

Digestive endoscopy and risk of upper limb biomechanical overload

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KEY WORDS

UL-WMSDs; endoscopist; colonoscopy

SUMMARY

Background: For several years the literature has reported a high prevalence of upper limb musculoskeletal disorders among medical staff carrying out digestive endoscopy. **Objectives:** The EPM research unit, in cooperation with the Italian Society of Digestive Endoscopy (SIED) and with the patronage of the Italian Society of Ergonomics (SIE), undertook research that would permit assessment of upper limb biomechanical overload using the OCRA method during gastroscopy and colonoscopy and, via a pilot study, collect health data on 179 workers employed in endoscopy services. **Results:** Risk analysis showed slight exposure levels for the arm bearing the instrument and a medium-to-high exposure for the other arm. However, the study of diseases in this sample showed a higher prevalence than in the reference population not exposed to risk for the upper limbs and in particular in the hand-wrist area. **Conclusions:** Risk analysis highlighted possible ergonomic measures that would be easy to implement and which would significantly reduce the risk.

RIASSUNTO

«*Endoscopia digestiva e rischio da sovraccarico biomeccanico degli arti superiori*». Da diversi anni la letteratura scientifica riporta elevate prevalenze di disturbi o di patologie fra il personale addetto all'esecuzione di esami endoscopici dell'apparato digestivo. Ad oggi tuttavia il rischio non è stato valutato con appropriati metodi. Per tale motivo il gruppo di ricerca EPM (Ergonomia della Postura e del Movimento, in collaborazione con la SIED (Società Italiana di Endoscopia Digestiva) e con il patrocinio della SIE (Società Italiana di Ergonomia) ha intrapreso una ricerca per valutare il rischio da sovraccarico biomeccanico degli arti superiori fra il personale addetto all'esecuzione di esami endoscopici dell'apparato digestivo e per verificare se anche in Italia la prevalenza dei disturbi o della patologia a carico degli arti superiori, fra questo gruppo di operatori, sia elevata. L'analisi del rischio con il metodo OCRA è stata condotta in due centri di endoscopia digestiva e la valutazione ha interessato solo la gastroscopia e colonoscopia. Per ogni tipo di esame endoscopico sono state effettuate quattro valutazioni del rischio con operatori diversi. Per l'analisi dei disturbi e delle patologie a carico degli arti superiori è stato condotto uno studio pilota somministrando un questionario specifico ai 180 convenuti al convegno SIED 2005, di questi hanno risposto 179. L'analisi del rischio ne ha evidenziato la presenza quando l'operatore effettua esami endoscopici per almeno 180 minuti per turno. Lo studio pilota sui disturbi e sulle patologie degli arti superiori ha confermato che anche fra gli endoscopisti italiani emergono prevalenze elevate con un interessamento particolare dei distretti mano-polso e della spalla. L'analisi ha evidenziato la possibilità di interventi ergonomici, anche a relativo basso impatto economico, attraverso i quali sarebbe possibile diminuire il rischio da sovraccarico biomeccanico degli arti superiori.

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INTRODUCTION

For several years the literature has reported a high prevalence of musculoskeletal disorders among endoscopists (3, 8, 10).

Buschbacher (3) performed a survey via a questionnaire sent to the members of the American Society of Gastrointestinal Endoscopists. The reported complaints revealed a high prevalence of pain in the upper limbs (shoulder, elbow, hands, thumb) and lumbar spine as well as tingling in the hand. Carpal tunnel syndrome was reported by approximately 6% of the subjects interviewed. A significant aspect – for risk assessment – was the fact that 91% of the subjects interviewed reported endoscopy activity that did not exceed 20 hours per week. A significant correlation was observed between hours per week of endoscopy activity and complaints (excluding shoulder and neck pain, and hand numbness).

Siegel reached the same conclusion (17). However, no difference was observed in complaint distribution as regards gender, prevailing limb, any hobbies that might overload the upper limbs and work seniority.

The study by O'Sullivan (15) specifically aimed at operators of Endoscopic Retrograde CholangioPancreatography (ERCP), showed that musculoskeletal complaints were reported by 67% of the subjects interviewed, 58% of whom reported complaints in at least two areas. Analysis of complaints by area gave: 57% back pain, 46% neck pain, 36% hand pain, 8% elbow and 16% shoulder pain; 38% experienced disorders during ERCP. From the statistical viewpoint, there was a positive correlation between complaints and years of work seniority, number of examinations performed and non-ergonomic workplace.

The ergonomic suggestions made by the subjects themselves were quite interesting, especially as regards the layout of the workplace: table with adjustable height and possibility of tilting it sideways, videoscopes instead of fibre optic scopes (specially for the neck), lighter lead aprons and more frequent work rests.

A specific problem concerning lumbar-sacral complaints is the use of lead aprons. Moore et al (11) and Ross et al (16) investigated this issue and concluded that there was a positive correlation be-

tween the use of lead aprons and lumbar-sacral spinal disorders.

This increasingly widespread diagnostic and therapeutic technique (and hence an increasing number of potentially exposed operators) justifies the occupational physician's interest. One only has to consider the recent Italian health plan for the prevention of colorectal cancer that will involve most of the Endoscopy Centres over the entire national territory.

The Research Unit "Ergonomics of Posture and Movement" (EPM), in collaboration with the Italian Society of Digestive Endoscopy (SIED), and under the patronage of the Italian Society of Ergonomics (SIE), initiated research aimed at providing – after a careful analysis of the problem – ergonomic solutions that would reduce the disorders and the diseases involving different muscular-tendinous areas of the upper limbs reported by many endoscopists.

In short, the research was planned in the following stages:

- a) a pilot study, at national level, to investigate the prevalence of musculoskeletal disorders among endoscopists;
- b) analysis of risk due to biomechanical overload of the musculoskeletal system in certain hospitals;
- c) assessment of risk and health-outcome data and proposed solutions.

To date the pilot study has been carried out by circulating self-administered questionnaires during the SIED Congress ("Endoscopic Trip", Milan, 11-12 April 2005). In the meanwhile, video movies were made during execution of esophagogastroduodenoscopy (EGDS) and colonoscopy, subject to agreement by patients and health care workers, to analyze the risk due to upper limb biomechanical overload. The results of these two investigations are reported below.

METHODS

Risk analysis

The risk due to upper limb biomechanical overload was assessed by the OCRA method (4, 5, 7,

13, 14). Organizational data (number and type of examinations, execution method, duration of examination and referral) were collected at two endoscopy services and four videos on gastroscopies and four videos on colonoscopies were made. At this stage the focus was only on endoscopists; the other professional figures will be considered at a later stage.

The OCRA method is used for risk assessment of upper limb biomechanical overload. The ISO 11228-3 standard ranks it as the preferred method and it has the additional advantage of being able to predict the incidence of upper limb diseases.

Since endoscopists' activity cannot be considered as having real work cycles that are continuously repeated, risk was assessed by considering some sample times (minutes) of the endoscopic examination. The minutes considered as causing most overload were: start of examination, bioptic, one casual specimen minute during execution and finally the minute preceding the end of the clinical examination.

Survey of upper limb disorders

The study was conducted by means of a questionnaire providing exposure data (number and type of endoscopic examinations carried out per month), diagnosis of upper limb diseases and lastly the complaints reported in the past twelve months were investigated for each joint area. The questionnaire was illustrated at the "Endoscopic Trip" Congress, held in Milan, 11-12 April 2005 and at the end of the Congress all participants handed in the self-administered questionnaire. The questionnaire was distributed to both endoscopists and nurses on the assumption that biomechanical overload of the upper limbs affects all operators working in endoscopy services.

RESULTS

Analysis of risk from upper limb biomechanical overload

Fixed screens of videoscopes, at a height of approximately 160 cm were available in both en-

doscopy services. Video movies concerned both gastroscopies – on average with a net execution time of approximately 3 minutes – and colonoscopies where the average duration was 20 minutes. Also, two different execution methods of endoscopic examination were investigated: one with the endoscopist not assisted by a health professional and the other with the operator assisted by a health professional who assured rotation of the endoscopic tube on its axis and movement of the endoscope forwards or backwards in the digestive portion under examination. These two working procedures produced no significant difference in the exposure level to the specific risk. All examinations were conducted by subjects holding the instrument in the left hand and using the right hand to move two small cogged wheels to direct the fibroscope end-part with right-angled movements.

The maximum duration of an examination was approximately 20 minutes, and at the end the operator accomplished a number of additional operations (removal of gloves, reassurance of the patient and a check on her/his clinical conditions). In these two services the operator drew up the referral on a Personal Computer and hence, the Recovery factor was set equal to 1 (optimal). Therefore risk was assessed assuming different scenarios with different execution times of endoscopic activity, as reported in table 1.

The six endoscopists, all right-handed, reported a force score, according to the Borg scale, for the left limb bearing the tool, equal to 1.5 and equivalent to the level considered as "light". For the right upper limb, the reported force level was "very light" for most of the examination execution time.

For the right arm, the risk index calculation was mainly influenced by a high frequency of technical actions per minute (approximately 60) as well as by awkward posture of the hand continuously moving to pinch the endoscope wheels. For the left arm, the static posture held in order to hold the instrument for the total duration of the examination produced a "fictitious" frequency equal to 45 actions per minute. Fine movements of the fingers due to the need to press a button for insufflation and air and water recovery do not achieve the value of fictitious frequency. The elbow flexor-extensor move-

Table 1. Levels of OCRA index as compared with different durations of repetitive work over the workshift

Execution time of endoscopic tests in workshift	Frequency No. of technical (actions/min)		Recovery	Force multiplier		Posture multiplier		Stereotypy		Additional factors		Ocro Index	
	right	left		right	left	right	left	right	left	right	left	right	left
120 minutes	60	45	1	0.84	0.75	0.6	0.7	0.7	0.7	1	1	3.0	2.0
180 minutes	60	45	1	0.84	0.75	0.6	0.7	0.7	0.7	1	1	3.5	2.4
240 minutes	60	45	1	0.84	0.75	0.6	0.7	0.7	0.7	1	1	4.0	2.7
300 minutes	60	45	1	0.84	0.75	0.6	0.7	0.7	0.7	1	1	4.6	3.1

ments (in any case quite limited) and wrist postures with ulnar deviation of the right arm, carried out by operators without the aid of another operator, did not produce significant differences in upper limb risk exposure level.

Upper limb musculoskeletal disorders

A total of 179 subjects replied to the self-administered questionnaire out of the 180 distributed, and were subdivided by age class and gender, as shown in table 2.

Table 3 reports the sample composition by profession and gender, also considering the probable different exposure of upper limbs and cervical spine to risk from biomechanical overload.

Table 2. Distribution of sample by age and gender

Age classes (years)	Males		Females	
	No.	%	No.	%
26-35	4	5.9	25	23.1
36-45	21	30.9	56	51.9
46-55	36	52.9	26	24.1
>55	7	10.3	1	0.9
Total	68	100	108	100

3 missing

Table 3. Distribution of sample by gender and profession

Profession	Males		Females		Total	
	No.	%	No.	%	No.	%
Physician	60	68.2	28	31.8	88	50
Nurse	8	9.1	80	90.9	88	50

3 missing

The average job seniority of endoscopists was 15.1 years (median=14.0) and is considerably higher than in nurses: 7.4 years (median=6,0).

The data showed that the sample of subjects examined carried out quite varying numbers of endoscopic examinations on average per month, as shown in table 4. There is some uncertainty as to the reliability of this response due to the questionnaire content: according to the questionnaire compilers the number of examinations should correspond to the actual number of examinations by each endoscopist and not to the total number of examinations carried out by the service. Therefore it is assumed that those who declared carrying out over 500 examinations/month referred to the entire service rather than to his/her activity.

The most surprising feature was the prevalence of upper limb diseases that had already been diagnosed: such prevalence was really high, especially concerning the shoulder and hand-wrist areas compared to the general population and reference samples of subjects not exposed to risk (1). Disease prevalence, analysed by profession, revealed 40.0% among endoscopists while in nurses it was 33.0%. Prevalence was 16.9% for the shoulder, 9% for the

Table 4. Number of subjects by number of endoscopic examinations/month

N. endoscopic examinations/month	No.	%
Up to 50	7	4.2
51 to 100	27	16.1
101 to 200	65	38.7
201 to 500	50	29.8
over 500	19	11.3

elbow and 25.8% for hand-wrist. Though we are well aware of the high number of confounding factors that were not accounted for, this figure is rather alarming and shows the probable presence of work-related causal factors.

The analysis of such work-related diseases (table 5) reports no remarkable differences among the different areas investigated but for the elbow: in this case physicians are more affected than nurses. Since the questionnaire does not specify which side is affected, it was impossible to assess prevalence of diseases on the right hand compared to the left hand.

In addition to diagnosed diseases, the complaints reported in the last year were collected, by single anatomic area, as shown in table 6. These complaints exceeded a given "threshold" defined as

Table 5. Diseases by involved anatomic area and by profession

Job	Shoulder		Elbow		Wrist-Hand	
	No.	%	No.	%	No.	%
Physicians	14	46.7	13	81.2	22	47.8
Nurses	16	53.3	3	18.8	24	52.2

Table 6. Upper limb complaint reported in the last 12 months

Type of complaint in the last 12 months	No.	%
Shoulder pain	61	34.3
Night Tingling	48	27
Day Tingling	32	18
Hand pain	30	16.8
Wrist pain	24	13.5
Elbow pain	21	11.8

Table 7. Analysis of musculoskeletal disorders by number of endoscopic examinations/month

No. endoscopic examinations per month	Shoulder pain		Elbow pain		Wrist pain		Hand pain		Night Tingling		Day Tingling	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Up to 50	3	5.2	1	5.3	0	-	-	0	0	-	1	2.2
51 to 100	9	15.5	4	21.1	3	12.5	4	13.3	4	14.3	10	21.7
101 to 200	19	32.8	4	21.1	8	33.3	11	36.7	6	21.4	15	32.6
201 to 500	22	37.9	7	36.8	11	45.8	12	40.0	15	53.6	17	37.0

11 missing

the presence of pain/tingling in the last 12 months lasting at least one consecutive week or at least one day per month (9). It is noteworthy that the trend of complaints may partially overlap diseases: the more affected areas were actually the shoulders and night numbness of the upper limb.

Analysis of these complaints, correlated to the number of endoscopic examinations carried out monthly (table 7), showed a positive trend. We excluded subjects reporting over 500 endoscopic examinations per month because most of them probably did not report the actual number of examinations performed personally but rather the number of examinations carried out by the service.

The last aspect analysed was the prevalence of complaints affecting only endoscopists (No.=88) by investigated area and by side. Table 8 shows major differences in elbow, wrist, hand areas and tingling that are more frequent in the right arm.

DISCUSSION AND CONCLUSIONS

The preliminary results of risk assessment from upper limb biomechanical overload, confined to

Table 8. Distribution of the upper limbs disorders in endoscopists by affected side (No. 80)

Type of discomfort in the last 12 months	Right No.	Left No.
Hand pain	18	4
Shoulder pain	17	15
Night paraesthesias	15	9
Elbow pain	11	4
Wrist pain	8	3

gastroscopy and colonoscopy, emphasize the presence of risk for the right upper limb even when the time dedicated to endoscopy examinations is reduced to 180 minutes per day. A different result was achieved for the left upper limb, which generally falls in the range of uncertain or very light risk. According to the OCRA index predictive models, 10 years after the start of exposure, the number of subjects suffering from UL-WMSDs is expected to be around 10%.

One factor that to a greater degree influences the calculation of risk due to upper limb biomechanical overload is posture ($F_p=0.6$ right upper limb and 0.7 left upper limb). As reported by Cotrim et al (6), however, this analysis is closely associated with the operator's movements, workplace layout and type of endoscopic examination. Fibroscope rotation by some operators, with elbow pronation-supination movements or ulnar or radial wrist deviations, does not last a sufficient length of time so as to change the posture score. This is due to pinching and gripping movements of the right upper limb, plus fine finger movements of the left upper limb.

As to the static grasp needed to handle the endoscope for the duration of the examination, it would be advisable to investigate fatigue more thoroughly. The first interviews made on the use of force required by endoscope handling gave results ranging between 1.5 and 2 on the Borg scale. In this condition, a static grasp lasting 3 minutes (as in EGDS), requires a recovery time of the same duration (12). A recovery time of 45 minutes would be necessary with a static contraction of approximately 7.5 minutes, and a force equal to 2 on the Borg scale. There are no data available in the literature indicating the onset time of muscular fatigue syndrome and possible recovery times with the reported force level (value 1.5 on Borg scale) and average duration of a colonoscopy (approximately 20 minutes). The study of this issue could also be useful in proposing organizational solutions.

Another factor is specific work organization, i.e., endoscopy examinations carried out by one or more operators. At least as a preliminary analysis, there appears to be no difference in risk exposure due to upper limb biomechanical overload in rela-

tion to the procedures used: i.e., alone or aided by another health care professional. This statement obviously requires further comparisons of data from other endoscopy services.

Risk was not assessed in ERCP examinations since so far it has only been possible to observe just one examination. This procedure is, however, slightly different from those mentioned above: at a later stage of the research analyses will be performed so as to obtain risk profiles by subject.

Since health data regarding diagnosed diseases and complaints reported in the last twelve months revealed a problem among nurses, "additional" activities (e.g. cleaning of devices, instruments, etc.) will be the subject of an analysis of risk due to upper limb biomechanical overload.

Analyses of upper limb diseases and complaints, although collected in a still limited sample, reveal a problem for nearly all body areas, but especially for the hand-wrist, and according to the number of endoscopies performed in a work shift.

The number and type of endoscopy examinations are significant parameters in order to define the possible risk exposure due to upper limb biomechanical overload. In the questionnaire the questions on this issue probably produced ambiguous replies since some operators did not report the number of endoscopic tests carried out personally but those carried out by the service as a whole, without however indicating the number of endoscopists involved.

What is more startling in this initial investigation is the number of already diagnosed upper limb diseases, which is considerably higher than the average for the population not exposed to this specific risk.

All the above confirms the results of similar studies conducted on staff performing digestive endoscopy.

Owing to the limited size of the sample examined, the data on cervical spine diseases are not reported, in spite of their frequency. No doubt the problem is associated with the use of fibre optic scopes involving frequent cervical spine flexions or with non-ergonomic positioning of the monitor. The solution of this problem is indicated in EN 1005-4 standard identifying, for static postures,

both the vision angle (between 0 and 40°, where 0 corresponds to eye height) and the acceptable angle range in cervical spine rotation and bending. Generally speaking, this standard, plus other European technical standards, could be used to advantage for an ergonomic design of the workplace (space, patients' bed, endoscopic device, lighting, etc.).

It is surprising that endoscopic equipment manufacturers do not produce hand-held devices that are adjustable to hand size: this fault could negatively affect the use of force needed to hold the instrument as reported by Berguer (2).

Certainly, technological solutions even if not specially advanced, such as reduced weight of the device or an arm rest on the chair (used for example by microscopists), might reduce the force applied and hence markedly reduce the risk: a cheap but significant solution.

Finally, new technologies, such as video pills or e-worm endoscopes, could significantly contribute to reducing or eliminating the risk for the musculoskeletal apparatus.

NO POTENTIAL CONFLICT OF INTEREST RELEVANT TO THIS ARTICLE WAS REPORTED

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