Ergonomic Issues during Bronchoscopy: A Local Case Study and Review of Literature

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ABSTRACT

Objective. This single-subject case study was done to evaluate the presence and evaluate the risk factors for the development of Work-Related Musculoskeletal Disorders (WMSDs) among the staff performing bronchoscopy in the bronchoscopy suite.

Methods. A single-subject case study to describe the ergonomic issues in bronchoscopy including identifying multiple factors that can potentially, either singly or in combination, affect physical work capacity. The study focused on the evaluation and control of occupational factors during bronchoscopy to improve awareness of ergonomic issues in bronchoscopy using the following data collection tools: 1) hierarchical task analysis, 2) activity sampling, 3) direct observation of the procedure (walk-around), 5) structured interview of the subject, and 5) utilization of checklists.

Results. During the process of bronchoscopy, identified factors that can cause pain in the wrists, fingers, and shoulders include repetitive movement and awkward positions of the hands and wrists coming from the need to move the directional controls and position the bronchoscope. For the back, prolonged standing with awkward postures is a concern. For the neck, the need to look at the monitor which is situated at the side of the patient and frequent shifting of the eyes and head from the monitor to the patient can cause neck pain and stiffness. Aside from the above, other factors would include job stress from the workload, inadequate time for rest and recovery, and the possibility of an uncomfortable environment due to poor air quality. Chronic exposure and repeated injury followed by inflammation and repair lead to structural and biochemical changes in the tissues affected by Cumulative Trauma Disorders (CTDs) leading to the development of WMSDs.

Conclusion. Although CTDs do not account for work-related deaths, they do account for a significant amount of human suffering, loss of productivity, and economic burden on the compensation system. Thus, ergonomic concerns must be addressed early to prevent WMSDs/CTDs.

Keywords: work-related musculoskeletal disorders, bronchoscopy, occupational health

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INTRODUCTION

Bronchoscopy is an interventional pulmonary procedure that involves direct visualization of the upper and lower respiratory tract for the diagnosis and management of a spectrum of inflammatory, infectious, and malignant diseases of the chest.[1,2] Bronchoscopy may include retrieval of tissue specimens (bronchial brush, forceps, needle), cell washings via bronchoalveolar cleavage, or removal of abnormal tissue by laser. It is performed by a specially trained physician and assisted by a specially trained healthcare professional.[2] In tertiary hospitals like the Philippine General Hospital, bronchoscopy is regularly performed by a designated team (trained pulmonologist and a bronchoscopy nurse or assistant) inside the endoscopy suite (where other endoscopic procedures are also performed), with the number of procedures being done ranging from 3 up to 8 per day. Each bronchoscopy takes from as short as 30 minutes to as long as 2 hours.

Considering the number of procedures performed and the length of time that is needed to perform a bronchoscopy, it would not be surprising that those individuals who perform the task might probably and potentially have signs and symptoms of musculoskeletal disorders.

To the author's knowledge, no local published study has yet identified ergonomic issues in bronchoscopy among bronchoscopy staff. Thus this single-subject case study is thought to be the first of its kind, and its ultimate goal would be to improve awareness of ergonomic issues in bronchoscopy in the local setting.

REVIEW OF RELATED LITERATURE

Ergonomics is the study of the interaction between the worker and their environment[3] (see Appendix 2 for operative definition). Through the science of ergonomic task analysis, the incidence of injury or long-term disability arising from poor work conditions can be minimized.[3] In the healthcare setting, the prevalence of healthcare-related work injuries among healthcare workers remains underreported.[4,5] The most commonly identified risk factors for these work-related injuries involve repetitive, forceful, or prolonged manipulation of hands and/or movements involving prolonged and awkward postures.[4] Health care providers, especially endoscopists are at an increased risk due to poor ergonomic design within healthcare facilities, devices, and situations.[5]

There has been a gap in available data regarding the ergonomic impact of bronchoscopy with a lack of well-designed prospective studies qualitatively and quantitatively describing the ergonomics and factors affecting work capacity. There have been only three published prospective studies to date[4-6] quantifying and qualifying the ergonomics in bronchoscopy despite the continuing development of the field of interventional pulmonology with the first modern-day fiber optic bronchoscope developed as early as 1966.[7]

According to the latest literature published in January 2020,[5] poor ergonomic positioning and excessive muscle strain appear present within bronchoscopy procedures. However, technological advances such as using rotational-head bronchoscopes have the potential to improve procedural ergonomics. However, the long-term impact of bronchoscopic ergonomics is still to be defined by future prospective studies.[5]

Factors potentially affecting work capacity

Multiple factors are identified which can potentially, either singly or in combination, affect physical work capacity. The following are some of the identified factors that would need to be considered:[8,9]

1. physical factors: age, body weight, gender, alcohol consumption, tobacco smoking, active/non-active lifestyle, training/sport, nutritional status, motivation, illness, and previous injury
2. environmental factors: atmospheric pollution, indoor air quality, ventilation, noise, extreme heat or cold
3. occupational factors: repetition, high force, manual handling, awkward and prolonged posture, direct pressure, vibration, and cold
4. psychosocial factors: monotony and job dissatisfaction, lack of job control and fear of layoff, outside stressors, unpleasant workplace, personal viewpoint, ability to adapt or cope to an injury/poor coping strategies, monetary compensation, distress and dissatisfaction with co-workers and bosses

Of these factors, the focus would be placed on the evaluation and control of occupational factors during bronchoscopy.

MATERIALS AND METHODS

A descriptive prospective single-subject case study to describe the potential ergonomic issues associated with bronchoscopy was done by looking into a case of a 55-year-old man, bronchoscopy assistant, left-handed, with no known ailments and vices. The subject has been employed in the Philippine General Hospital for 30 years, initially as a laboratory aide, later becoming an assistant in performing most procedures done in the pulmonary diagnostics suite (including ultrasound-guided procedures such as biopsy and thoracentesis, aside from bronchoscopy). He has an 8-hour workday with 1 ½ hours of lunch break, 5 days per week, with intermittent light to moderate but intense work – there would be times that procedures continuously are done for 3–4 hours, but there would also be times that no procedures are performed. On average, he assists in performing 10–20 procedures daily. According to the subject, he notices on and off pain over the wrists, shoulder, and lower back, especially after a day with a heavy workload, for which intake of as need analgesics still works.

Data Collection Techniques

No standards or guidelines are currently available to evaluate risk factors and ergonomic disorders associated with bronchoscopy, but there are various methods to analyze the work process and identify areas or tasks that would need intervention to minimize or eliminate ergonomic problems. Among the tools that have been utilized to evaluate bronchoscopy were: 1) hierarchical task analysis; 2) activity sampling; 3) direct observation of the procedure (walk-around); 4) structured interview of the subject, and 5) utilization of checklists.

RESULTS

Hierarchical Task Analysis (HTA)

To make it easier to understand the process of bronchoscopy and identify the specific tasks that can potentially cause ergonomic problems, hierarchical task analysis (HTA) was performed.[10] HTA involves describing the task in terms of a hierarchy of operations and plans to meet a system's goals – as in this case, completing the task of bronchoscopy.

As can be viewed from Figures 1 to 5, the process of bronchoscopy involves four basic tasks that have numerous subtasks. The cycle time can also be noted for each task.

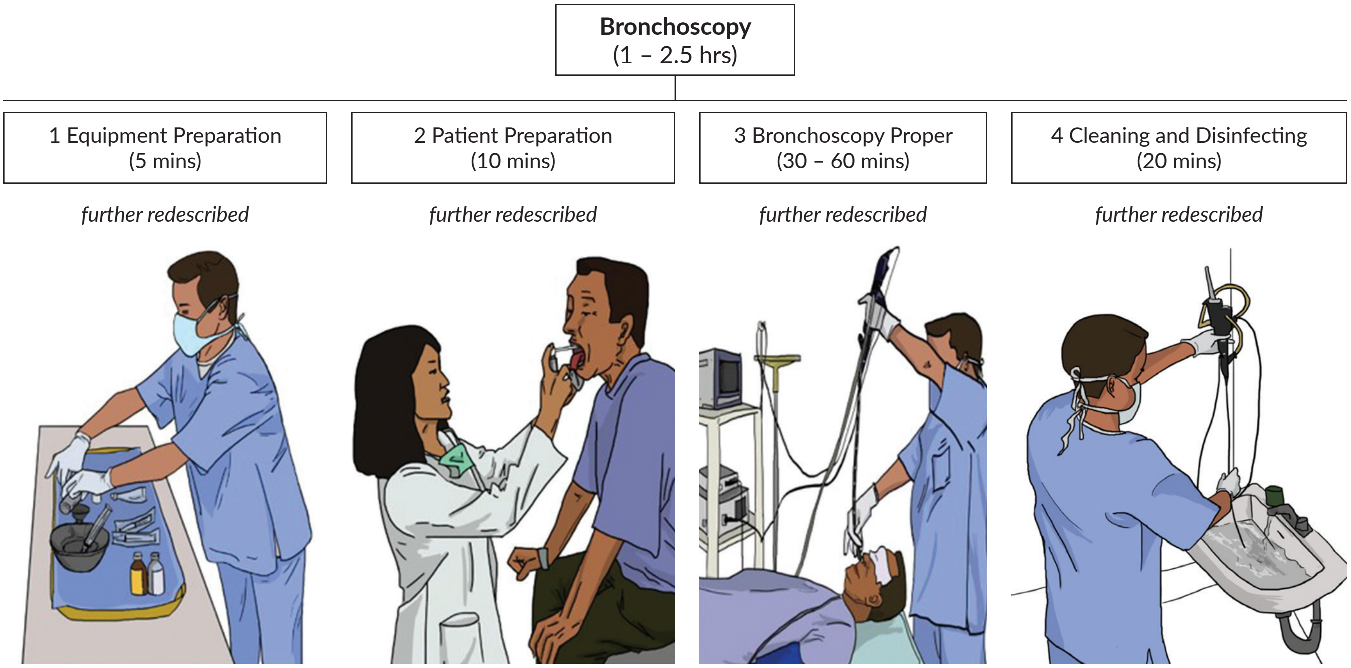


Figure 1. Hierarchical Task Analysis (HTA).

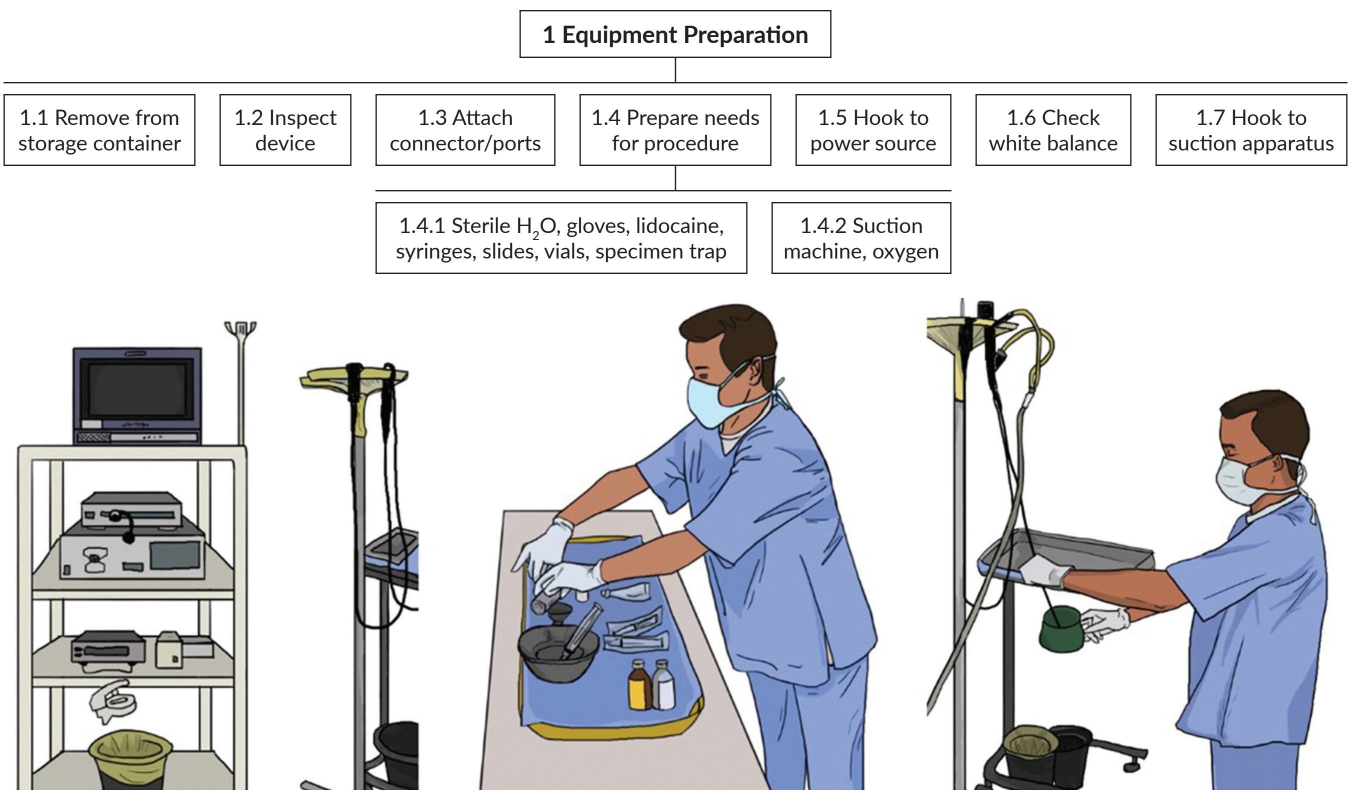


Figure 2. HTA Subtask: Equipment Preparations.

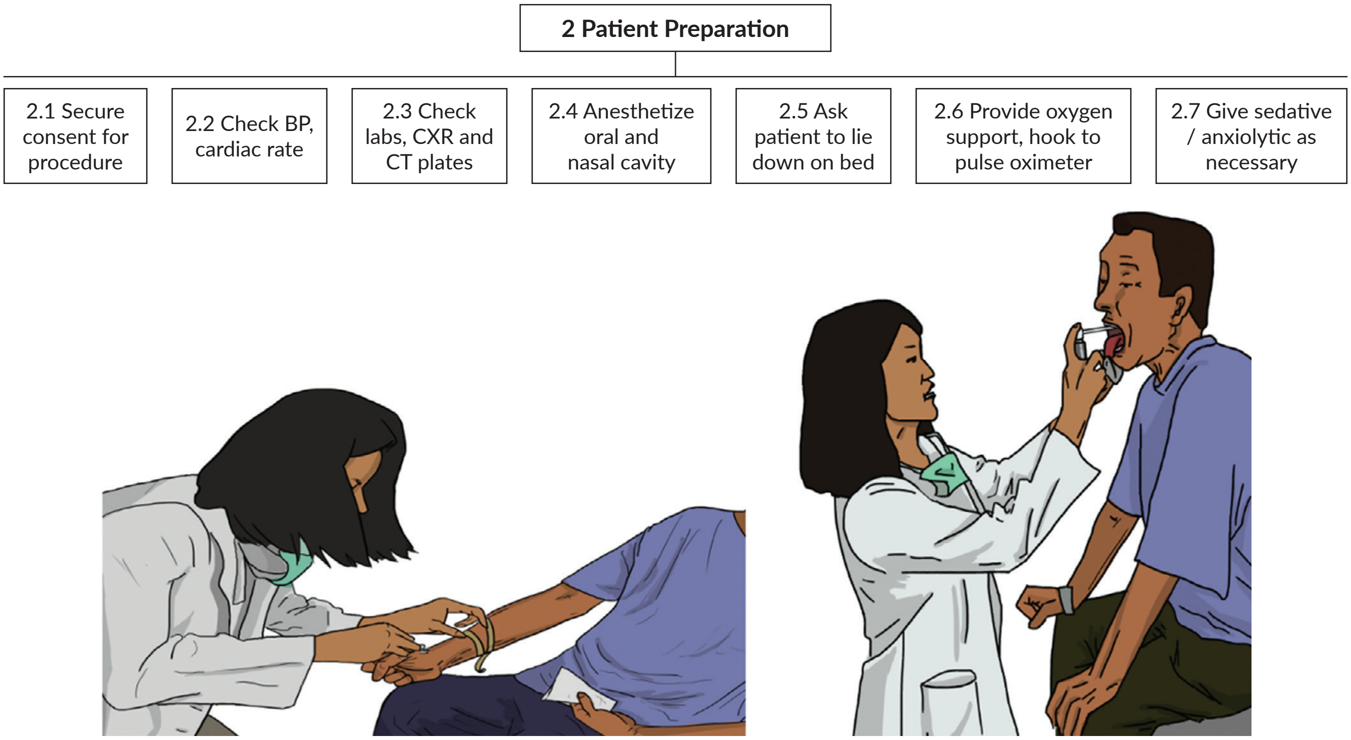


Figure 3. HTA Subtask: Patient Preparations.

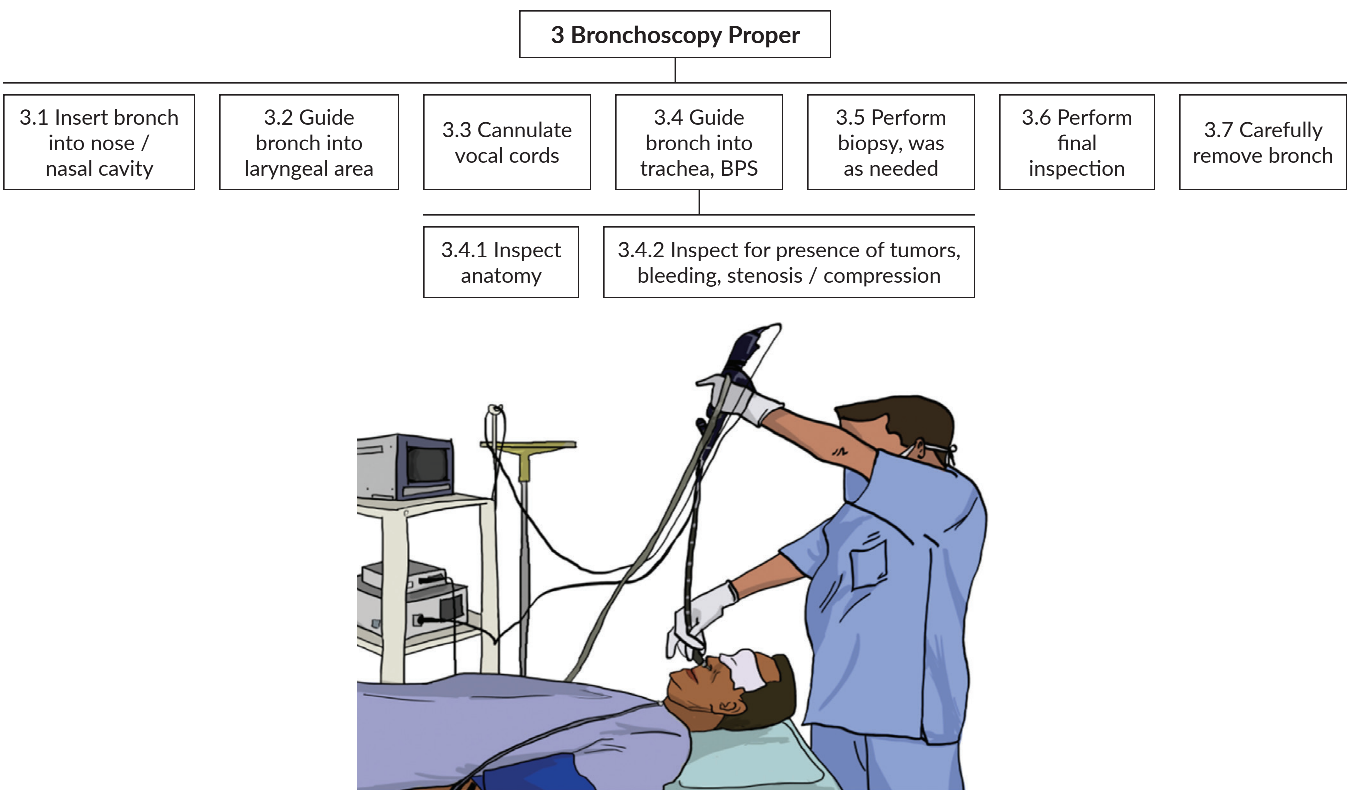


Figure 4. HTA subtask: Bronchoscopy proper.

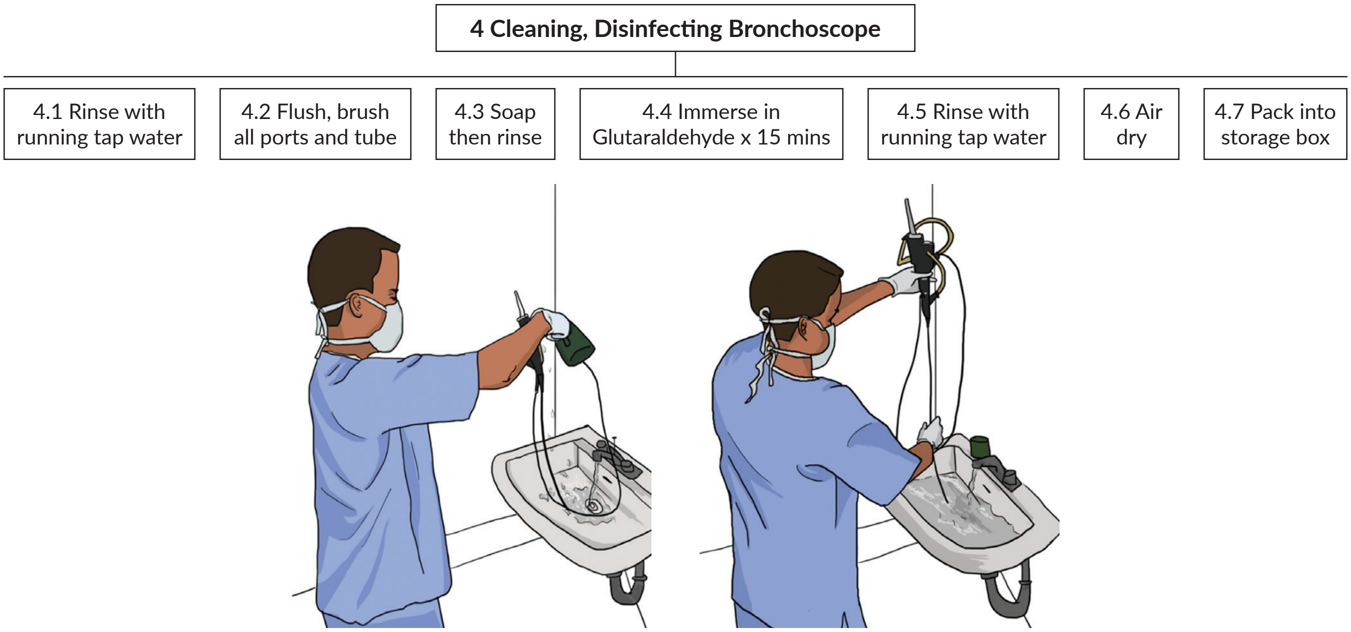


Figure 5. HTA Cleaning, Disinfecting and Bronchoscope subtasks.

From the HTA, it can be seen that the most demanding task in terms of time necessary for its completion is the third one – bronchoscopy proper. Depending on many conditions (e.g., patient's tolerance, ease of cannulation of vocal cords, the intensity of secretions, the skill of the bronchoscopist, need for biopsy), bronchoscopy proper can be as long as 2 ½ hours. This is likewise the task identified to most likely cause ergonomic problems due to the duration, the need to assume awkward and repetitive wrist positions (i.e., bent and flexed wrists) for periods of time, and the need to assume static standing postures with a periodically twisted neck. Other issues identified during bronchoscopy proper that can potentially cause not only ergonomic problems are the presence of glare from looking at the video monitor and more importantly the limited but high levels of exposure from biological agents (i.e., direct exposure to tubercle bacilli and microorganisms through the open airways). The rest of the tasks during bronchoscopy were primarily of short duration and provided more dynamic movement thus were not perceived to cause ergonomic complaints.

Aside from HTA, another set of tools utilized to evaluate the potential ergonomic hazards of bronchoscopy was the use of checklists. Tables 1 and 2 show the National Institute for Occupational Safety and Health (NIOSH) workstation and task analysis checklist[11] (see Appendix 2 for operative definition), wherein any no response would merit the need for further evaluation. From the checklist filled up by the subject, it can be noted that the workstation and tasks does not eliminate the need for bending or twisting of the wrists, back and trunk, static muscle loading, and raised elbows.

To properly evaluate the exposure of the subject to postures, forces, and muscle activities known to contribute to upper limb disorders, the Rapid Upper Limb Assessment (RULA)[12] technique that uses observations of postures adopted by the upper limb, neck, back, and legs was utilized (Figure 6, see Appendix 2 for operative definition, Appendix 3 for RULA protocol). From the website accessed and filled up, the results (see below) showed that the process of bronchoscopy had a score of 6/6, which meant that further investigation and interventions are required soon to arrest or minimize ergonomic problems. Reviewing the illustration, it was apparent that there were significant upper extremity repetitive movements with awkward positioning especially of the wrists, and static loading/postures of the trunk and back. There was however minimal force and exertion required from the procedure.

From the interview of the subject and on review of his medical records, it was found that he would notice episodic back, wrist, shoulder, and neck pain, especially after several hours of intense workload, which was relieved by rest and the use of non-steroidal anti-inflammatory medications (NSAIDs). Infrequently, severe back pain has caused the subject to seek clinic consult and become absent.

Another set of checklists that was utilized to concretely measure symptoms and muscular discomfort were those being advocated by Cornell University[13,14] (Figures 2 to 9, Appendix 4 for Cornell University Musculoskeletal Discomfort Questionnaire). Musculoskeletal discomfort for a standing male was 14.5, and left-hand discomfort was 9.0. As the subject was left-handed with most of the wrist twisting, flexion, and repetitive motions being performed by the left hand, no significant complaints were recorded for the right hand.

Table 1. NIOSH Task Analysis Checklist

	Yes	No
1. Does the design of the primary task reduce or eliminate		
bending or twisting of the back or trunk?	[ ]	[X]
crouching	[ ]	[ ]
bending or twisting the wrist?	[ ]	[X]
extending the arms?	[ ]	[ ]
raised elbows?	[ ]	[X]
static muscle loading?	[ ]	[X]
clothes wringing motions?	[ ]	[ ]
finger pinch grip?	[ ]	[ ]
2. Are mechanical devices used when necessary?	[ ]	[ ]
3. Can the task be done with either hand?	[ ]	[ ]
4. Can the task be done with two hands?	[ ]	[ ]
5. Are pushing or pulling forces kept minimal?	[ ]	[ ]
6. Are required forces judged acceptable by the workers?	[ ]	[ ]
7. Are the materials		
able to be held without slipping?	[ ]	[ ]
easy to grasp?	[ ]	[ ]
free from sharp edges and corners?	[ ]	[ ]
8. Do containers have good handholds?	[ ]	[ ]
9. Are jigs, fixtures, and vises used where needed?	[ ]	[ ]
10. As needed, do gloves fit properly and are they made of the proper fabric?	[ ]	[ ]
11. Does the worker avoid contact with sharp edges when performing the task?	[ ]	[ ]
12. When needed, are push buttons designed properly?	[ ]	[ ]
13. Do the job tasks allow for ready use of personal equipment that may be required?	[ ]	[ ]
14. Are high rates of repetitive motion avoided by		
job rotation?	[ ]	[ ]
self-pacing?	[ ]	[ ]
sufficient pauses?	[ ]	[ ]
adjusting the job skill level of the worker?	[ ]	[ ]
15. Is the employee trained in		
proper work practices?	[ ]	[ ]
when and how to make adjustments?	[ ]	[ ]
recognizing signs and symptoms of potential problems?	[ ]	[ ]

DISCUSSION

Ergonomic Problems Identified

During the process of bronchoscopy, identified factors that can cause pain in the wrists, fingers, and shoulders include repetitive movement and awkward positions of the hands and wrists coming from the need to move the directional controls and position the bronchoscope inside the lungs (Figure 10). Not much high force, manual handling, and direct pressure are involved. For the back, prolonged standing with awkward postures (twisted trunk) is a concern. For the neck, the need to look at the monitor which is situated

Table 2. NIOSH Workstation Checklist

	Yes	No
1. Does the work space allow for full range of movement?	[ ]	[ ]
2. Are mechanical aids and equipment available?	[ ]	[ ]
3. Is the height of the work surface adjustable?	[ ]	[ ]
4. Can the work surface be tilted or angled?	[ ]	[ ]
5. Is the workstation designed to reduce or eliminate		
bending or twisting at the wrist?	[ ]	[X]
reaching above the shoulder?	[ ]	[ ]
static muscle loading?	[ ]	[X]
full extension of the arms?	[ ]	[ ]
raised elbows?	[ ]	[X]
6. Are the workers able to vary posture?	[ ]	[ ]
7. Are the hands and arms free from sharp edges on work surfaces?	[ ]	[ ]
8. Is an armrest provided where needed?	[ ]	[ ]
9. Is a footrest provided where needed?	[ ]	[ ]
10. Is the floor surface free of obstacles and flat?	[ ]	[ ]
11. Are cushioned floor mats provided for employees required to stand for long periods?	[ ]	[ ]
12. Are chairs or stools easily adjustable and suited to the task?	[ ]	[ ]
13. Are all task elements visible from comfortable positions?	[ ]	[ ]
14. Is there a preventive maintenance program for mechanical aids, tools, and other equipment?	[ ]	[ ]

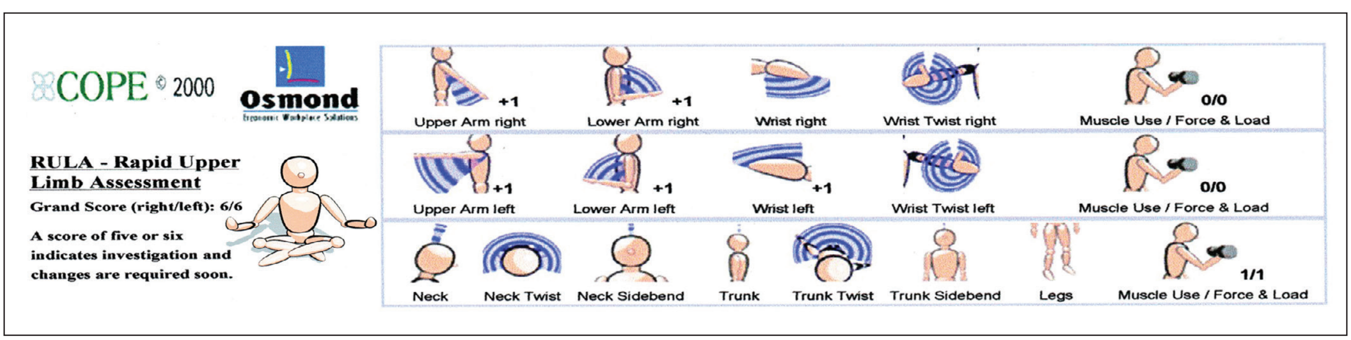
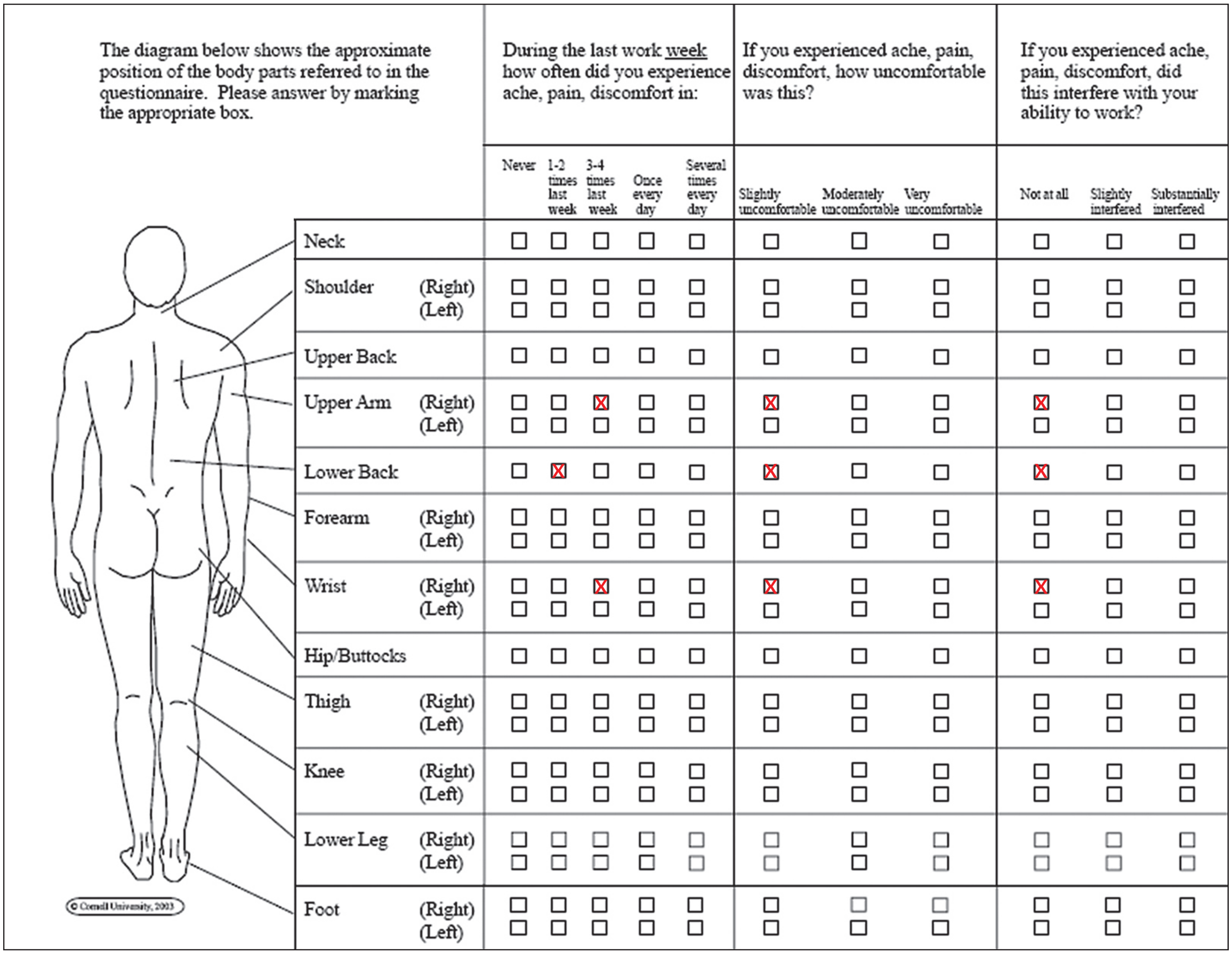


Figure 6. RULA Scoring System.



The diagram below shows the approximate position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.		During the last work week how often did you experience ache, pain, discomfort in:					If you experienced ache, pain, discomfort, how uncomfortable was this?			If you experienced ache, pain, discomfort, did this interfere with your ability to work?		
		Never	1-2 times last week	3-4 times last week	Once every day	Several times every day	Slightly uncomfortable	Moderately uncomfortable	Very uncomfortable	Not at all	Slightly interfered	Substantially interfered
Neck		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Shoulder	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Back		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Upper Arm	(Right)	☐	☐	☒	☐	☐	☒	☐	☐	☒	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Back		☐	☒	☐	☐	☐	☒	☐	☐	☒	☐	☐
Forearm	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Wrist	(Right)	☐	☐	☒	☐	☐	☒	☐	☐	☒	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Hip/Buttocks		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Thigh	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Knee	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Lower Leg	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Foot	(Right)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
	(Left)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 7. Cornell University Musculoskeletal Discomfort Questionnaire (Standing male).

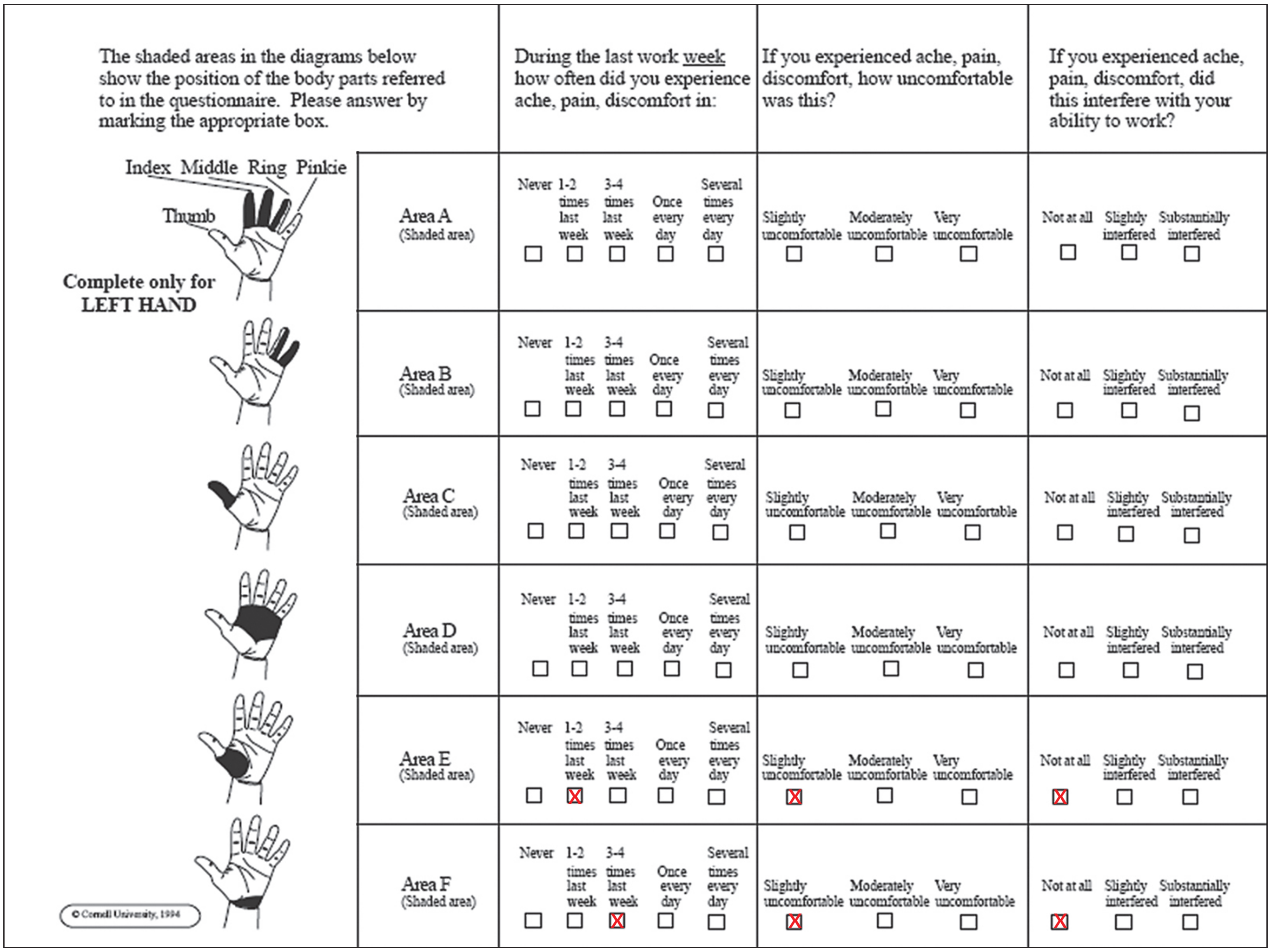
at the side of the patient and frequent shifting of the eyes and head from the monitor to the patient can cause neck pain and stiffness. Aside from the above, other factors would include job stress from the workload, inadequate time for rest and recovery, and the possibility of an uncomfortable environment due to poor air quality – enclosed airconditioned room with no ventilation and limited air circulation, aside from high likelihood of contamination by airborne microorganisms. Also worth mentioning is eye fatigue from the glare of the monitor. At least at the time of evaluation, no psychosocial factor to explain the symptoms could be identified.

In terms of pathophysiology, among the explanations for the development of WMSDs include repetitive microtrauma leading to structural and biochemical changes in the tissues affected by Cumulative Trauma Disorders (CTDs)[15] (Figure 11, see Appendix 2 for operative definition). Chronic exposure and repeated injury are followed by inflammation and repair with fibroblast proliferation, collagen deposition, regeneration, and tissue contraction. These events may lead to pain, swelling, and some loss of motion and strength.[15,16] As for the back, because of the slow and progressive onset of this internal injury, the condition is often ignored until the symptoms become acute, often resulting in disabling injury.[16,17] Injuries can arise in muscle, ligaments, vertebrae, and discs, either singly or in combination.[15-17]

Uncorrected ergonomic issues can lead to low back pain and upper limb repetitive strain disorders such as ligament and tendon disorders, bursitis, myofascial pain, and nerve entrapment disorders.[4,5,15-17] However, more than those ailments, WMSDs can lead to reduced productivity, increased absenteeism, and ultimately to increased company expenses as can be exemplified in the problem tree in Appendix Figure 1 which shows the interrelationships of the different risk factors and their effects.[5]

Control Measures/Interventions

Knowing the potentially debilitating effects of WMSDs, and their effects on productivity and operating expenses,



The shaded areas in the diagrams below show the position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.		During the last work week how often did you experience ache, pain, discomfort in:	If you experienced ache, pain, discomfort, how uncomfortable was this?	If you experienced ache, pain, discomfort, did this interfere with your ability to work?
Index Middle Ring Pinkie Thumb Complete only for LEFT HAND	Area A (Shaded area)	☐ Never ☐ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☐ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☐ Not at all ☐ Slightly interfered ☐ Substantially interfered
	Area B (Shaded area)	☐ Never ☐ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☐ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☐ Not at all ☐ Slightly interfered ☐ Substantially interfered
	Area C (Shaded area)	☐ Never ☐ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☐ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☐ Not at all ☐ Slightly interfered ☐ Substantially interfered
	Area D (Shaded area)	☐ Never ☐ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☐ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☐ Not at all ☐ Slightly interfered ☐ Substantially interfered
	Area E (Shaded area)	☐ Never ☒ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☒ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☒ Not at all ☐ Slightly interfered ☐ Substantially interfered
© Cornell University, 1994	Area F (Shaded area)	☐ Never ☐ 1-2 times last week ☒ 3-4 times last week ☐ Once every day ☐ Several times every day	☒ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☒ Not at all ☐ Slightly interfered ☐ Substantially interfered

Figure 8. Cornell University Musculoskeletal Discomfort Questionnaire (left hand).

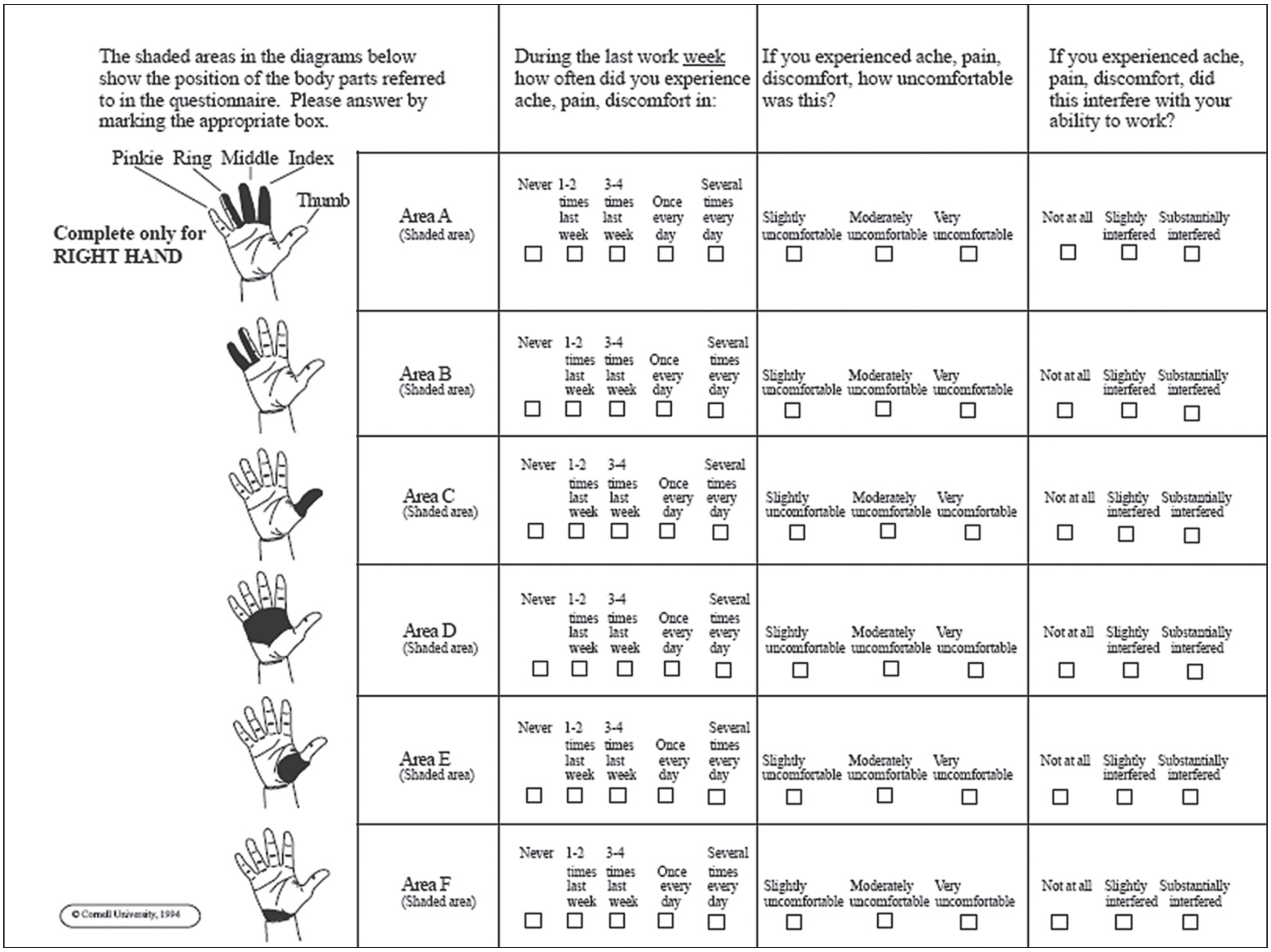
control measures would need to be instituted. Among the basic principles of interventions in ergonomic problems are:

1. ergonomics (re)design: reduce the required static and asymmetric postures, reduce the loads, remove sharp edges, improved tool design and balancers
2. workplace practices: consultation with end-users, work breaks, job rotation, increased manpower, automation, feedback signals, training programs
3. job analysis and measurements: surveillance of hazardous exposures, people at risk, early symptoms

Looking at the process of bronchoscopy, addressing the first principle would mean the purchase of a lighter-weighing bronchoscope, which is not easy to address considering the cost that a new unit costs. Simpler intervention would include the placement of the video monitor directly in front of the bronchoscopist instead of at his side to reduce frequent neck twisting. Another possible solution would be the provision of a semi-sitting or high chair for the bronchoscopist to limit static standing postures.

Administrative control (see Appendix 2 for operative definition) measures or workplace practices that can be done to reduce WMSDs include simplifying work by using efficiency principles - planning, organizing, and balancing work with rest to reduce stress on joints. These include:

- workload planning – planning so that the schedule won't be overbooked and sufficient time is allocated for rest. Patients tend to have less pain when they avoid rushing, simplify tasks, and spread out difficult tasks such as cleaning activities
- organizing tasks – having supplies at easy-to-reach locations (i.e., local anesthesia, syringes), prevents excess strain on joints. Duplicating supplies in different locations avoids excess energy expenditure, and eliminating clutter helps patients avoid awkward positions and save time and energy finding items
- resting – patients should schedule rest breaks during the day. Breaks give patients the opportunity to rest their joints, thereby avoiding pain and inflammation. Alternating heavy and light tasks is another way to take



The shaded areas in the diagrams below show the position of the body parts referred to in the questionnaire. Please answer by marking the appropriate box.		During the last work week how often did you experience ache, pain, discomfort in:	If you experienced ache, pain, discomfort, how uncomfortable was this?	If you experienced ache, pain, discomfort, did this interfere with your ability to work?
Pinkie Ring Middle Index Thumb Complete only for RIGHT HAND	Area A (Shaded area)	☐ Never ☐ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☐ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☐ Not at all ☐ Slightly interfered ☐ Substantially interfered
	Area B (Shaded area)	☐ Never ☐ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☐ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☐ Not at all ☐ Slightly interfered ☐ Substantially interfered
	Area C (Shaded area)	☐ Never ☐ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☐ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☐ Not at all ☐ Slightly interfered ☐ Substantially interfered
	Area D (Shaded area)	☐ Never ☐ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☐ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☐ Not at all ☐ Slightly interfered ☐ Substantially interfered
	Area E (Shaded area)	☐ Never ☐ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☐ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☐ Not at all ☐ Slightly interfered ☐ Substantially interfered
© Cornell University, 1994	Area F (Shaded area)	☐ Never ☐ 1-2 times last week ☐ 3-4 times last week ☐ Once every day ☐ Several times every day	☐ Slightly uncomfortable ☐ Moderately uncomfortable ☐ Very uncomfortable	☐ Not at all ☐ Slightly interfered ☐ Substantially interfered

Figure 9. Cornell University Musculoskeletal Discomfort Questionnaire (right hand).

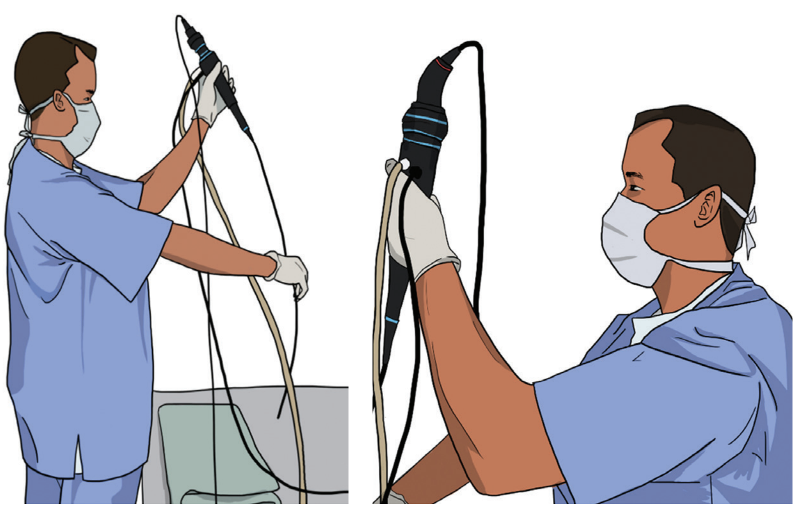


Figure 10. Posture and position on handling a bronchoscope.

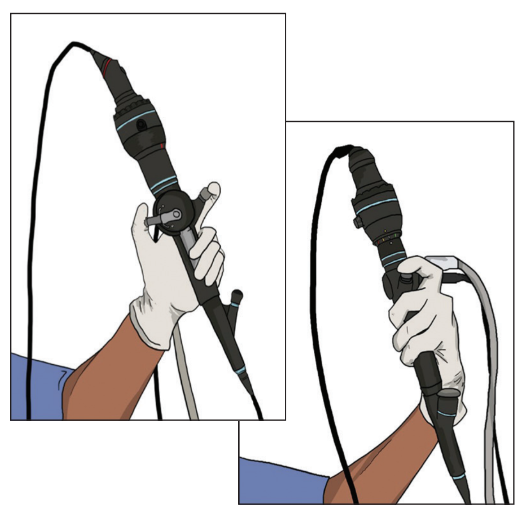


Figure 11. Hand and wrist position when using the bronchoscope.

pressure off joints. Many people alternate sitting and standing activities to put less strain on joints. If work requires prolonged standing in one location, placing a block of wood on the floor (or utilization of a footstool) and stepping on it and alternating feet may reduce strain.

Proper posture is particularly important, and some principles that can be applied are:

- respect pain – learning to respect pain involves attending to it by taking more rest breaks, performing tasks with adapted equipment, and/or otherwise modifying how they carry out activities
- distribute the load – distribute the load over stronger joints and/or larger surface areas.
- Avoid prolonged immobility – avoid maintaining the same joint position for prolonged periods
- Reduce excess body weight – excess weight puts a strain on the body, especially lower extremity joints such as the low back area, hips, knees, and ankles.
- Use good posture and body mechanics – each joint should be used in its most anatomically stable and functional plane. A slumped posture, a rigid military posture, or sustained sitting or standing in a single position without positional shift can contribute to spine discomfort
- Use the minimum necessary force – squeezing and pinching activities put stress on the small joints of the hand. Patients can use less force by consciously holding equipment with less effort, taking rest breaks, and using special equipment.
- Adaptive devices – specially made or adapted devices allow forces to be spread over larger areas and permit joints to operate nearer the mid-range of their motion.

Training on joint protection techniques – joint protection is a process involving individualized assessment of a patient's activities to ascertain the potential of each to contribute to worsening pain, inflammation, instability, and/or deformity of an already abnormal joint. It also involves the creation of a program of behavioral modifications, supplemented if necessary with splints, braces, or other equipment designed to minimize further joint damage. The process of joint protection also includes energy conservation and more efficient use of muscles and joints.

Training should also include general principles of ergonomics, recognition of hazards and injuries, procedures for reporting hazardous conditions, and methods and procedures for early reporting of injuries.

Other interventions would include consultation and evaluation by an occupational therapist and provision of time for warm-up exercises of the upper body, wrists, and hands, regular job analysis, and monitoring of signs and symptoms (medical surveillance).

To minimize handling of bronchoscope during cleaning and disinfecting, it is recommended that a stand or bracket to support the device, and to avoid eye strain, when brakes are taken, the subject should focus on distant objects for a while and likewise eliminate glare by placing an add-on glare screen; adjust the brightness and contrast controls of the monitor; have vision checked regularly.

If WMSDs have already developed, to prevent worsening of the ailment splinting of the elbow, wrist metacarpophalangeal (MCP), and interphalangeal (IP) joints may be beneficial. In particular, prefabricated soft wrist splints increase pinch and grip strength, decrease pain, decrease inflammation and improve the patient's ability to carry out everyday tasks. The most consistent effect of splinting is the reduction of pain. Prefabricated wrist splints are better accepted than hard (plastic or thermoplastic) splints by patients.

CONCLUSION

Although CTDs do not account for work-related deaths, they do account for a significant amount of human suffering, loss of productivity, and economic burden on the compensation system. Thus, it would be pertinent to address ergonomic concerns early on to prevent WMSDs/CTDs.

Limitations of the Study

The study is a single-subject case study and may not lead to generalizable conclusions. In addition, prospective studies with larger populations and longer follow-up periods are needed to establish the long term impact of these bronchoscopic procedures.

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Statement of Authorship

Both authors contributed in the conceptualization of work, acquisition and analysis of data, drafting and revising and approved the final version submitted.

Author Disclosure

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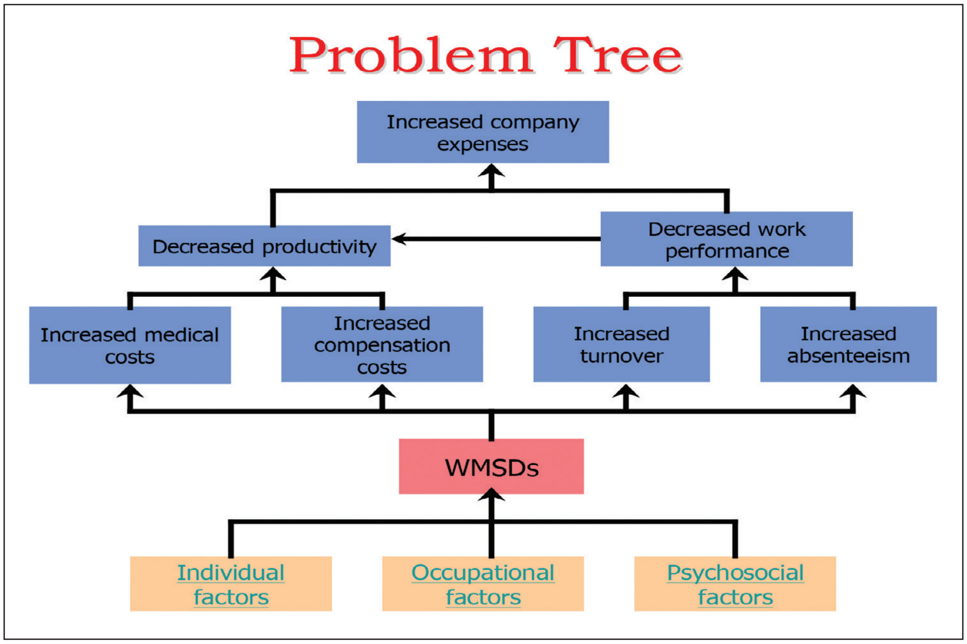
APPENDICES



Appendix Figure 1. Problem Tree.

Appendix 2. Glossary of Terms

Administrative Control: Work practices, work methods, policies and procedures established by the employer with the goal of reducing exposure to a work-related risk / hazard. Ear plugs are an administrative control to reduce the risk of hearing loss. Some administrative controls designed to reduce the risk of WMSDs include: scheduling more rest breaks, job rotation schemes, worker training, etc.

Awkward Posture: Any fixed or constrained body position that overloads muscles, tendons, or joints. Generally, the more a joint deviates from the neutral position the more the posture is considered to be 'awkward' and the greater the risk of injury.

Contact Stress: Exposure of a body part to a hard or sharp surface/edge from a workstation or a hand tool, e.g., leaning forearms against the sharp edge of a desk/table. Contact stress has been associated with the development of some WMSDs.

Cumulative Trauma Disorder (CTD): A term, also referred to as Repetitive Motion Disorders (RMDs) or Repetitive Strain Injuries (RSIs), used to describe work-related injuries to the muscles, tendons, or nerves. Term implies that the injury is the result of a build up of trauma over a period of time which may or may not be the case. WMSDs is the term preferred by Ergonomists.

Cycle: A time interval during which a regularly recurring sequence of events is completed. It an be the time to complete a task with many elements or the time to complete a single operation in a repetitive task.

Ergonomics: Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

Force: Force can either be applied by the body (i.e., through muscular effort) or to the body. When doing 'work' the body uses muscles to generate force to allow for movement of body segments, to resist the 'force' of objects being lifted / carried, or to apply force to an object to move it. When your muscles contract they also generate 'reaction' forces in the body at the joints (e.g., shoulder, vertebrae, etc.). Force can also refer to the amount of force that is applied to the body from an external source. When using a pair of pliers the handles of the pliers press into the palm of the hand. When resting the forearm on the edge of the desk the desk exerts force on the muscles, nerves, and blood vessels in the forearm.

Frequency: Frequency, in ergonomics terms, refers to how often we repeat / do something. The 'units' of interest for frequency will vary depending on the task being looked at. For many repetitive type tasks we are interested in looking at frequency in terms of the number of repetition / actions per minute. In the case of an office worker we may be interested in knowing how many times per hour the worker gets up out of their chair. Or, we may want to know how many times a shift a certain action or task is performed. (See Repetition)

Glare: There are two sorts of glare – discomfort glare and disability glare. The mechanisms of both are unknown, but the conditions under which discomfort glare occurs and the ways in which disability glare can affect performance are well known.

Discomfort glare: When a portion of the visual field has a much higher luminance than its surround, a feeling of discomfort around the eyes and brow may occur. This increases with an increase in the luminance of the glare source, and with an increase in the angular size of the glare source at the eye, and decreases with an increase in the luminance of the background and with an increase in the angular position of the source relative to the line of sight.

Disability glare: An extraneous light source can affect visual performance. The problem with disability glare is that it reduces contrast, causing a washing out – the whole scene looks grey. Like discomfort, the disability glare is often reduced by increasing the light level. Think about a car's headlights on full during the day; there's lots more light, and as a result, the car's headlights are less of a problem.

Hazard: Any condition, situation, physical property or action that may result in illness, injury or other negative outcome. Also, a p potential source of physical injury and/or damage to the health of people or damage to property or the environment.

Job enlargement: Job enlargement is the name given to the process of extending the work cycle by adding related tasks to the job description. An example might be to involve the workers in cleaning, and maintaining their own plant, and perhaps also to obtain their own materials from a central store, thereby doing tasks that were once done by service departments. Like job rotation, job enlargement introduces variety.

Job enrichment: This is the process of providing workers with greater responsibility for their work output. It can be accomplished by perhaps having them do their own QC and making them responsible for basic maintenance. It is also important to recognize achievement and to give due recognition of a job well done.

Job rotation: Job rotation is where workers perform a variety of different, not necessarily related jobs during their work day / shift. A good job rotation scheme will be designed to allow each worker to be exposed to a variety of physical and mental demands during the shift.

Job Satisfaction: A multi-dimensional psychophysical measure that compares a person's opinions about job requirements to individual goals for meaningful work.

NIOSH: The US based National Institute for Occupational Safety and Health. The researchers at NIOSH have developed and revised a well-accepted method for assessing lifting and handling tasks (i.e., the NIOSH Equation).

Posture: The general position of the whole body (e.g., standing, sitting, kneeling) or, more specifically, the position of any body part / joint with respect to adjacent body parts or the joint's full range of motion.

Psychosocial Risk Factors: Various factors can impact a person from both the psychological and social point-of-view. Some of these factors include work organization, job design, shift schedule design, work load, feedback, job stress, co-worker relationships, relationships with supervisors, etc. When one or more of these factors is seen as negative by a person then the person's health and well-being can suffer and the rate of accidents, injuries and other work-related disorders can increase.

Repetition: The number of similar exertions or actions / tasks performed in a specified amount of time. Repetition may be measures in terms of minutes, hours or work day (e.g., 3 per minute, 25 per hour, 30 times per shift). See Frequency

RULA (Rapid Upper Limb Assessment): A procedure to assess the exposure of people to postures, forces and muscle activities known to contribute to upper limb disorders. The RULA technique uses observations of postures adopted by the upper limb, neck, back and legs. Values are recorded by comparison with assessment charts along with values for muscle use and loads. The total scores then indicate if any action is recommended.

Static Exertion: Static exertions refer to physical exertions (gripping, holding a posture) in which the same position or posture is held throughout the exertion (also referred to as "static loading").

Task Analysis: An systematic approach for documenting and assessing the risks associated with a specific task or job. Hierarchical Task Analysis (HTA) involves looking at a job as a series of main or key tasks or objectives and then breaking these key tasks or objectives down into sub-tasks and sub-task actions.

Workplace: The physical area in which a person performs job activities; includes tables or counters, chairs, any controls and displays necessary, the lighting and other environmental factors.

Work Related Musculoskeletal Disorders (WMSDs): Work-related musculoskeletal disorders (also referred to as Repetitive Strain Injuries, Cumulative Trauma Disorders, Musculoskeletal Injuries) affect muscles, tendons, nerves, ligaments, and joints in various parts of the body. WMSDs are, by definition, work related, and many different work factors may contribute to their development. The key physical risk factors are force, posture, repetition and duration. Psychosocial risk factors, such as stress and workload also play a role.

Walk-around: A process of evaluation wherein the investigator interviews the workers, and also observe the worker's postures, lifting techniques, weights of objects carried, determines the frequency and duration of tasks, and measures the dimensions of the workplace.

Appendix 3. Protocol for Rapid Upper Limb Assessment

Rapid Upper Limb Assessment (RULA) is a survey method developed for use in ergonomic investigations of workplaces where work related upper limb disorders are reported. RULA is a screening tool that assesses biomechanical and postural loading on the whole body with particular attention to the neck, trunk and upper limbs. A RULA assessment requires little time to complete and the scoring generates an action list which indicated the level of intervention required to reduce the risks of injury due to physical loading on the operator. RULA is intended to be used as part of a broader ergonomic study.

Step 1 Observing and selecting the posture(s) to assess

A RULA assessment represents a moment in the work cycle and it is important to observe the postures being adopted whilst undertaking the tasks prior to selecting the posture(s) for assessment. Depending upon the type of study, selection may be made of the longest held posture or what appears to be the worst posture(s) adopted. In some instances, for example when the work cycle is long or the postures are varied it may be more appropriate to take an assessment at regular intervals. It will be evident that if assessments are taken at set intervals over the working period the proportion of time spent in the various postures can be evaluated.

Step 2 Scoring and recording the posture

Decide whether the left, right or both upper arms are to be assessed. Score the posture of each body part using the software. Review the scoring and make any adjustments if required.

Step 3 Action Level

The grand score can be compared to the Action Level List however it must be remembered that since the human body is a complex and adaptive system, they provide a guide for further action. In most cases, to ensure this guide is used as an aid in efficient and effective control of any risks identified, the actions lead to a more detailed investigation.

Appendix 4. Protocol for Cornell University Musculoskeletal Discomfort Questionnaire

Scoring Guidelines

These questionnaires are for research screening purposes and not for diagnostic purposes. Scores can be analyzed in 4 ways:

- by simply counting the number of symptoms per person
- by summing the rating values for each person
- by weighting the rating scores to more easily identify the most serious problems as follows:
  Never = 0
  1-2 times/week = 1.5
  3-4 times/week = 3.5
  Every day = 5
  Several times every day = 10
- by multiplying the above Frequency score (0, 1.5, 3.5, 5, 10) by the Discomfort score (1, 2, 3) by the Interference score (1, 2, 3)

In the computational analyses missing values can be coded as 0. If the missing value is for the frequency score then use this as a zero in multiplying, i.e., all combinations of Frequency, Discomfort and Interference become 0. However, if the missing value is in the Discomfort or Frequency score then treat it as missing so that the multiplied score will be at least the value of the Frequency score.