 3** Relative risk of endoscopy-related procedure time affecting local body site on musculoskeletal pain.

Total time engaged in (min/month)	Pooled adjusted OR (95 %CI)							
	Neck	*P*	Right shoulder	*P*	Left shoulder	*P*	Low back	*P*
Upper GI endoscopy								
▪ 0–150	1		1		1		1	
▪ 150–350	2.7 (0.4–16.8)	0.29	2.3 (0.4–14.1)	0.38	1.7 (0.2–13.8)	0.61	0.8 (0.1–3.9)	0.73
▪ 351–550	3.3 (0.5–22.7)	0.23	0.3 (0.0–4.4)	0.41	2.4 (0.3–19.9)	0.42	0.2 (0.0–1.3)	0.09
▪ 551 ≤	1.8 (0.2–16.5)	0.59	3.2 (0.4–28.7)	0.29	3.9 (0.3–43.4)	0.27	0.4 (0.1–3.1)	0.40
Lower GI endoscopy								
▪ 0–250	1		1		1		1	
▪ 251–750	1.6 (0.5–5.6)	0.43	2.5 (0.6–10.1)	0.19	1.3 (0.3–5.2)	0.70	0.8 (0.4–1.5)	0.70
▪ 751 ≤	0.9 (0.1–6.1)	0.95	0.6 (0.1–6.9)	0.70	0.7 (0.1–6.5)	0.73	0.5 (0.0–2.3)	0.41
Upper ESD								
▪ none	1		1		1		1	
▪ 1–90	0.5 (0.1–3.2)	0.51	0.4 (0.0–4.0)	0.47	0.8 (0.1–4.9)	0.82	1.2 (0.2–8.3)	0.82
▪ 91–180	0.8 (0.2–3.0)	0.74	1.1 (0.3–4.4)	0.94	0.3 (0.0–1.5)	0.13	1.3 (0.3–5.6)	0.73
▪ 181 ≤	1.4 (0.7–3.1)	0.64	1.4 (0.6–3.3)	0.68	0.6 (0.2–1.4)	0.52	5.7 (1.3–25.0)	0.02
Upper GI treatment								
▪ none	1		1		1		1	
▪ 1–30	2.4 (0.4–13.6)	0.34	0.7 (0.1–3.9)	0.72	0.3 (0.1–2.0)	0.25	1.5 (0.3–7.3)	0.62
▪ 31–60	6.1 (0.9–39.4)	0.06	1.2 (0.5–2.9)	0.86	0.6 (0.1–3.9)	0.60	0.9 (0.3–2.4)	0.91
▪ 61 ≤	4.1 (0.7–25.1)	0.12	1.2 (1.0–1.3)	0.85	0.6 (0.3–1.4)	0.56	2.7 (1.2–5.9)	0.21
Lower ESD								
▪ none	1		1		1		1	
▪ 1–90	0.7 (0.1–3.9)	0.68	0.4 (0.1–1.3)	0.45	0.7 (0.1–6.7)	0.73	4.9 (1.1–22.0)	0.04
▪ 91–180	1.3 (0.3–5.0)	0.72	2.0 (0.9–4.4)	0.36	5.0 (1.2–20.2)	0.04	2.2 (1.0–4.8)	0.30
▪ 181 ≤	1.2 (0.2–7.7)	0.87	1.8 (0.3–12.4)	0.57	1.0 (0.1–11.2)	0.98	4.5 (0.8–24.0)	0.08
Lower GI treatment								
▪ 0–75	1		1		1		1	
▪ 76–525	0.7 (0.2–2.7)	0.64	0.6 (0.1–2.9)	0.54	0.7 (0.1–3.6)	0.63	1.1 (0.3–4.5)	0.89
▪ 526 ≤	1.0 (0.2–4.0)	0.99	1.3 (0.3–5.4)	0.75	2.0 (0.4–10.1)	0.39	5.6 (2.3–13.3)	0.05
Enteroscopy								
▪ none	1		1		1		1	
▪ 1–225	0.8 (0.2–3.1)	0.71	1.0 (0.4–2.2)	0.99	2.6 (1.2–5.8)	0.24	2.9 (0.7–11.6)	0.13
▪ 226 ≤	0.6 (0.1–2.9)	0.47	0.8 (0.3–1.9)	0.78	1.8 (0.4–9.3)	0.47	3.9 (1.0–15.8)	0.06
ERCP								
▪ none	1		1		1		1	
▪ 1–120	1.3 (0.2–8.6)	0.77	–	–	–	–	1.9 (0.3–14.3)	0.52
▪ 121–270	3.1 (0.9–11.0)	0.08	2.1 (0.5–7.9)	0.28	0.9 (0.2–3.5)	0.87	2.6 (0.6–11.8)	0.22
▪ 271 ≤	0.4 (0.1–2.5)	0.33	0.2 (0.0–1.3)	0.10	0.4 (0.1–2.1)	0.28	2.6 (0.6–12.5)	0.23

▶ **Table 3** (Continuation)

Total time engaged in (min/month)	Pooled adjusted OR (95 %CI)							
	Neck	*P*	Right shoulder	*P*	Left shoulder	*P*	Low back	*P*
EUS								
▪ none	1		1		1		1	
▪ 1–90	1.6 (0.4–6.3)	0.52	0.4 (0.1–2.4)	0.31	0.2 (0.0–1.2)	0.08	0.9 (0.2–5.0)	0.95
▪ 91–180	1.8 (0.4–7.3)	0.42	2.3 (0.5–10.3)	0.28	0.5 (0.1–2.5)	0.41	2.6 (0.6–11.2)	0.19
▪ 181 ≤	0.7 (0.1–4.8)	0.75	0.9 (0.1–6.1)	0.91	0.2 (0.0–0.5)	0.13	1.9 (0.4–9.0)	0.43

GI, gastrointestinal; ESD, endoscopic submucosal dissection; ERCP, endoscopic retrograde cholangiopancreatography; EUS, endoscopic ultrasound.
Analyses were adjusted for sex, age, certified fellow of endoscopy, seniority (yrs), working hours (h/wk) and sedentary time (h/d)
–: The value was not calculated due to less frequency.

cedure, and could not reveal other risk factors associated with neck pain.

Low back MSDs

Notably, longer total time per month of upper ESD, lower ESD, and lower gastrointestinal treatment were the risk factors significantly associated with symptoms in the low back. These endoscopic procedures were originally longer in comparison with the conventional endoscopic examination. A previous study revealed that the frequency of >30 colonoscopies per week was associated with low back MSDs, indicating that sitting when possible is useful for the prevention of low back and foot injuries [5]. In another report, endoscopists performing upper endoscopy while sitting had a lower prevalence of severe MSDs [6]. In contrast, a recent European study claimed that the sitting posture for environment modifications was a non-significant factor for the prevention of MSDs [12].

The discrepancy could be attributed to a variety of postures of endoscopists during performing. Prolonged standing or sitting posture may be related to musculoskeletal injuries, especially low back injuries. A recent trend in Ergonomics field can be found in sit-stand workstations designed to improve the alertness and performance of workers, as well as reduce the development of MSDs [30]. Such workstations allow workers to change their posture as they wish. We hypothesize that sit-stand endoscopic workstations may diminish the occurrence of some endoscopy-related MSDs. A sit-stand workstation equipped with a unique wearable chair was developed to prevent laparoscopy-related MSDs. This chair can be fitted and removed rapidly and easily [31]. Furthermore, we demonstrated the usage of the ergonomic wobble stool for endoscopists, endoscopy nurses, and assistants in the endoscopy unit. This stool allowed staff to rapidly change from a sitting position to a standing position [32]. In the current survey, however, almost all endoscopists selected the standing position during these procedures: upper ESD (95.5 %), lower ESD (90.4 %), and lower gastrointestinal treatment (95.2 %). Therefore, we could not reveal the effect of endoscopic postures that influence low back injuries. Prospective studies are warranted to compare the reduction of endoscopy-related MSDs between the sitting position, standing position, and sit-stand workstation.

Shoulder MSDs

Longer total time per month of lower ESD was a significant risk factor for symptoms in the left shoulder. Appropriate adjustment of the bed height to achieve a neutral posture of the head, neck, back, shoulders, and elbows of endoscopists has been recommended [22, 27–29]. However, endoscopists have to lift the specific control of the endoscope using the left shoulder during the lower ESD procedure [29]. One of the ergonomic solutions might be use of an endoscopic holder for diminishing shoulder injury [33].

Association between other endoscopic procedures and MSDs

Enteroscopy, endoscopic retrograde cholangiopancreatography (ERCP), and interventional EUS require the usage of lead aprons and long endoscopy times. These procedures may also involve awkward postures for prolonged periods of time if the fluoroscopic, endoscopic, and ultrasound monitor is placed excessively high or to the side of the endoscopist [34]. It is thought that these procedures are more likely to lead to MSDs than other procedures [8, 22, 27]. However, in the current study, the time of these procedures was not a significant factor associated with MSDs. This discrepancy in the data may be attributed to the small sample size. Hence, further large surveys are warranted to confirm these findings.

Practical implication of endoscopy-related work-rest schedule

In contrast to 20 years ago, most gastroenterologists spend >40 % of their time performing endoscopies [9, 22]. The ASGE survey showed a relationship between the time spent performing endoscopy and the prevalence of endoscopy-related MSDs (>40 %, $P = 0.002$) [9]. In the current study, endoscopic work occupied 42 % of daily work. We have to recognize the working hours that gastroenterologists are engaged in endoscopy and the interaction between the endoscopists, devices, and workstation to reduce the occurrence of overuse injuries based on ergonomics. According to the ASGE survey, only 10 % of endoscopists took regular breaks [9]. Endoscopy is a physically challenging procedure. Rest breaks during endoscopy are essential to provide the muscles, tendons, and ligaments a chance to recover from the strain exerted by the endoscopic procedure. Endoscopists should take care of their bodies and recognize the importance of stretching and microbreaks to avoid injury [27, 29, 35].

Furthermore, the manager of the endoscopic unit has to effectively manage the total time spent in endoscopic procedures per month to minimize the risk of endoscopy-related MSDs, especially during ESD and lower gastrointestinal treatment (e. g., polypectomy). The ergonomic timeout can ensure proper positioning and height of the monitor and bed, such that the head, neck, back, shoulders, and elbows are in neutral postures [11, 22]. Furthermore, the ergonomic timeout should emphasize the need for regular breaks during endoscopy before the initiation of longer endoscopic procedures.

Another practical implication of this study provides an important holistic view of endoscopic related MSDs. Work-related MSDs of medical workers have been analyzed with a focus on ergonomics [3, 26]. Endoscopy-related MSDs in the endoscopic unit are not limited to endoscopists. Studies are also required to assess the MSDs occurring in endoscopic nurses, endoscopic technicians, and sanitation staff. Education in ergonomics for endoscopists and endoscopic staff is warranted to prevent the development of endoscopy-related MSDs later in their career [28].

Study limitations

Some limitations of this study have to be acknowledged. Although the response rate on the current survey was generally sufficient (51.6 %), the larger samples were needed to evaluate the role of recent diagnostic and therapeutic endoscopic procedures (e. g., enteroscopy, ERCP, and interventional EUS) in the development of MSDs. Odds ratios could not calculate due to the low number of endoscopy-related MSDs in the hands and wrists. Furthermore, recall bias may have influenced the responses of the participants. In our survey, the number of endoscopists who required environments modifications and specific treatments for endoscopy-related MSDs were not investigated.

Conclusions

This study revealed that most endoscopists struggle against endoscopy-related MSDs mainly on neck, shoulders, and low back. We also found evidence suggesting a direct correlation between the endoscopy-related procedure time of ESD or lower gastrointestinal treatment and the risk of MSDs mainly low back and left shoulder. Managing monthly total endoscopic time, in light of organizational ergonomics, could contribute to minimizing such risks of endoscopy-related MSDs.

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Competing interests

The authors declare that they have no conflict of interest.

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