DEPARTMENT OF OCCUPATIONAL SAFETY AND HEALTH
MINISTRY OF HUMAN RESOURCES
MALAYSIA

GUIDELINES
ON ERGONOMICS RISK ASSESSMENT AT WORKPLACE

2017

PREFACE

These guidelines may be cited as the Guidelines on Ergonomics Risk Assessment at Workplace.

The purpose of these guidelines is to provide a systematic plan and an objective approach in identifying, assessing and controlling ergonomics risk factors associated with the work tasks and activities in the workplace.

These guidelines will be of interest to employers, employees, safety and health practitioners to assess the level of ergonomics risk at their workplace in order to implement more effective control measures based on identified risks.

Currently there are many cases of occupational diseases caused by ergonomics risk factors have been reported to DOSH. Indirectly, this will affect labor productivity, profitability and costs of compensation. These guidelines are expected to help the industry to resolve these issues which could reduce cases of occupational diseases.

The Department would like to thank all the committee for their effort and contribution in the preparation of these guidelines.

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2017

ACKNOWLEDGEMENT

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ABBREVIATION

DOSH	Department of Occupational Safety and Health
UPM	Universiti Putra Malaysia
PETRONAS	Petroliam Nasional Berhad
UNIMAP	Universiti Malaysia Perlis
UPNM	Universiti Pertahanan Nasional Malaysia
CUCMS	Cyberjaya University College of Medical Sciences
UKM	Universiti Kebangsaan Malaysia
UTHM	Universiti Tun Hussein Onn Malaysia
NIOSH	National Institute of Occupational Safety and Health
SOCSO	Social Security Organisation
ERA	Ergonomics Risk Assessment
OHD	Occupational Health Doctor
PPE	Personal Protective Equipment
OSHA	Occupational Safety and Health Act
RULA	Rapid Upper Limb Assessment
REBA	Rapid Entire Body Assessment
OWAS	Ovako Working Posture Analysis System
MAC	Manual Handling Assessment Chart
OCRA	Occupational Repetitive Assessment
ROSA	Rapid Office Strain Assessment
MSDs	Musculoskeletal Disorders
WRLLDs	Work Related Lower Limb Disorders
WRULDs	Work Related Upper Limb Disorders
OD	Occupational Disease
WBV	Whole Body Vibration
HAV	Hand Arm Vibration

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1.0 INTRODUCTION

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 (International Ergonomics Association, 2015).

Ergonomics consists of three main domains as shown in **Figure 1.1.** However, these guidelines are only concerned with the physical ergonomics of the workplace. Physical ergonomics is about the human body's responses to physical and physiological work demands. Cumulative trauma disorders from repetition, vibration, force, and posture are the most common types of issues, and thus have design implications.

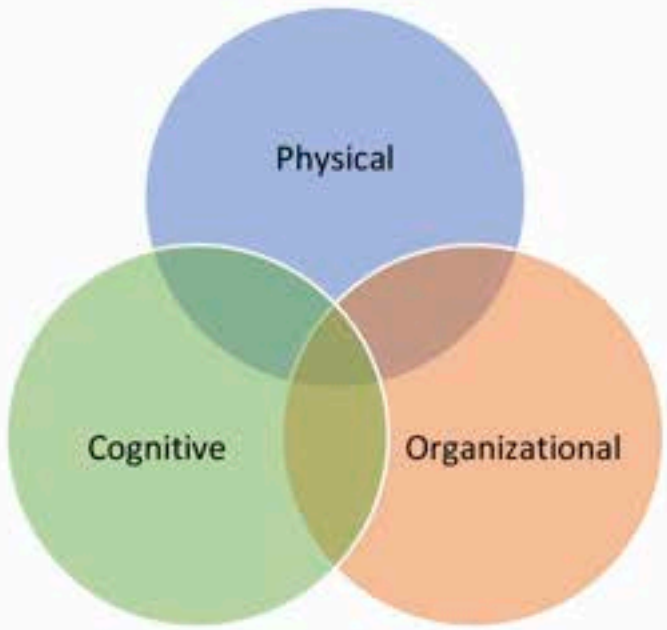

Figure 1.1. Domains in ergonomics

Physical ergonomics is related to the objective of Occupational Safety and Health Act 1994 (OSHA 1994), that is to promote occupational environment for person at work which adapted to their physiological and psychological needs. It shall be a duty of the employer to provide a safe and healthy workplace for their employees and persons other than their employees.

Ergonomics-related disorders have recently emerged as near epidemic trend in the workplace. Based on **Figure 1.2**, Social Security Organization (SOCSO) (2015) has reported an exponentially increasing trend of reported cases. Nevertheless, the trend was postulated to be due to the increase in awareness among Malaysian employers and employees as the reporting rate increases.

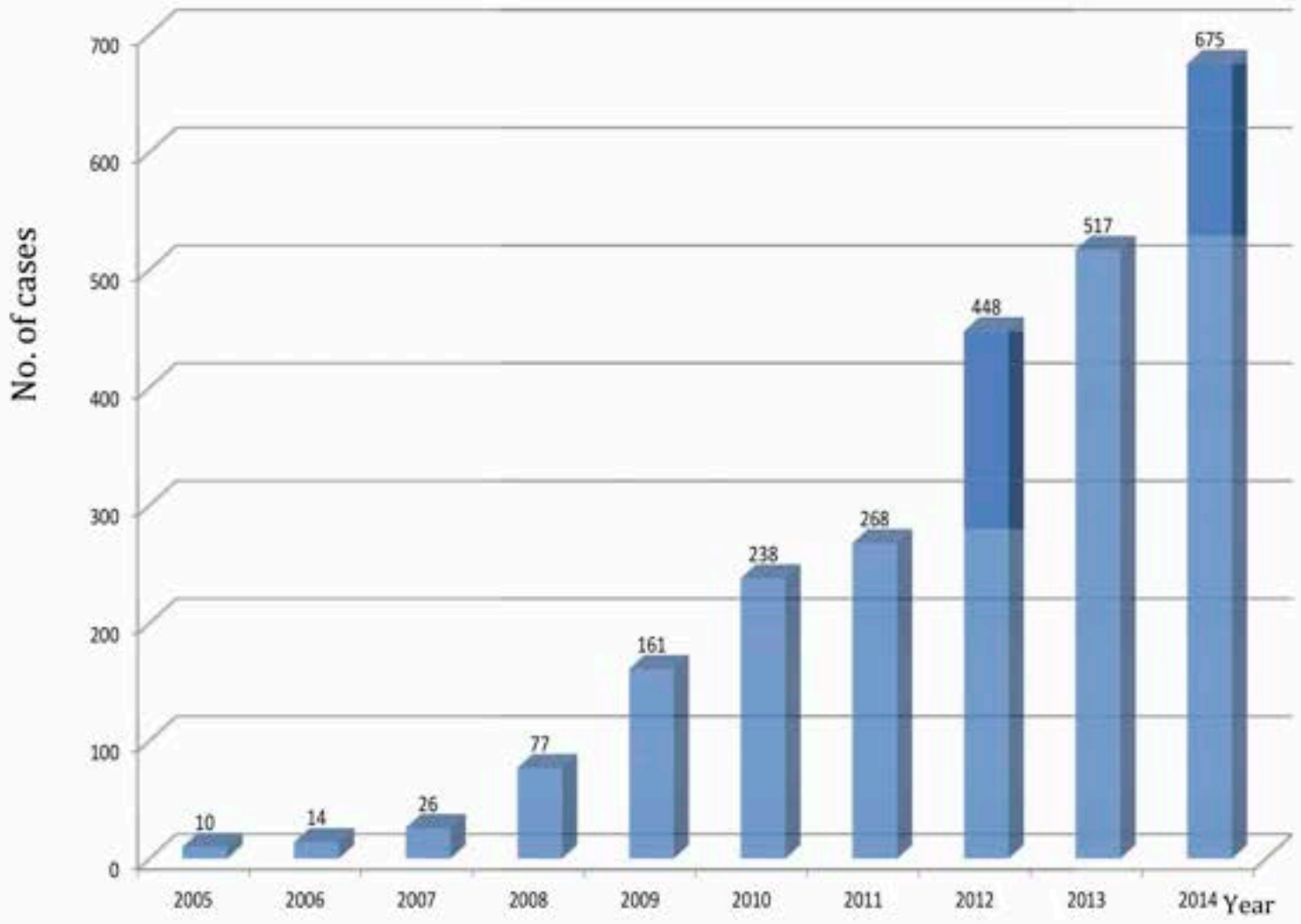

Figure 1.2: Trend of reported musculoskeletal disorders (MSDs) from 2005 – 2014

Based on **Figure 1.3**, SOSCO has reported increasing trend of employees' compensation of occupational diseases (permanent and temporary benefit) from RM2.65 million in 2009 to RM14.05 million in 2014. From the total compensation for occupational diseases, the compensation due to musculoskeletal disorders constitutes a significant portion which was also showing an overall increasing trend from 2009 to 2014.

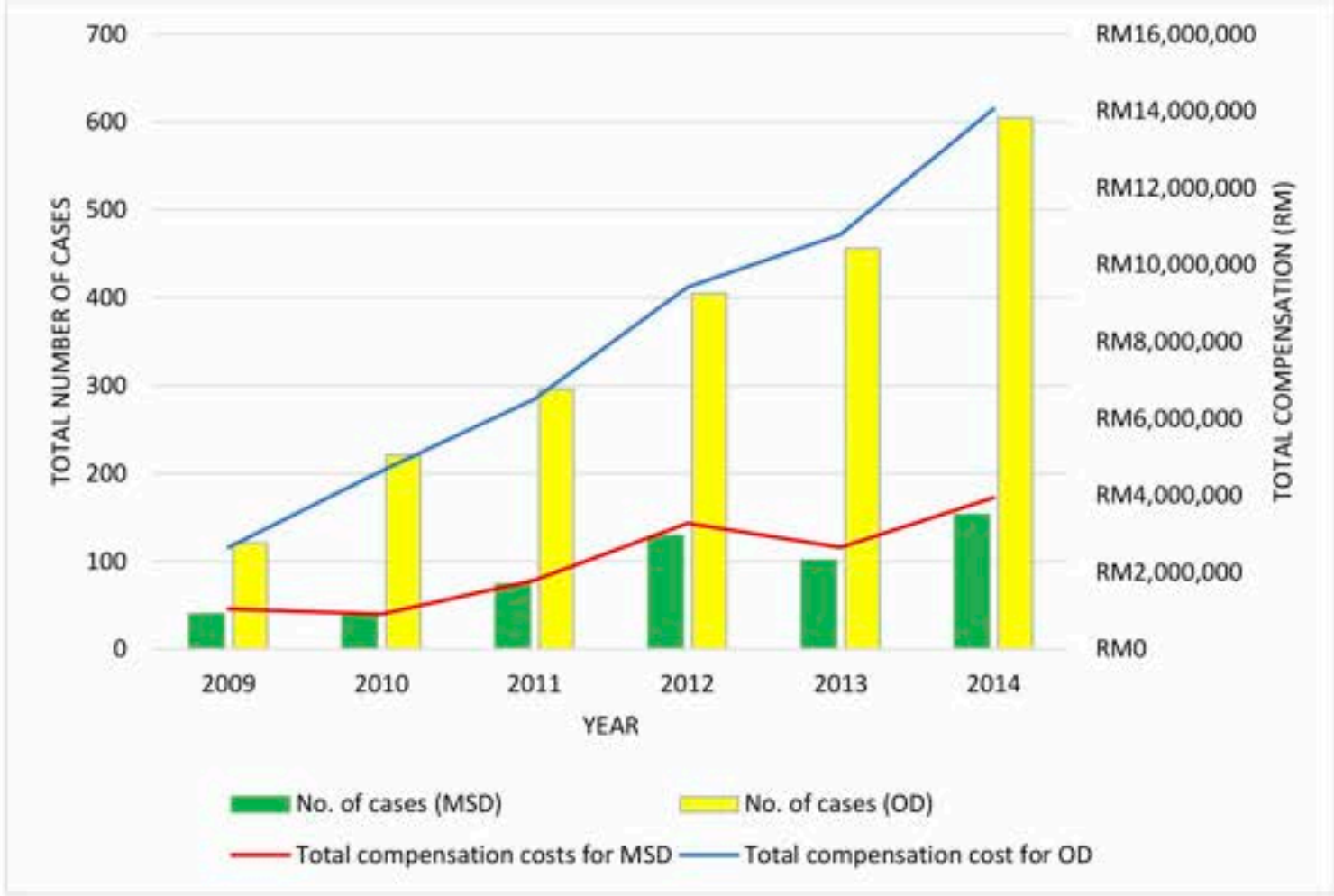

Figure 1.3: Trend of recorded musculoskeletal disorders relative to occupational diseases cases and compensation reported for permanent disability from 2009 – 2014

1.1 Purpose

The purpose of these guidelines is to provide a systematic plan and an objective approach in identifying, assessing and controlling ergonomics risk factors associated with the work tasks and activities in the workplace.

1.2 Objectives and Benefits of Ergonomics Risk Assessment (ERA)

The objectives of conducting ERA are to: -

a) identify most ergonomics risk factors that may cause harm to employees;
b) determine the likelihood of harm arising from exposure to the ergonomics risk factors;
c) recommend appropriate control measures towards risk reduction.

The benefits are: -

a) enable employers to plan, implement and monitor preventive measures;
b) reduction of ergonomics-related injuries and MSDs;
c) reduction of compensation cost, medical expenses and employee absenteeism.

1.3 Scope and Application

These guidelines cover issues related to physical ergonomics in the workplace as stipulated under OSHA 1994. These guidelines may be used by any employer, employee of the organization, and occupational safety and health practitioner.

1.4 Terms and Definition

1.4.1 Ergonomics Risk Factor

An ergonomics risk factor is any attribute, characteristic or exposure that may cause or contribute to a musculoskeletal injury; the mere presence of a risk factor may not in itself result in an injury. In general, two or more risk factors may be present at one time, thereby increasing the risk of injury.

1.4.1.1 Awkward Posture

Awkward posture refers to positions of the body while performing work activities that deviate significantly from the neutral position. Examples of awkward postures are twisting, bending, over-reaching, working with the hands above the head, elbows above the shoulders, working with the neck or back bent more than 30 degrees without support and lack of ability to vary posture.

1.4.1.2 Forceful and Sustained Exertions

Forceful exertion involves the use of high level force while transporting or supporting load, including lifting, lowering, pushing, pulling, carrying and moving a load using hands or through the application of bodily force.

Forceful exertion can also exist in sustained postures which place excessive force on joints and overload the muscles and tendons.

1.4.1.3 Repetitive Motion

Repetitive motion involves repeated movements of the same groups of joints and muscles too frequent, too quickly and over a long duration. A job is considered highly

repetitive if the cycle time is 30 seconds or less. Tasks with repetitive movements usually involve other risk factors such as fixed body position and force.

1.4.1.4 Static and Sustained Posture

Static or sustained posture refers to minimal or restricted or no movement where the body held on to a particular position over a prolonged period. Maintaining a fix posture can leads to fatigue, pain and injuries which give rise to various disorders. Among the most common examples are prolonged standing and sitting.

Prolonged standing refers to any work activities involving standing position for duration more than 2 hours. Prolonged sitting refers to any work activities involving sitting position for duration more than 30 minutes. However, the duration is subjective, and may vary depending on the assessment of the trained person.

1.4.1.5 Vibration

Vibration includes whole-body vibration (WBV) and hand-arm vibration (HAV).

WBV refers to the kinetic energy which is mechanically transmitted through the seat or feet of employees such as driving mobile machines, or other work vehicles, over rough and uneven surfaces.

HAV refers to the exposure of the hands and arm to kinetic energy from vibrating and percussive hand-held power tools.

1.4.1.6 Contact Stress

Contact stress can be internal or external.

Internal contact stress refers to a condition when a tendon, nerve, or blood vessel is stretched or bent around a bone or tendon.

External contact stress refers to a condition when part of the body rubs against a component of the workstation, such as the chair seat pan or edge of the desk.

1.4.1.7 Environmental Risk Factors

Environmental risk factors refer to stressful factors in the environment that affect human comfort, activity and health. This includes thermal environments, illumination, noise, and extreme atmospheric pressure environments.

1.4.2 Ergonomist

An ergonomist is a professional who contributes to the design and evaluation of tasks, jobs, products, environments and systems in order to make them compatible with the needs, abilities and limitations of people (International Ergonomics Association, IEA 2015).

1.4.3 Occupational Health Doctor (OHD)

Occupational Health Doctors are registered medical practitioners (under Medical Act, 1971) with valid Annual Practicing Certificate (APC), who are also registered with Department of Occupational Safety and Health (DOSH) and possess a valid OHD certificate.

1.4.4 Low Back Work-Related Musculoskeletal Disorders

Low back work-related MSDs affect the bones, muscles, ligaments and tendons of the lumbar spine associated with physical work, manual handling and vehicle driving activities, involving lifting, twisting, bending, static postures, prolonged seating and WBV.

Low back work-related MSDs include spinal disc problems, muscle and soft tissue injuries.

1.4.5 Non-Specific Work-Related Lower Limb Musculoskeletal Disorders

The non-specific work related MSDs are musculoskeletal disorders that have less well-defined symptoms, spread over many areas such as nerves, tendons and other anatomical structures. The symptoms involve pain, discomfort, numbness and tingling without evidence of any discrete pathological condition such as bruises and swelling.

1.4.6 Physical Ergonomics

Physical ergonomics is a domain of ergonomics dealing with the anatomy, anthropometry, physiology and biomechanics characteristics associated with physical activity. Some application includes work postures, materials handling, repetitive movements, work related musculoskeletal disorders, workplace layout, workstation design and safety and health (International Ergonomics Association, 2015).

1.4.7 Trained Person

A trained person is someone who has undergone ergonomics risk assessment training and is able to conduct the assessment and/or in-house training for the employees of the organization.

1.4.8 Work-Related Musculoskeletal Disorders

Musculoskeletal Disorders affect human musculoskeletal system (muscles, ligaments, or other soft tissues of the body joints). Affected soft tissues include:

a) Muscles – contractile tissue of the body: skeletal, cardiac/smooth muscles. Function is to produce force and cause motion.

b) Ligaments – connective tissue that joins one bone to another.

c) Tendons – similar to ligaments, but tough fibrous connective tissue that connects muscle to bone.

d) Nerves – conduct sensory information. Spinal nerves connect through spinal column to spinal cord. Cranial nerves connect to brain stem.

e) Spinal disc – also known as intervertebral discs as they are located in between the vertebrae of the spinal bone.

f) Bursa sacs – small sacs filled with synovial fluid, and made of white fibrous tissue. It provides a cushion between bones and tendons and/or muscles around a joint.

Other MSDs terms are Occupational Overuse Syndrome; Repetitive Strain Injury, Repetitive Stress Injury, Repetitive Motion Injuries; Cumulative Trauma Disorders; Upper Limb Disorders, and Upper Extremity Musculoskeletal Disorders.

1.4.9 Work-Related Lower Limb Musculoskeletal Disorders (WRLLDs)

WRLLDs affect the hips, knees and legs due to overuse of muscles and activities such as repetitive kneeling and/or squatting; prolonged standing without a break; frequent jumping from a height.

The most common WRLLDs are:

a) Hip/thigh conditions: osteoarthritis, hamstring strains, joint pain;
b) Knee/lower leg: osteoarthritis, bursitis;
c) Ankle/foot: Achilles tendonitis, foot corns, bunions, plantar fasciitis, sprained ankle;
d) Varicose veins.

1.4.10 Work-Related Upper Limb Musculoskeletal Disorders (WRULDs)

WRULDs affect any region of the neck, shoulders, arms, forearms, wrists and hand. An example of activity which may cause WRULDs is working with hand above the shoulder (over-reaching).

Common WRULDs are:

a) Neck: Tension neck syndrome, cervical spine syndrome;

b) Shoulder: Tendonitis, bursitis, thoracic outlet syndrome;

c) Elbow: Epicondylitis, bursitis, radial tunnel syndrome, cubital tunnel syndrome;

d) Wrist/Hand: De-quervain disease, tenosynovitis, synovial cyst, trigger finger, carpal tunnel syndrome, hand-arm vibration syndrome.

2.0 PLANNING AND CONDUCTING ERGONOMICS RISK ASSESSMENT

An ergonomics risk assessment involves a process from planning, assessing to controlling as illustrated in **Figure 2.1**. This part deals with planning and assessing only.

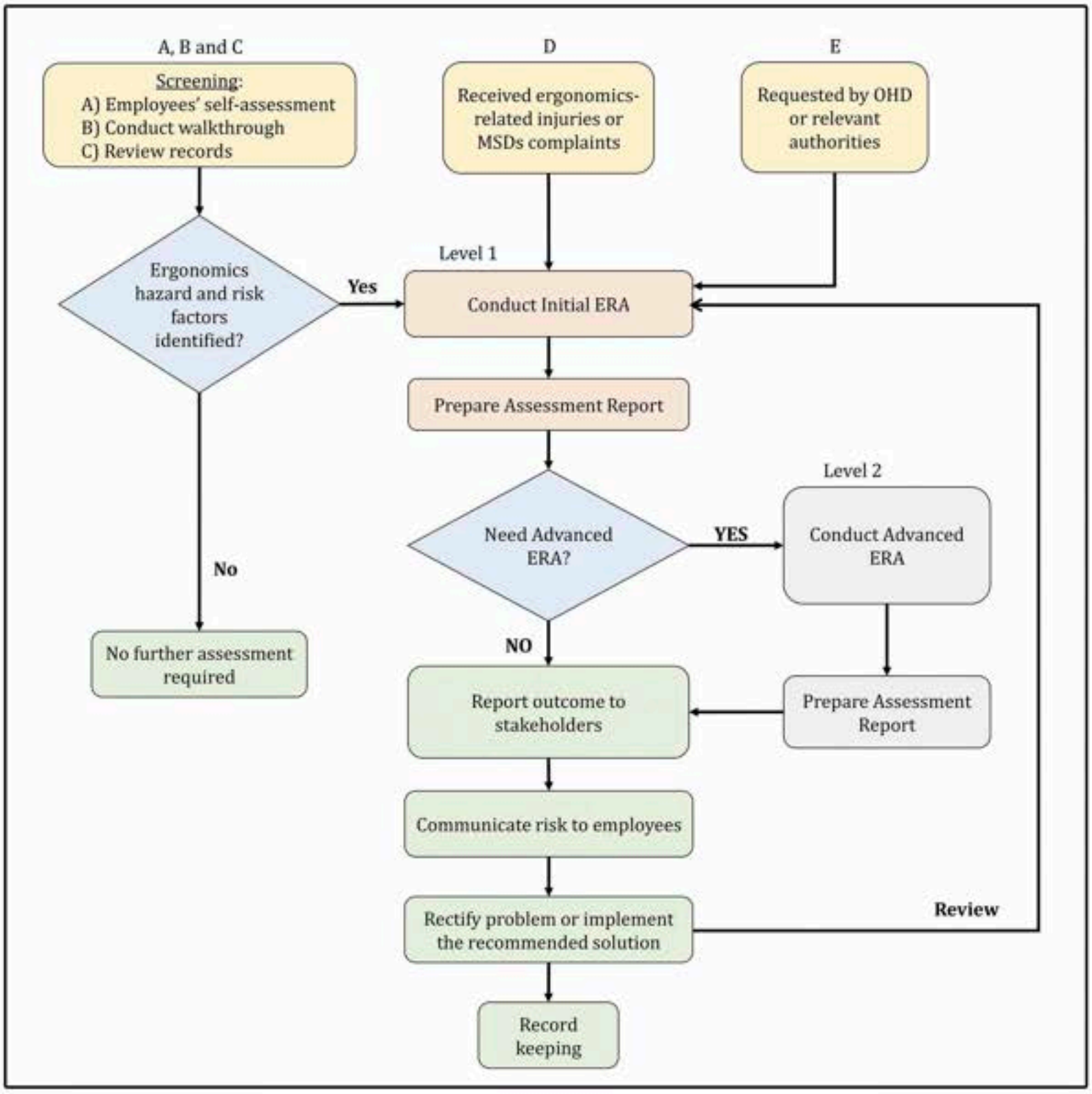

Figure 2.1: Framework for ergonomics risk assessment

2.1 Initiating an ERA

There are two approaches for initiating ergonomics risk assessment: proactive and reactive. Proactive approaches include **A**, **B** and **C** while reactive approaches are **D** and **E**.

A) Self-assessment by the employee – An employee who has previously attended ergonomics awareness training can report to the management, safety and health officer or safety and health committee on any work-related complaint due to ergonomics risk factors. The employee should use a self-assessment form provided by the organization. An example of a self-assessment form is given in **Appendix 1** (Self-Assessment Musculoskeletal Pain/Discomfort Survey Form).

B) Walkthrough inspection by the trained person - A trained person can initiate an ERA by conducting a walkthrough.

C) Review of records – A trained person can initiate ERA based on the general risk assessment conducted such as Hazard Identification, Risk Assessment and Risk Control, Job Safety Analysis or Health Risk Assessment.

In reference to Figure 2.1, the decision for **A**, **B** and **C** is as follow:

An initial ERA is REQUIRED if:

i) there is pain or discomfort identified from the self-assessment form, OR
ii) based on the professional judgment of the trained person that there is probable risk.

An initial ERA is NOT REQUIRED if:

i) there are no pain or discomfort identified from the self-assessment form, OR
ii) based on the professional judgment of the trained person that there is no probable risk.

For the following **D** and **E**, initial ERA will be required:

D) Ergonomics related injury and MSDs complaints – After a trained person has received complaints related to MSD from any of the employees, he/she should initiate an initial ERA.

There should be a formal complaint by the employee related to ergonomics disorders and the conviction that the problem arises from ergonomics risk factors. An example of a complaint form is given in **Appendix 2** (Ergonomics and Musculoskeletal Pain/Discomfort Complaint Form).

E) Request by OHD or relevant authorities – Initial ERA should be initiated upon request by OHD or relevant authorities such as DOSH and SOCSO.

For D and E, an initial ERA should be conducted without the need to assess the claim of ergonomics risk.

To summarize the ergonomics assessment route, three conditions that may initiate an organization to conduct ERA is shown in Figure 2.1.

2.2 Levels of ERA

There are two levels of ERA:

a) Level 1- Initial ERA
b) Level 2- Advanced ERA

A trained person should start the assessment using an initial ERA checklist. The outcome will determine if there is a need to carry out an advanced ERA.

In conducting ERA, a trained person should refer to Part 3: Process for initial ERA and Part 4: Process for advanced ERA.

The trained person should suggest ergonomics solutions to the problem towards improving the work conditions. A trained person should report and present the findings to the stakeholder and subsequently communicate the outcome to the employee concerned.

2.3 Preparing for an Assessment

Preparing for an assessment requires various considerations such as: team formation, instruments, materials and facilities, communication and coordination.

2.3.1 Team Formation

Implementation of ERA requires team work and good coordination. The team should be led by a trained person who is responsible for the overall management of assessment. This is to ensure that the assessment is being conducted in a smooth and systematic manner.

2.3.2 Instruments, Materials and Facilities

Preparation of instruments, materials and facilities are important before conducting an assessment. This includes but not limited to the following:

Table 2.1: Instruments, materials and facilities for conducting ERA

Items	Example
Instruments	Measurement tapes
	Audio video and image capturing tools (i.e.: smartphones, video camera, etc)
	Assessment forms and checklist
	Personal Protective Equipment (PPE)
	Measurement tools that can assist the ergonomics risk assessment such as luxmeter, goniometer, push-pull gauge, hand dynamometer, etc
Materials	Stationeries – paper, pencil, etc.
	Writing board – flip chart, white board, etc.
Facilities	Meeting room
	Drinking water
	Computing equipment – laptop, printer, etc.

2.3.3 Communication and Coordination

Before conducting ERA it is important that the management, supervisor, employee concerned, and any other related parties be informed on the:

a) Objective(s) of assessment;

b) Work unit to be assessed;

c) ERA tools to be used;

d) Duration of assessment.

Confidentiality of assessment should also be discussed when communicating with the management. This is to ensure that the assessment will be conducted with the full cooperation of all parties involved.

2.4 Implementation of ERA

The implementation of ERA should be based on the following considerations:

a) Align with objective(s) of ERA, including determination of risk level, assessment for claim compensation, improvement of work units, and so forth as required by the organization.

b) Communicate and coordinate with the person-in-charge:

   i) Concerning the employee to be assessed;

   ii) Adjustment of work schedule. The trained person needs to arrange time for assessment so that it does not interfere with the work process;

   iii) Retrieval of documents such as accidents and injuries reports, critical incidents, medical records, standard operation procedure and company work process. If documents are unavailable during the assessment, trained person should retrieve the related documents after the assessment.

c) Conduct walkthrough inspection by trained person to obtain information such as:

   i) Work posture and work activities

   ii) Work environment

   iii) Existing ergonomics control measures

2.4.1 Duration of Assessment

The duration of conducting an ERA should consider the following:

a) Objective(s) of the assessment.

b) Number of employees to be assessed.

c) Complexity of work process. A simple work process can be assessed in 1-2 hours. If work cycle can be represented by a single work activity, the trained person can sample the work to represent the overall work cycle. If the employee has to

perform multiple tasks, the trained person should assess all tasks and determine the task to be prioritized.

d) Scope of assessment such as specific work area (i.e.: warehouse, production, and storeroom).

2.4.2 Closure of Assessment

There must be a closure to each assessment. A closure meeting should be conducted after the assessment. This includes a summary of the assessment. The findings and recommendation need not be presented during the closure meeting to allow further analysis of the results.

3.0 PART 3: PROCESS FOR INITIAL ERA

The process for conducting initial ERA is as follows:

3.1 Musculoskeletal Assessment

This musculoskeletal assessment should be conducted for all types of risk factor in order to identify and validate the affected body parts.

In addition, a trained person may investigate any other complaint from the employee concerned. For the musculoskeletal assessment, the trained person may use any available forms such as Nordic Musculoskeletal Questionnaire, Dutch Musculoskeletal Questionnaire, Cornell Musculoskeletal Questionnaire, etc.

An example of musculoskeletal assessment forms (Cornell Musculoskeletal Questionnaire) is as given in **Appendix 3**.

3.2 Ergonomics Risk Factors Assessment

The assessment depends on the types of ergonomics risk factors identified. The exposure duration of each work posture may differ depending on the professional judgment of the trained person. A summary or consolidated checklist of Initial ERA is as provided in Appendix 6.

3.2.1 Awkward Posture

The work posture of the employees should be observed using the checklist as given in **Table 3.1**, and documented using audio visual and image capturing devices from various perspectives such as from the front, back and sides.

Table 3.1: Checklist for awkward posture

Body Part	Physical Risk Factor	Maximum Exposure Duration (continuously or cumulatively)	Illustration	Please tick (/)	
				Yes	No
Shoulders	Working with hand above the head OR the elbow above the shoulder	More than 2 hours per day			
	Working with shoulder raised	More than 2 hours per day			
	Work repetitively by raising the hand above the head OR the elbow above the shoulder more than once per minute	More than 2 hours per day			
Head	Working with head bent downwards more than 45 degrees	More than 2 hours per day			

Body Part	Physical Risk Factor	Maximum Exposure Duration (continuously or cumulatively)	Illustration	Please tick (/)	
				Yes	No
	Working with head bent backwards	More than 2 hours per day			
	Working with head bent sideways	More than 2 hours per day	 		
Back	Working with back bent forward more than 30 degrees OR bent sideways	More than 2 hours per day			
	Working with body twisted	More than 2 hours per day			

Body Part	Physical Risk Factor	Maximum Exposure Duration (continuously or cumulatively)	Illustration	Please tick (/)	
				Yes	No
Hand/ Elbow/ Wrist	Working with wrist flexion OR extension OR radial deviation more than 15 degrees	More than 2 hours per day			
	Working with arm abducted sideways	More than 4 hours per day			
	Working with arm extended forward more than 45 degrees OR arm extended backward more than 20 degrees.	More than 2 hours per day	 		

Body Part	Physical Risk Factor	Maximum Exposure Duration (continuously or cumulatively)	Illustration	Please tick (/)	
				Yes	No
Leg/ Knees	Work in a squat position.	More than 2 hours per day			
	Work in a kneeling position	More than 2 hours per day			
Sub Total (Number of tick(s))					

The total score for awkward posture is **13**. **YES** score of **6** and above will initiate an advanced assessment.

3.2.2 Static and Sustained Work Posture

Static and sustained work posture should be assessed through interview and observation of employee work activities to determine exposure duration for each body parts using the checklist given in Table 3.2.

Table 3.2: Checklist for static and sustained work posture

Body Part	Physical Risk Factor	Maximum Exposure Duration	Illustration	Please tick (/)	
				Yes	No
Trunk/Head/ Neck/Arm/ Wrist	Work in a static awkward position as in Table 3.1	Duration as per Table 3.1			
Leg/Knees	Work in a standing position with minimal leg movement.	More than 2 hours continuously			
	Work in seated position with minimal movement.	More than 30 minutes continuously			
Sub Total (Number of tick(s))					

The total score for static and sustained work posture is **3**. **YES** score of **1** and above will initiate an advanced assessment.

3.2.3 Forceful Exertion

The assessment of forceful exertion should consider the weight of materials or force relative to the types of activities or the manual handling task. The following information should be gathered:

i) gender
ii) height of hand
iii) carrying distance
iv) lifting/lowering distance
v) frequency of forceful exertion
vi) obstruction along the pathway
vii) lighting, vibration
viii) physiological and psychological requirements

3.2.3.1 Lifting and Lowering

For lifting and/or lowering operation, the recommended weight is shown in **Figure 3.1**. Use **Table 3.3** to assist the assessment.

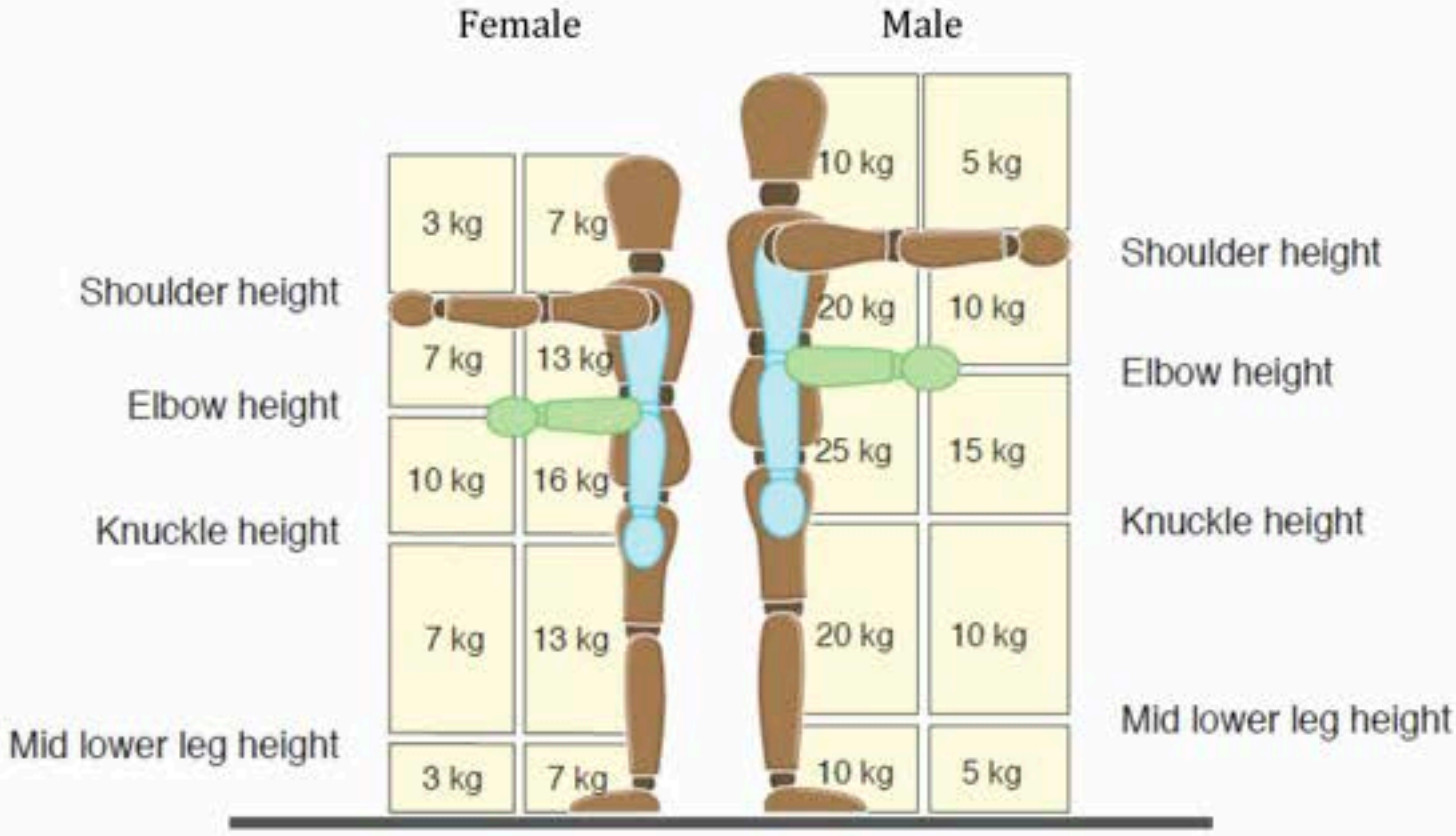

Figure 3.1: Recommended weight

Note: If the lifter's hands enter more than one box during the operation, then the smallest weight figure applies. An intermediate weight can be chosen if the hands are close to a boundary between boxes.

Table 3.3: Recommended weight limit for lifting and/or lowering

Working Height (where force is applied)	Recommended weight limit (male or female)	Current weight handled	Exceed limit?	
			Yes	No
Between floor to mid-lower leg				
Between mid-lower leg to knuckle				
Between knuckle height and elbow				
Between elbow and shoulder				
Above the shoulder				

Guide to use Table 3.3

Step 1: Determine the gender of the employee.
Step 2: Determine the working height of the employee.
Step 3: Determine the proximity of the handling during forceful exertion (further away or close to the body).
Step 4: Key in the recommended weight based on Figure 3.1.
Step 5: Determine the current weight handled.
Step 6: Compare if the limit is exceeded based on the current weight handled.

3.2.3.2 Repetitive Lifting and Lowering

If the manual handling task involve repetitive lifting and/or lowering, reduce the recommended weight limit as shown in **Table 3.4** with reference to **Figure 3.1**.

Table 3.4: Recommended weight limit for lifting and/or lowering with repetitive operation

If employee repeats operations	Weight limit * should be reduced by
Once or twice per minutes	30%
Five to eight times per minute	50%
More than 12 times per minute	80%

* weight limit based on the Figure 3.1

Example:

A male employee is carrying a weight between knuckle and elbow height close to his body. Based on **Figure 3.1,** the recommended weight limit is 25 kg. After observing the employee's frequency of lifting per minute, it was found that the average lifting frequency was between 7 to 8 times per minute. Therefore, the recommended weight

limit is up to 12.5 kg only. If the employee was found to carry more than recommended weight limit the trained person should recommend an advanced ERA.

3.2.3.3 Lifting and Lowering with Twisted Body Posture

If the manual handling task involve lifting and/or lowering with twisted body posture (if applicable), reduce the recommended weight limit as shown in **Table 3.5**, with reference to **Figure 3.1**.

Table 3.5: Recommended weight limit for lifting and/or lowering with twisted body posture

If employee twists body from forward facing to the side	Weight limit * should be reduced by
45 degrees	10%
90 degrees	20%

*weight limit based on the Figure 3.1

Example:

A male employee is carrying a weight between knuckle and elbow height close to his body. Based on **Figure 3.1,** the recommended weight limit is 25 kg.

The employee needs to twist his body to the right side in order to place the weight on a shelf above. Based on observation, it was found that the degree of twisting was approximately 45 degrees. Thus, the recommended weight limit is 22.5 kg.

In addition, the employee was also observed to lift on average 5 to 8 times per minute, thus the recommended weight limit is 10 kg. If the employee was found to carry more than recommended weight limit the trained person should recommend an advanced ERA.

3.2.3.4 Pushing and Pulling

For activities involving pushing and/or pulling, the guidelines addressed in **Table 3.6** is applied with the following considerations:

a) Force is applied with the hands;

b) Hands are between knuckle and shoulder height;

c) Distance for pushing or pulling is less than 20 m;

d) Load is being supported on wheels;

e) Pulling or pushing is using a well maintained handling aid, that is, the wheels are properly aligned and in good condition.

If any of the above conditions (item (a) through (e)) are not met, advanced ERA is recommended for the pushing and/or pulling tasks.

Table 3.6: Recommended load weight based on type of activity for pushing and/or pulling

Activity	Recommended weight	
	Male	Female
Stopping or starting a load	approximately 1000kg load (equivalent to 200N pushing or pulling force) on smooth level surface using well maintained handling aid	approximately 750kg load (equivalent to 150N pushing or pulling force) on smooth level surface using well maintained handling aid
Keeping the load in motion	approximately 100kg load (equivalent to 100N pushing or pulling force) on uneven level surface using well-maintained handling aid	approximately 70kg load (equivalent to 70N pushing or pulling force) on uneven level surface using well-maintained handling aid

As a rough guide, the amount of force that needs to be applied in order to move a load over a flat, level surface using a well-maintained handling aid is at least 2% of the load weight. On an uneven surface or when there is a high slope and/or a ramp, it is recommended that the force required or load weight could be reduced by 10%.

3.2.3.5 Handling in Seated Position

For handling of load in a seated position, an advanced ERA should be performed when:

a) The load is beyond the recommended weight limit for male or female OR

b) The load is beyond the 'box zone' as indicated in **Figure 3.2**.

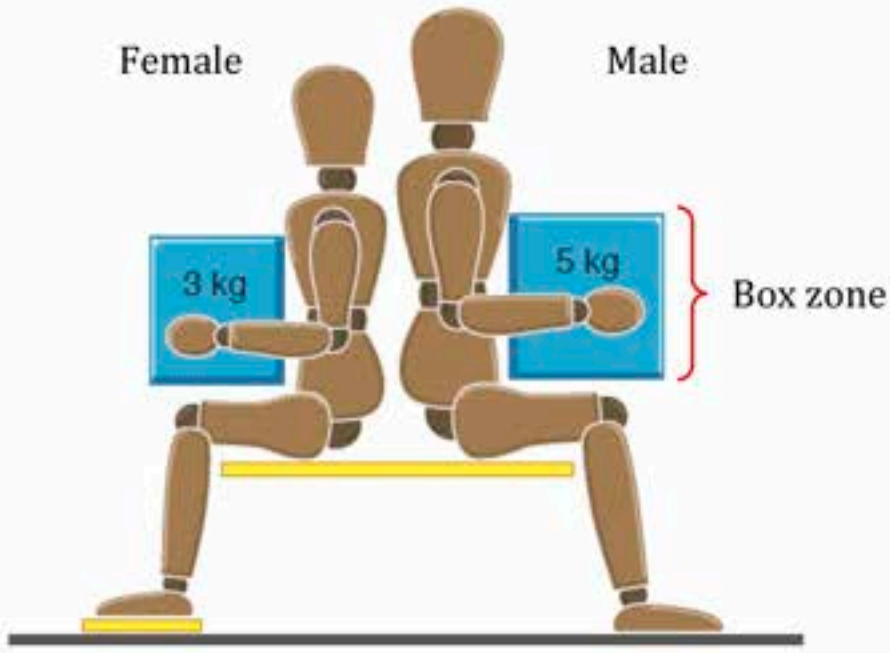

Figure 3.2: Recommended weight for seated position

3.2.3.6 Carrying

When the task involves carrying load following lifting, several factors must be considered as follow:

a) Floor surface

i) The floor surface is dry but in poor condition, worn or uneven

ii) Contaminated/wet or steep sloping floor or unstable surface or unsuitable footwear

b) Environmental factor

Observe the work environment and score if the carrying operation takes place: in extremes of temperature; with strong air movements; or in extreme lighting conditions (dark, bright or poor contrast).

c) Carry distance

Observe the task and estimate the total distance that the load is carried. An acceptable distance should be within 2 to 10 meters. More than 10 meters considered as exceeding the limit.

d) Obstacles en route

Observe the route. If the operator has to carry a load up a steep slope, up steps, through closed doors or around tripping hazards, or if the task involves carrying the load up ladders or if the task involves more than one of the risk factors (eg a steep slope and then up ladders), an advanced ERA should be conducted.

Summary for carrying activities is shown in **Table 3.7.**

Table 3.7: Summary for carrying activity

Factor	Condition	Outcome
Floor Surface	Dry and clean floor in good condition	Acceptable
	Dry floor but in poor condition, worn or uneven	Conduct advanced ERA
	Contaminated/wet or steep sloping floor or unstable surface or unsuitable footwear	
Other environmental factors	No factors present	Acceptable
	One or more factor present (i.e. poor lighting condition, extreme temperature)	Conduct advanced ERA
Carry distance	2 m—10 m	Acceptable
	More than 10 m	Conduct advanced ERA
Obstacles en route	No obstacles and carry route is flat	Acceptable
	Steep slope or up steps or through closed doors or trip hazards or using ladders	Conduct advanced ERA

An advanced ERA for manual handling activity with carrying operation should be conducted if the outcome from any of the factor above is not acceptable.

3.2.3.7 Summary of manual handling activity (forceful exertion)

Table 3.8: Summary table for a single manual handling activity (forceful exertion)

Activity (where applicable)	Recommended weight limit	Exceed limit?	
		Yes	No
Lifting and lowering only; or	based on Figure 3.1 and Table 3.3		
Repetitive lifting and lowering; or	based on Figure 3.1 and Table 3.4		
Twisted body posture while lifting and lowering; or	based on Figure 3.1 and Table 3.5		
Repetitive lifting and lowering with twisted body posture; or	based on Figure 3.1, Table 3.4 and Table 3.5		
Pushing and pulling; or	based on Table 3.6		
Handling in seated position; or	based on Figure 3.2		
Carrying	based on Table 3.7		

Forceful exertion in any of the manual handling activities in **Table 3.8** with a **YES,** score of **1** requires an advanced assessment.

3.2.4 Repetitive Motion

For analysis of repetitive motion, a trained person should use the checklist as shown in **Table 3.9.**

Table 3.9: Checklist for repetitive motion

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)	
			Yes	No
Neck, shoulders, elbows, wrists, hands, knee	Work involving repetitive sequence of movement more than twice per minute	More than 3 hours on a "normal" workday OR More than 1 hour continuously without a break		
	Work involving intensive use of the fingers, hands or wrist or work involving intensive data entry (key-in)			
	Work involving repetitive shoulder/arm movement with some pauses OR continuous shoulder/arm movement			
	Work using the heel/base of palm as a "hammer" more than once per minute	More than 2 hours per day		
	Work using the knee as a "hammer" more than once per minute.	More than 2 hours per day		
Sub Total (Number of tick(s))				

The total score for repetition is **5**. **YES** score of **1** and above will initiate an advanced assessment.

3.2.5 Hands-Arm and Whole Body Vibration

For analysis of work involving hands-arm and/or whole body vibration, a trained person should use the checklist as given in **Table 3.10**.

Table 3.10: Checklist for vibration

Body parts	Physical Risk Factor	Maximum Exposure Duration	Please tick (/)	
			Yes	No
Hand-Arm (segmental vibration)	Work using power tools (ie: battery powered/electrical pneumatic/hydraulic) without PPE*	More than 50 minutes in an hour		
	Work using power tools (ie: battery powered/electrical pneumatic/hydraulic) with PPE*	More than 5 hours in 8 hours shift work		
Whole body vibration	Work involving exposure to whole body vibration	More than 5 hours in 8 hours shift work		
	Work involving exposure to whole body vibration combined employee complaint of excessive body shaking	More than 3 hours in 8 hours shift work		
Sub Total (Number of tick(s))				

*PPE related with protection to vibration

The total score for vibration is **4**. **YES** score of **1** and above will initiate an advanced assessment.

3.2.6 Environmental Risk Factors

For analysis of environmental risk factors in the work area a trained person should evaluate using methods such as:

a) interview
b) observation
c) measurement using equipment for a real time assessment.

The trained person should make a professional judgement based on methods above.

For advanced ERA of the work environment, a trained person should refer to applicable Regulations, Industrial Code of Practice, Standard and Guidelines.

3.2.6.1 Lighting

Lighting intensity should consider the following:

a) Type of activity, including general work and precise work, industrial or office;
b) Type of lighting – natural and/or artificial.

It is recommended to use real time measurement using a lux meter. However, if the equipment is not available, based on his observation or feedback from employee, a trained person should decide the adequacy of the lighting and record the findings in **Table 3.11.**

Table 3.11: Checklist for lighting

Physical Risk Factor	Please tick (/)	
	Yes	No
Inadequate lighting		

Any evidence of inadequate lighting in the workplace **(YES, score = 1)** requires an advanced assessment. (refer to Table 4.1)

3.2.6.2 Extreme Temperature

In assessing extreme temperature, a trained person should consider hot or cold condition.

For heat stress, trained person should refer to DOSH Guidelines on Heat Stress Management at Workplace, 2016. It is recommended to use a heat stress meter to assess the temperature.

However, if measurement tool is not available, based on his observation or feedback from employee, a trained person should decide whether an employee is exposed to the

extreme temperature and record the findings in **Table 3.12.** Factors to consider include: increase/decrease of sweat rate, hyper/hypoventilation, and increase/decrease of heart rate.

Table 3.12: Checklist for extreme temperature

Physical Risk Factor	Please tick (/)	
	Yes	No
Extreme temperature (hot/cold)		

Any evidence of extreme temperature in the workplace **(YES, score = 1)** requires an advanced assessment. (refer to Table 4.1)

3.2.6.3 Ventilation

For assessment of adequate ventilation, refer to the previous record on ventilation assessment of the workplace if available.

It is recommended that a trained person use an appropriate equipment to assess the ventilation. However, if the equipment is not available, based on his observation or feedback from employee, a trained person should decide the adequacy of air ventilation and record the findings in **Table 3.13**. Factors to consider include: symptoms related to respiratory, odor, irritation of nose, throat or eyes.

Table 3.13: Checklist for air ventilation

Physical Risk Factor	Please tick (/)	
	Yes	No
Inadequate air ventilation		

Any evidence of air ventilation in the workplace **(YES, score = 1)** requires an advanced assessment. (refer to Table 4.1)

3.2.6.4 Noise

For assessment of noise at the workplace refer to previous record on noise monitoring that is conducted based on the legal requirements under Factory and Machinery (Noise Exposure) Regulations 1989.

It is recommended that a trained person use a sound level meter to assess the noise level. However, if the equipment is not available, based on his observation or feedback from employee, a trained person should decide whether an employee expose to

excessive noise and record the findings in **Table 3.14**. Factors to consider include: difficulty in holding conversation and temporary ear ringing.

Table 3.14: Checklist for noise

Physical Risk Factor	Please tick	
	Yes	No
Noise exposure above Permissible Exposure Limit (PEL) (based on previous reports or measurement)		
Exposed to annoying or excessive noise during working hours		

The total score for noise is **2**. **YES** score of **1** and above will initiate an advanced assessment. (refer to Table 4.1)

3.3 Result of Initial ERA

Initial ERA should be scored based on each factor observed and analyzed. The assessment score outcome is summarized in **Table 3.15**.

Table 3.15: Initial ERA form

<table>
<tr><th>Risk factors</th><th>Total Score</th><th>Minimum requirement for advanced assessment</th><th>Result of Initial ERA</th><th>Any Pain or Discomfort due to risk factors as found in Musculoskeletal Assessment (refer Part 3.1) (Yes/No)</th><th>Need Advanced ERA? (Yes/No)</th></tr>
<tr><td>Awkward Postures</td><td>13</td><td>≥ 6</td><td></td><td rowspan="10">YES / NO

If YES, please tick (√) which part of the body
<table><tr><td>Neck</td><td></td></tr><tr><td>Shoulder</td><td></td></tr><tr><td>Upper back</td><td></td></tr><tr><td>Upper arm</td><td></td></tr><tr><td>Lower back</td><td></td></tr><tr><td>Forearm</td><td></td></tr><tr><td>Wrist</td><td></td></tr><tr><td>Hand</td><td></td></tr><tr><td>Hip/buttocks</td><td></td></tr><tr><td>Thigh</td><td></td></tr><tr><td>Knee</td><td></td></tr><tr><td>Lower leg</td><td></td></tr><tr><td>Feet</td><td></td></tr></table></td><td></td></tr>
<tr><td>Static and Sustained Work Posture</td><td>3</td><td>≥ 1</td><td></td><td></td></tr>
<tr><td>Forceful Exertion</td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td>Repetitive Motion</td><td>5</td><td>≥ 1</td><td></td><td></td></tr>
<tr><td>Vibration</td><td>4</td><td>≥ 1</td><td></td><td></td></tr>
<tr><td>Lighting</td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td>Temperature</td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td>Ventilation</td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td>Noise</td><td>2</td><td>≥ 1</td><td></td><td></td></tr>
</table>

4.0 PROCESS FOR ADVANCED ERA

This Part describes the process for undertaking an advanced ERA. The results from an initial ERA should enable a trained person to focus on the specific workplace that has been identified as having significant ergonomics risk factors. The process is summarized in **Figure 4.1**.

Figure 4.1: Flow diagram for advanced ERA

4.1 Step 1: Review of Initial ERA and Adequacy of Existing Control Measures

Obtain a summary of finding from initial ERA. Identify the control measures implemented and assess if the existing control measure are adequate. This information should be included in advanced ERA report.

If additional information is required, go to Step 2. If information is sufficient, proceed to Step 3.

4.2 Step 2: Gathering of Additional Information

Obtain further information for advanced ERA, such as:

a) History of MSDs,
b) Origin of problem - work-related or non-work-related,
c) Relevant documents relating to work instructions;
d) Clinical/medical records.

The above information should be included in the advanced ERA report.

Example of the additional information form as in the **Appendix 4** will be useful to assist the assessment team. This form includes demographic information such as name, age, gender, Body Mass Index (BMI), type of hobbies including outside activities. Non-occupational information such as previous injury due to accidents, congenital anomalies related to musculoskeletal disorders, pregnancy, medication taken, current and previous diseases that have been verified by medical practitioner. All this information is vital in eliminating non-ergonomics risk factors that can confound ergonomics related disorders during assessment.

4.3 Step 3a: Ergonomics Risk Level Assessment

A trained person should use **Table 4.1** to select the appropriate method for the specific risk factor. Details of selected assessment tools* are given in **Appendix 5**.

Table 4.1: Method for assessing ergonomics risk factor

Risk Factor	Assessment Methods
Posture	i) Rapid Upper Limb Assessment (RULA)* ii) Rapid Entire Body Assessment (REBA) iii) Ovako Working Posture Analysis System (OWAS) iv) Biomechanics Analysis v) Etc
Forceful Exertion	i) Manual Handling Assessment Chart (MAC)* ii) Borg Scale iii) Liberty Mutual Manual Material Handling Tables (Snook Table) iv) Revised NIOSH Lifting Equation v) Etc
Repetitive Motion	i) Assessment of Repetitive Tasks (ART) ii) Occupational Repetitive Action (OCRA) Checklist* iii) OCRA Index iv) Etc
Workstation design	i) Rapid Office Strain Assessment (ROSA)* ii) Anthropometry Analysis iii) Etc

Risk Factor	Assessment Methods
Environmental	i) Comply to applicable Regulations, Industrial Code of Practice Standard and Guidelines ii) Use designated specific measurement instruments

Note: (*) Refer to selected assessment tools in Appendix 5

4.4 Step 3b: Workstation Configuration Assessment

If in the opinion of the trained person that the ergonomics problems are due to the workstation arrangement, workstation configuration assessment should be carried out. The assessment can be carried out concurrently or separately from the methods listed in Table 4.1 with the aim to help reconfigure an improved workstation.

The improvements must focus on the relationship between the employee and the tasks to be performed at the workstation, the equipment being used and the physical arrangement of workspace. Preferably, the assessment should be conducted with an ergonomist or human factors consultant.

If reconfiguration of a workstation is required, trained person should consult the outcome of advanced ERA with the expert.

4.5 Step 4: Summarize the Findings

Summarize the findings of advanced ERA. In the case of multiple risk factors, the results should be summarized together in order to determine the appropriate control measures. Examples of summary are shown in **Table 4.2** and **Table 4.3**.

Table 4.2: Example of an advanced ERA of lifting operation

Work Activity	Evidence of MSDs	Existing Medical history	Safety & Health Hazard	Risk Factors	Method Used	Outcome	Existing Control Measure	Recommendations	
								Short Term (Corrective)	Long Term (Preventive)
Lifting 15 kg box from conveyer to lorry	Neck, Shoulder, Upper back & lower back	Not Available	Slippery Floor	Awkward Posture	Rapid Upper Limb Assessment (RULA)	High Risk: Action level = 7	NA	Train/Retrain and Supervise correct lifting technique	Redesign task and workstation Review Standard Operating Procedure
				Forceful exertion	Manual handling assessment checklist (MAC)	High Risk: Action level = 3	Gloves and Safety Boots	Use Mechanical aid	

Table 4.3: Example of an advanced ERA of office workstation

Work Activity	Evidence of MSDs	Existing Medical history	Safety & Health Hazard	Risk Factors	Method Used	Outcome	Existing Control Measure	Recommendations	
								Short Term (Corrective)	Long Term (Preventive)
Office admin working with computer	Back pain	Not Available	Sharp table edge	Awkward posture	Rapid Office Strain Assessment	Significant risk = 7 (Action Level > 5)	None	Regular short breaks, exercise	Chair (fit to employee's anthropometry) and sit-stand desk

4.6 Step 5: Priority for Ergonomics Improvement Using Priority Setting Table

Generally, recommended ergonomics improvement based on each and every assessment in Step 4 should be implemented. However, in situation where multiple work units or tasks are assessed, trained person can prioritize the ergonomics improvement by using the priority setting table as shown in **Table 4.4**.

This is in consideration of scarcity or limited organizational resources such as financial, time, manpower and expertise to implement the corrective actions. In the table, colors are used to indicate the level of action to be taken as follows:

- RED indicates HIGH priority action;
- YELLOW indicates MEDIUM priority;
- GREEN indicates LOW priority.

The table will be used to determine the priority of control measures implementation. The use of priority setting table is limited to 3 main risk factors of posture, forceful exertion and repetition. Therefore, a trained person should incorporate other significant risk factors in setting priority for control measures.

Table 4.4: Priority setting table

RFP	RFP	RFP
HHH	MHH	LHH
HHM	MHM	LHM
HHL	MMH	LHL
HMH	MHL	LMH
HMM	MMM	LMM
HLH	MLH	LLH
HML	MML	LML
HLM	MLM	LLM
HLL	MLL	LLL

Legend

R – Repetitive motion
F – Forceful exertion
P – Awkward posture

H – High risk
M – Medium risk
L – Low risk

Highest priority for ergonomics improvement

Moderate priority for ergonomics improvement

Lower priority for ergonomics improvement

5.0 HIERARCHY OF CONTROL BASED ON ERGONOMICS APPROACH

5.1 Elimination

In the application of ergonomics, elimination is the process of removing of unnecessary process, tools or machines or substances from the workplace. For example, instead of lifting and transferring the object or raw material to another work section, the risks of ergonomics arising from manual handling can be totally eliminated by performing the work process immediately.

5.2 Substitution

Substitution in application of ergonomics is maintaining the existing process but replacing the existing tools or equipment, mechanization and automation in the mitigation of risks of ergonomics. Some example of substitution is given as follows;

a) The weight of object can be substantially reduced for lifting in manual handling by substituting wooden crates to a lighter yet stronger material such as plastics crates. This directly reduces the force required for lifting.

b) Substitute existing tool or equipment which emits high level of vibration or noise to one which produces low or no vibration or noise.

5.3 Isolation

Isolation is a common strategy used to separate the hazards from the employees or operators. In the case of ergonomics, environmental risk factors such as noise can be isolated using barrier; either wall or partition of soundproof material to contain the noise produced by machineries or processes.

5.4 Engineering Control

Engineering controls in the application of ergonomics focus on the physical modification of jobs, workstations, tools, equipment, or work processes. The engineering control may comprise the following;

5.4.1 Mechanization and Automation

Mechanization in engineering control is typically applied on basic or simple tools which still extensively requires human operator. For mechanization, the need for forceful exertion in harvesting fresh fruit bunches in oil palm plantation can be mitigated using a motorized harvesting sickle or chisel. This indirectly improves productivities significantly.

However, it should be cautious that the use of motorized sickle may introduce a different form of ergonomics risk factor such as vibration. As such, control measures should not only focus on a single approach but in combination with other hierarchy to ensure efficiency and efficacy of the engineering control applied.

Automation or robotic technology can be used for work tasks in the need for large lifting equipment or mechanism which may not be feasible in certain work situation. For automation, the need for large amount of human strength (forceful exertion) can be substituted with the use of robots particularly in rescue mission and cleanup activities following structural collapse.

5.4.2 Tools and Jigs

Various tools and jigs has been developed or modified in mitigation of risks of ergonomics especially awkward posture. For example, extended tree cutters in reducing over-reaching, ergonomically designed handheld tools such as pliers, scissors, screwdrivers, etc., padded handle to reduce contact stress, etc.

5.4.3 Lift Assisted Devices

Lift assisted devices is a tool or equipment which can be integrated into existing system or separately as a standalone. The use of these devices not only reduces the requirement for forceful exertion significantly but also concurrently reduces postural stress in certain setting and/or sustained exertion.

For example, different types of conveyers, cranes, lifts or hoists can be built into existing workplace. Besides that, the use of forklift, trolley or specific lift assisted devices such as patient lifter in healthcare setting should also considered.

5.4.4 Workstation Design and Configuration

Often, many ergonomics problems at workplace can be resolved simply by improving workstation layout and configuration. The rearrangement of workstation applies the most basic principles of ergonomics which is to fit the job to the person at work. In layout rearrangement or reconfiguration, the elements in the workstation should specifically conform to the anthropometry of the employee.

As a general rule, the common consideration in layout arrangement is to place frequently used items, tools or equipment immediately in front of body within hands' radius reach where elbow is bent at 90° (Example in Figure 5.1). On the other hand, occasionally used items, tools or equipment should be within arms' reach where arm is extended out. Seldom or rarely used items, tools or equipment can be placed slightly further away or at the end of hands' reach.

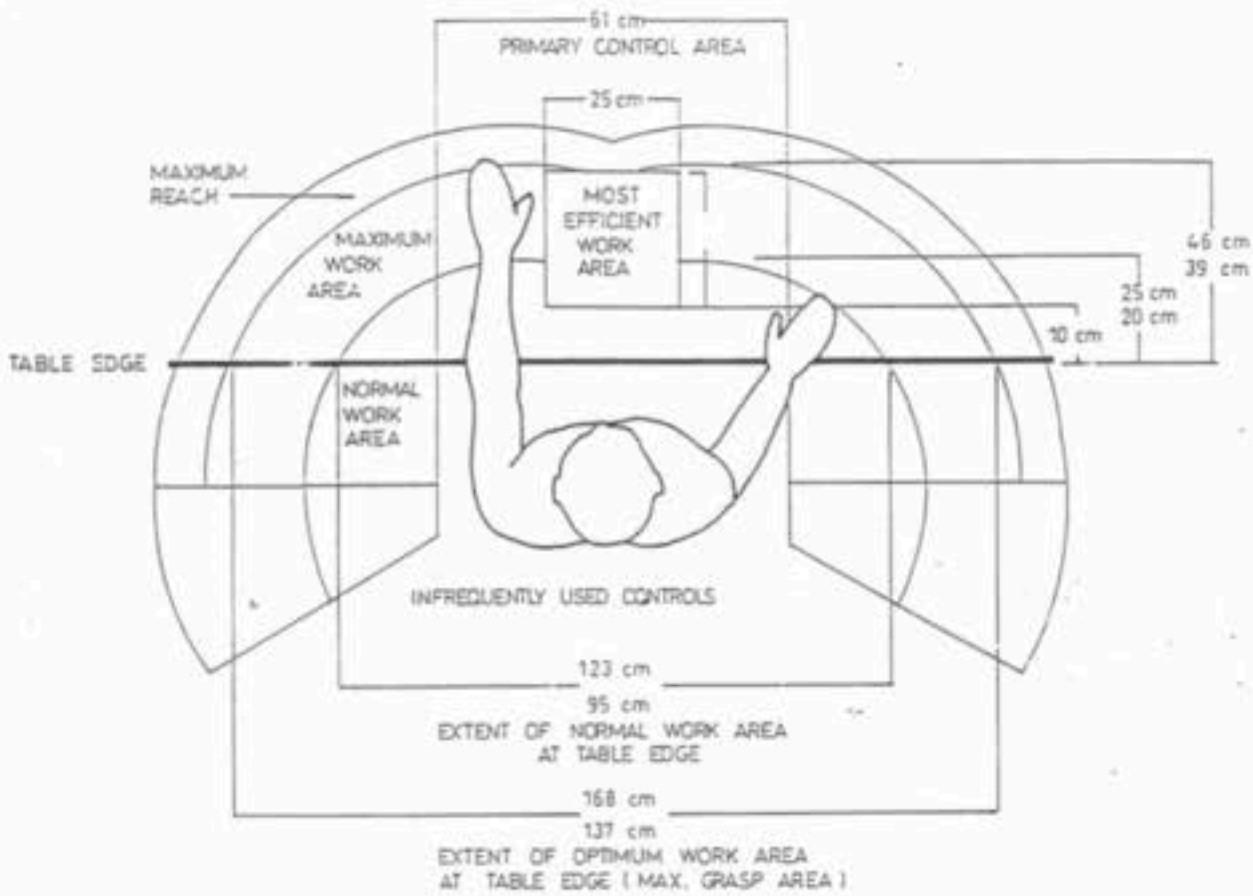

Figure 5.1: Workspace envelope – The ideal measurements of a workspace envelope

In terms of workstation design and configuration, the primary considerations are heights of the tables (or workbench), chairs (or stools) and the posture at work. Properly adjusted height tables and chairs will allow employee to work optimally as they assume neutral posture and distance appropriate to exert their strength without unnecessary or excessive stress on the musculoskeletal system.

Where applicable, the following are among consideration of workstation design and configuration:

a) Task
b) Posture (standing or sitting)
c) Work surface (smooth, rough, etc.)
d) Chair and table (heights and adjustability)
e) Computer, equipment and accessories (monitor, printers, keyboard, etc.)
f) Office environment (lighting, temperature, etc.)

5.5 Administrative Control

Where control of the higher hierarchy is not feasible, administrative control is useful in mitigating ergonomics risk factors. In the application of ergonomics, administrative control may comprise of policy/standard operating procedure/manual, awareness training and education, job/work rotation, physical and medical management program, audit and review.

However, administrative controls are generally not favored due to the following:

a) ergonomics risk factors are not actually removed or reduced
b) difficulty in implement or maintained

5.5.1 Policy, Standard Operating Procedure and/or Manual

At administrative level, a policy is a showcase of commitment through statement which pledge reasonable amount of resources and effort in order to achieve a certain objective. In the application of ergonomics, the management is recommended to develop policy directed at ergonomics improvement. However, it should be noted that the element of ergonomics is commonly being addressed generally altogether with safety, health and welfare policy.

Standard operating procedures (SOP) and/manual is an example of implementation of policy at operational level. In the application of ergonomics, SOP or manual usually integrates the elements of ergonomics in the work process. For example, a SOP or manual can be revised in such way to contain instruction for work that prevents ergonomics risk factors such as awkward posture, unnecessary forceful exertion contact stress, etc.

5.5.2 Awareness Training and Education

Proper and effective awareness training and education is essential in order to ensure the desired outcome. Often, awareness training and education fail to deliver the anticipated outcome due to various reasons such as competency of trainer, training contents, audience education level, etc.

As such, ergonomics awareness training and education should be made simple with multiple examples, hands-on training and practical content. Additionally, the duration of training should not be too long. The training can be modular or being conducted continuously in order to ensure compliance. The basic ergonomics awareness training and education for employees is as addressed in Part 8 of these guidelines.

Ergonomics education could also be communicated through various methods such as email, bulletin board, distribution of education material and video.

5.5.3 Job/Work Rotation

Job or work rotation is the organized movement of employee within the organization. Job rotation can be conducted based on hourly, daily or weekly basis according to standard and regulations relevant to each risk factor. The objective of job rotation is to control the continuous and/or monotonous exposure of ergonomics risk factors to employees due to stagnation and job boredom.

Job rotation allows intermittent changes of the body posture, force level required, work pace, etc. based on requirement of different job tasks. In addition, employees who participate in job rotation have been reported to develop a wide range of work skills and are multi-talented compared to single skills employees. For example, employees can be rotated to manual handling activities such as in warehouse, assembly line and forklift operation distributed over 8 hours or in a single week.

5.5.4 Physical Exercise Program

As part of the administrative control, physical exercise program is commonly used by established organization to reduce the risk of MSDs. It has been widely reported that physical strengthening program such as exercise is effective to a certain extent, increases range of motion, flexibility and endurance towards ergonomics risk factors.

For example, intermittent work break with exercises promotes blood circulation of the muscles and loosen joints by stretching after working for certain duration at office workstation. Besides that, studies have also reported that organization with high frequency and duration of manual handling activities has benefited from back strengthening exercises program.

5.5.5 Medical Prevention Program

Medical prevention program focuses on the prevention of MSDs by targeting susceptible individual. Employees with sign and symptoms of MSDs at workplace can be appropriately identified where early preventive actions can be taken prior to the development of MSDs. For example, pillows behind their chairs, self-massages of wrist, complaints of pain, stiffness or soreness are among sign and symptoms which can be observed.

Most of the time, MSDs in the early detection are reversible particularly by removing the ergonomics risk factors. In the case where MSDs has progressed and took place, the medical prevention program includes but not limited to the following:

- medication,
- prescription of suitable duties according to capability and the person limitation and
- temporary medical removal with continuous monitoring is essential to limit employee's exposure
- surgery

However, it should be reminded that OHD should be consulted in the medical prevention program. For example, where employee is reporting signs and symptoms of carpal tunnel syndrome, affected employee can be reassigned to perform tasks which do not further affect the hand-wrist or being given appropriate work rest instead of costly and expensive invasive surgery which will then require extensive medical leave with limitation to movements.

5.6 Personal Protective Equipment

Personal protective equipment (PPE) is frequently used with existing work practice especially when the other hierarchy of control such as engineering and administrative controls could not provide sufficient protection or reduction of risk factors. Sometimes, they are used in combination with engineering and administrative control (Figure 5.2).

In the application of ergonomics, the uses of PPE to control ergonomics risk factors are limited. Examples of PPE which provide protection in reducing risk factors are as follows:

- Noise – earplugs, earmuff
- Vibration – anti-vibration gloves
- Heat/cold – coveralls, gloves
- Contact stress – gloves

Anti-vibration gloves

Anti contact stress gloves

Coverall

Ear muff

Figure 5.2: Examples of PPE

Where the use of PPE is required, it is strongly recommended that a PPE program is established in order to ensure optimal or maximum protection. The PPE program should address a clear procedure for:

a) Selection of PPE,
b) Training in the use of PPE,
c) Distribution and record keeping,
d) Monitoring of effectiveness
e) Care and maintenance (cleaning and storage)

6.0 ASSESSMENT REPORT

All ERA activities, information and outcomes should be finalized and documented in the form of a report. The report should be presented to the management of the organization and kept as a record. The information in the report should include but not limited as follow:

An initial ERA report must be produced whether or not the assessment shows the needs of Advanced ERA.

6.1 Content of Initial ERA Report

The report should minimally contain the following information: -

a) Name and address of the workplace;
b) Description of work tasks and activities in each work units;
c) Attachment of the initial ERA checklist used **(Appendix 6)**;
d) Risk evaluation and the score of initial ERA;
e) Recommendations for further action ergonomics improvement and the needs for Advanced ERA (if any);
f) Name of the trained person conducted the assessment and relevant certificate of training attended.

6.2 Content of Advanced ERA Report

The report should minimally contain the following information: -

a) Name and address of the workplace;
b) Description of work tasks and activities in each work units;
c) Occupational history and medical history of employees involved;
d) Description of the methods used for the assessment of ergonomics risk factors;
e) Risk evaluation and conclusion of the assessment;
f) Recommendations for further action ergonomics improvement;
g) Name of the trained person conducted the assessment and relevant certificate of training attended.

7.0 REVIEW OF ASSESSMENT

The ERA needs to be reviewed from time to time. The ERA needs to be reviewed in event of the following:

a) When there has been a significant change in the work to which the assessment relates. A significant change in the work means that the risk situation has changed, such as due to:

   i) Change of an employee at a designated work area (which has significant difference of anthropometry from the previous employee);

   ii) Changes in methods or rate of work or work process; or

   iii) Deterioration in the efficiency of control measures

b) When there are symptoms or complaints of ergonomics-related injuries or musculoskeletal disorders;

c) When so directed by the Director General, Deputy Director General, or the Director of Occupational Safety and Health.

The review ERA report should minimally contain the following information: -

a) Name and address of the workplace;
b) Description of new work tasks and new activities in each work units;
c) Occupational history and medical history of employees involved;
d) Description of the methods used for the assessment of ergonomics risk factors;
e) Previous risk evaluation and conclusion of the assessment
f) Risk evaluation and conclusion of the assessment of the new work tasks and new activities in each work units;
g) Recommendations for further action ergonomics improvement;
h) Name of the trained person conducted the assessment and relevant certificate of training attended.

8.0 RESPONSIBILITY AND ACCOUNTABILITY

The trained person who completed the ERA must ensure proper communication of the findings to the employer or his representative. The employer is responsible for ensuring that effective and timely control measures are applied to the hazard and communicating the results back to the affected employees.

9.0 INSTRUCTION, TRAINING AND CONSULTATION

9.1 Instruction

Employees should follow all instructions given by the employer with respect to the work tasks, process or activities as recommended by the assessment report for improvement and mitigation of risks of ergonomics-related injuries and MSDs.

9.2 Training

Awareness training and education should be conducted for the employees at work, trained person and management. The contents and scope of training should be as follow:

9.2.1 Employees

The employer should ensure that the employees are trained to the following topics but not limited to:

a) Ergonomics risk factors;
b) Sign and symptoms of ergonomics-related injuries and MSDs;
c) Correct manual handling techniques;
d) Skills and knowledge to perform work that meets ergonomics requirement;
e) Control measures for mitigating ergonomics-related injuries and MSDs.
f) Procedure to correctly fill in the employee self-assessment form. **(Appendix 1)**

9.2.2 Trained Person

The level of training for trained person varied upon the 2 different level of ERA to be conducted.

9.2.2.1 Initial ERA Training:

It is necessary for trained person to attend training for conducting initial ERA. The scope of training for trained person conducting initial ERA should minimally include:

a) Introduction to physical ergonomics
b) Health effect due to exposure to ergonomics risk factor
c) Sign and symptoms of ergonomics-related injuries and MSDs
d) Procedure to correctly fill in and manage self-assessment form **(Appendix 1)** and complaint form **(Appendix 2)**

e) Ergonomics risk factors
f) Use of ergonomics checklist (including hands-on practical)
g) Ergonomics control measures, improvement and management program
h) Report writing

9.2.2.2 Advanced ERA Training:

It is necessary for trained person to attend training for conducting advanced ERA. As the trained person is expected to be able to use existing established ergonomics risk assessment method, the training for advanced ERA will focus intensively on the various tools to cater for assessment of different types and combination of ergonomics risk factors.

The scope of training for trained person conducting advanced ERA should minimally include:

a) Introduction to physical ergonomics
b) Health effect due to exposure to ergonomics risk factors.
c) Sign and symptoms of ergonomics-related injuries and MSDs
d) Procedure to correctly fill in and manage self-assessment form **(Appendix 1)** and complaint form **(Appendix 2)**
e) Ergonomics risk factors
f) Use of ergonomics checklist (including hands-on practical)
g) Advanced methods for assessment for the following risks:
    i) Postural
    ii) Manual handling
    iii) Repetitive motion
    iv) Vibration
    v) Environmental ergonomics
h) Ergonomics control measures, improvement and management program
i) Report writing

9.3 Consultation

In order to ensure the ERA conducted is accurate, the trained person should consult with the relevant safety and health representative(s), supervisors or employees who are directly or indirectly involved with the work tasks assessed. Consulting directly with employees and drawing on their experience and knowledge is more accurate and effective in reducing risk.

In the event of inadequate expertise in conducting the ergonomics assessment or solution, particularly for the advanced ERA, the trained person can engage external consultants to assist with the ERA.

10.0 RECORD KEEPING

10.1 Format of the Records

The ERA report should be kept either in print or electronic format which should be made available to employees and DOSH or other relevant authorities at any time.

10.2 Records to be Kept

Under these guidelines, the records to be kept include:

a) Self-assessment forms
b) Complaint records or related medical records
c) Walkthrough inspection and initial findings
d) Investigation report
e) Assessment report
f) Corrective action report
g) Training records

10.3 Retention of Records

All records that are generated under these guidelines should be kept for a period of not less than five years except assessment report and investigation report, which should be kept for a period of not less than thirty years.

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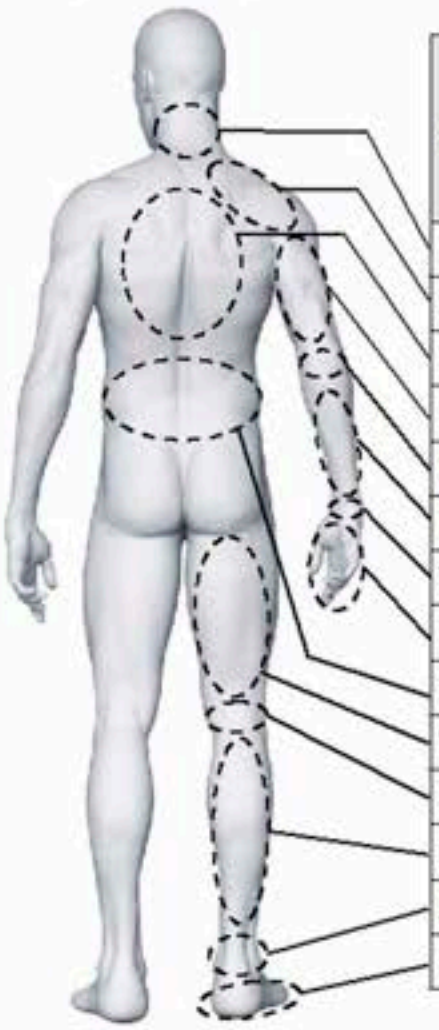
Appendix 1: SELF ASSESSMENT MUSCULOSKELETAL PAIN / DISCOMFORT SURVEY FORM (Refer to Part 2.1)

Instruction:

1. Tick (√) on any body parts (Column A) if you feel discomfort/pain during your work in the last 12 months
2. For those body parts you were feeling pain/discomfort, tick (√) (Column B) if in your opinion, the pain is due to your work.



Body Parts	A		B	
	I have pain/ discomfort in the following body parts.		I think the pain/ discomfort comes from work.	
Neck				
Shoulder				
Upper back				
Upper arm	L	R	L	R
Elbow	L	R	L	R
Lower arm	L	R	L	R
Wrist	L	R	L	R
Hand	L	R	L	R
Lower back				
Thigh	L	R	L	R
Knee	L	R	L	R
Calf	L	R	L	R
Ankle	L	R	L	R
Feet	L	R	L	R

Name: _____ Staff ID No.: _____

Department: _____ Job tasks _____

Contact No.: _____ Email: _____

Date: _____

(Do not write anything in the below section. To be filled by trained person only)

Is/Are the symptom(s) work related? Yes ☐ No ☐

Comments: _____

_____

Name: _____ Signature and stamp:

Date: _____

Appendix 2: ERGONOMICS AND MUSCULOSKELETAL PAIN / DISCOMFORT COMPLAINT FORM

(Refer Part 2.1)

This form can be filled out by any employee of the company/organization. This form should be used for any work-related complaints on physical ergonomics and/or musculoskeletal disorders/pain. Ergonomics problem includes any workstation or work practices which could contribute to musculoskeletal disorders/pain.

Date: _____

Name: _____ Staff ID No.: _____

Department: _____ Job tasks/title: _____

Contact No.: _____ Email address: _____

Please briefly describe the nature of the complaint and any potential cause.

1. What is the nature of the problem?

2. Where is the problem experienced?

3. When was the problem first experienced?

If we need to contact you to discuss about your complaint, when is the best time to reach you?

So that we can respond promptly, please return this form to:

(Name of the Trained Person)
(Email and Contact number of the Trained Person)

(Do not write anything in the below section. To be filled by trained person only)

File number: Received by:
Date received:

Is the nature of the complaint ergonomics-related? Yes ☐ No ☐

Action taken: Investigation/Others (specify action taken/closed file)

Appendix 3: CORNELL MUSCULOSKELETAL AND HAND DISCOMFORT QUESTIONNAIRES

(Refer Part 3.1)

There are two body parts component of the Cornell Musculoskeletal and Hand Discomfort Questionnaires; entire body parts in general and specifically for hands.

The questionnaire for entire body parts questionnaire were further divided for male and female and sub-divided to sedentary work and standing at work. On the other hand, the hand discomfort questionnaires were divided to left and right hand.

Nevertheless, it should be noteworthy that the questionnaires should be used for investigative and research purposes only. They should not be used as diagnostic tools where various other factors should be considered in the assessment of musculoskeletal disorders.

The scores outcome from the questionnaire can be analyzed in 4 ways:

a) by simply counting the number of symptoms per person,

b) by summing the rating values for each person,

c) 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

d) by multiplying Frequency Score in (3) with
   i) the Discomfort Score (1,2,3) or
   ii) 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.

The individual items should also be analyzed to determine where there may be a postural problem for the person.

1) What is the importance or benefit of multiplying frequency score by discomfort score by the interference score?

This is just a way of spreading the scores so that assessor can more easily find the most severe cases. For example, if someone who has right shoulder pain every day (score of 5), and this is very uncomfortable (score of 3) and it substantially interferes with their work (score of 3), if we added their score it would only be 5+3+3 = 11, but if we multiply their score for the right shoulder it is 5x3x3 = 45.

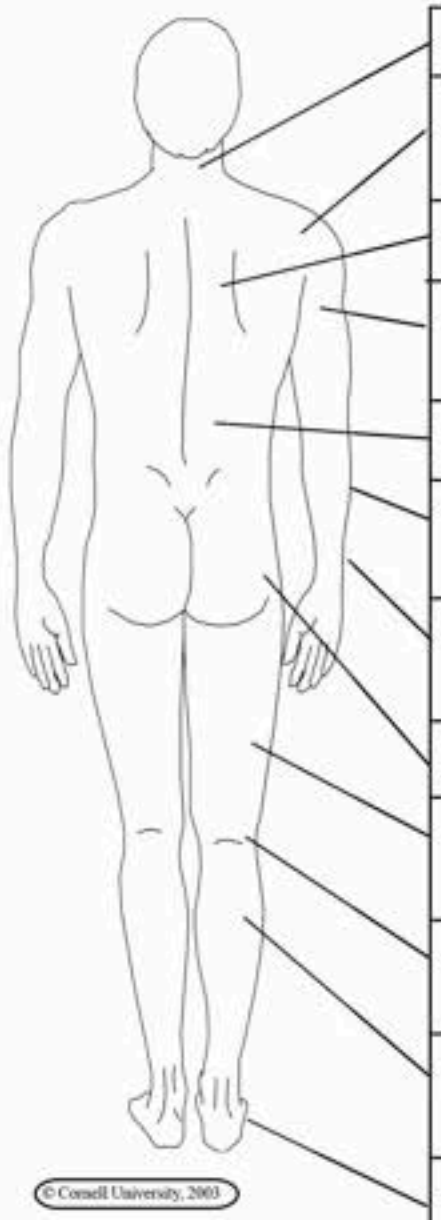
So let's compare this to someone who says they had right shoulder pain 3-4 times in the last week (score of 3.5) that is was moderately uncomfortable (score of 2) and that it slightly interfered with their work (score of 2), then if we added their score it would be 3.5+2+2 = 7.5, which doesn't seem that much different from 11 for the previous person, but if we multiple their scores for the right shoulder it is 3.5x2x2 = 14, which is almost 1/3 of that for the previous.

So by multiplying out the scores it really stretches the scales and lets us more easily see those people with the greatest problems.

2) How can assessor classify the severity of discomfort into mild, moderate, or more?

The discomfort score is a severity of discomfort. Originally we had it as 'mild', 'moderate' and 'severe discomfort', but we found that people more easily understood the categories 'slightly', 'moderately' and 'very uncomfortable'. The assessor can replace the scale point titles with 'mild', 'moderate' and 'severe discomfort'.

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)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

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)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

APPENDIX 3

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?
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
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

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.

Complete only for LEFT HAND

	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?
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
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

APPENDIX 3

Appendix 4: ADDITIONAL INFORMATION *(Refer Part 4.2)*

Part A – Socio-demographic Background

Name:				Age:	
Gender:		Male	Height (cm):		
		Female	Weight (kg):		
Race		Malay		Indian	
		Chinese		Others	
Education level:		No formal education		Primary education	
		Secondary education		Tertiary education	
Marital status		Married		Single	
	If married, no. of children under 6 years old:				

Part B – Working conditions

Department :				
Position/Job title:				
Staff No.:				
Work schedule:		Full-time. Total no. of working hours:		
		Part-time. Total no. of working hours:		
		Shift work. Total no. of working hours:		
No. of work breaks		Once		Twice
		Thrice		Quarce
Break duration:		Lunch. _____minutes		Other. _____minutes
No. of people working with you:		Alone		2 – 5 person
		6 – 10 person		>10 person

Part C – Social/Lifestyle

Do you smoke:		Yes		No
	If smoking, no. of cigarrete smoked in a single day:			
Hobby/Leisure time activity:		Hunting		Gardening
		Fishing		Browsing internet
		Sports		Others: _____

Part D – Medical History

Were you diagnosed of any diseases by the doctors?		Yes		No
	If yes, please describe the diseases:			
Are you taking any medication?		Yes		No
	If yes, what medication are you taking?			

Appendix 5

Appendix 5A: POSTURAL ASSESSMENT – RAPID UPPER LIMB ASSESSMENT (RULA)

RULA is a pen and paper diagnostic tool developed by McAtamney & Corlett (1993) to evaluate the exposure of individual employees to ergonomics risk factors associated with upper extremity MSD. It assesses biomechanical and postural load requirements of job tasks/demands on the neck, trunk and arms & wrists. A single page form or worksheet with assistive infographics is used to evaluate required body posture, force, and repetition.

RULA is easy to use as it requires no advanced degree in ergonomics or expensive equipment. Using the RULA worksheet, the assessor assigns a score for each of the following body regions: upper arm, lower arm, wrist, neck, trunk, and legs in the respective sections. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score in section C that represents the level of MSD risk.

There are basically 4 levels of MSD risk which are categorized as in the following table:

RULA SCORE	INTERPRETATION
1-2	Negligible risk, no action required
3-4	Low risk, change may be needed
5-6	Medium risk, further investigation, change soon
7	Very high risk, investigate and implement change now

RULA is only capable to evaluate from one side of the employee, hence it is important that the assessor prepare prior to the assessment. It is recommended that the assessor observe the employee's movements and postures during several work cycles to understand the job tasks.

Selection of the postures to be evaluated should be based on:

a) The most difficult postures and work tasks (based on employee interview and initial observation),
b) The posture sustained for the longest period of time, or
c) The posture where the highest force loads occur.

The RULA can be conducted quickly, so multiple positions and tasks within the work cycle can usually be evaluated without a significant time and effort. After interviewing and observing the employee, the assessor can determine if only one arm should be evaluated or if both sides should be assessed.

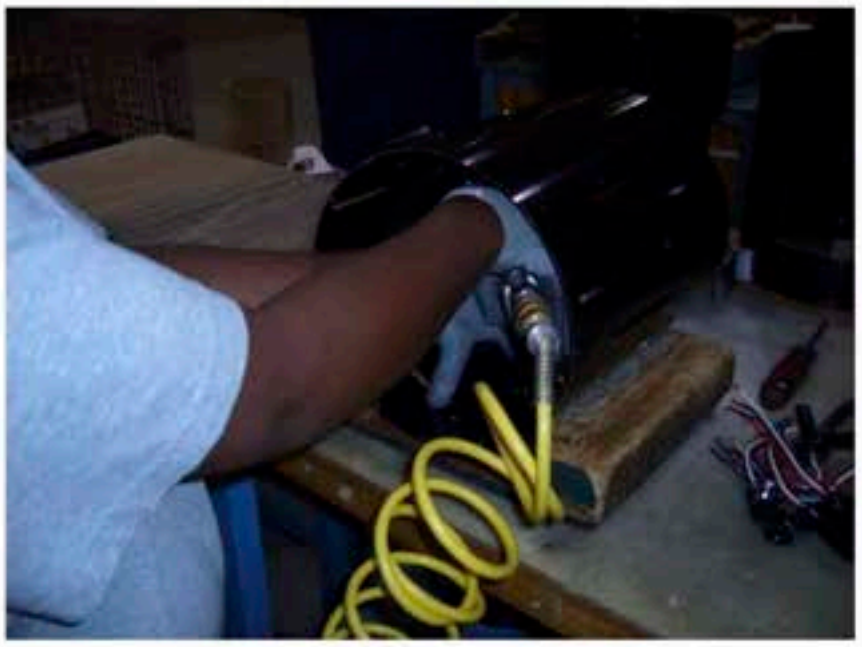
RULA Form

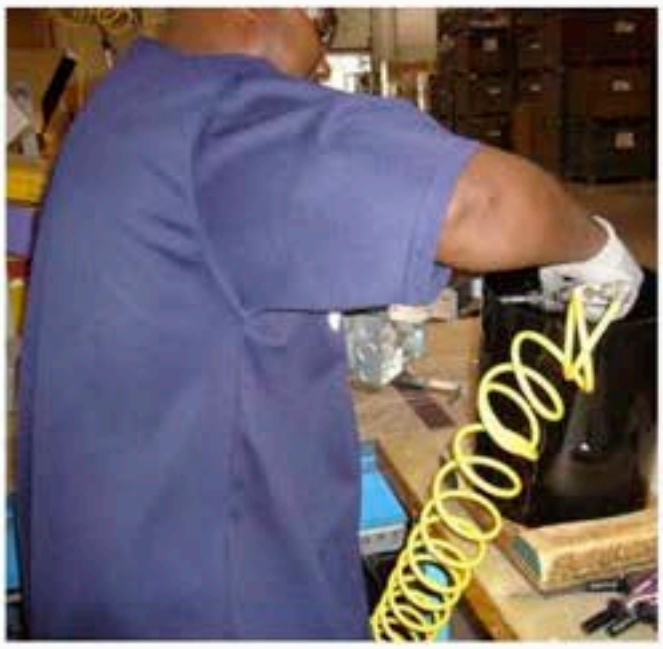
The RULA worksheet is divided into two body segment sections on the labeled A and B. Section A (left side) covers the arm and wrist. Section B (right side) covers the neck, trunk and legs. This segmenting of the worksheet ensures that any awkward or constrained postures of the neck, trunk or legs which might influence the postures of the arms and wrist are included in the assessment.

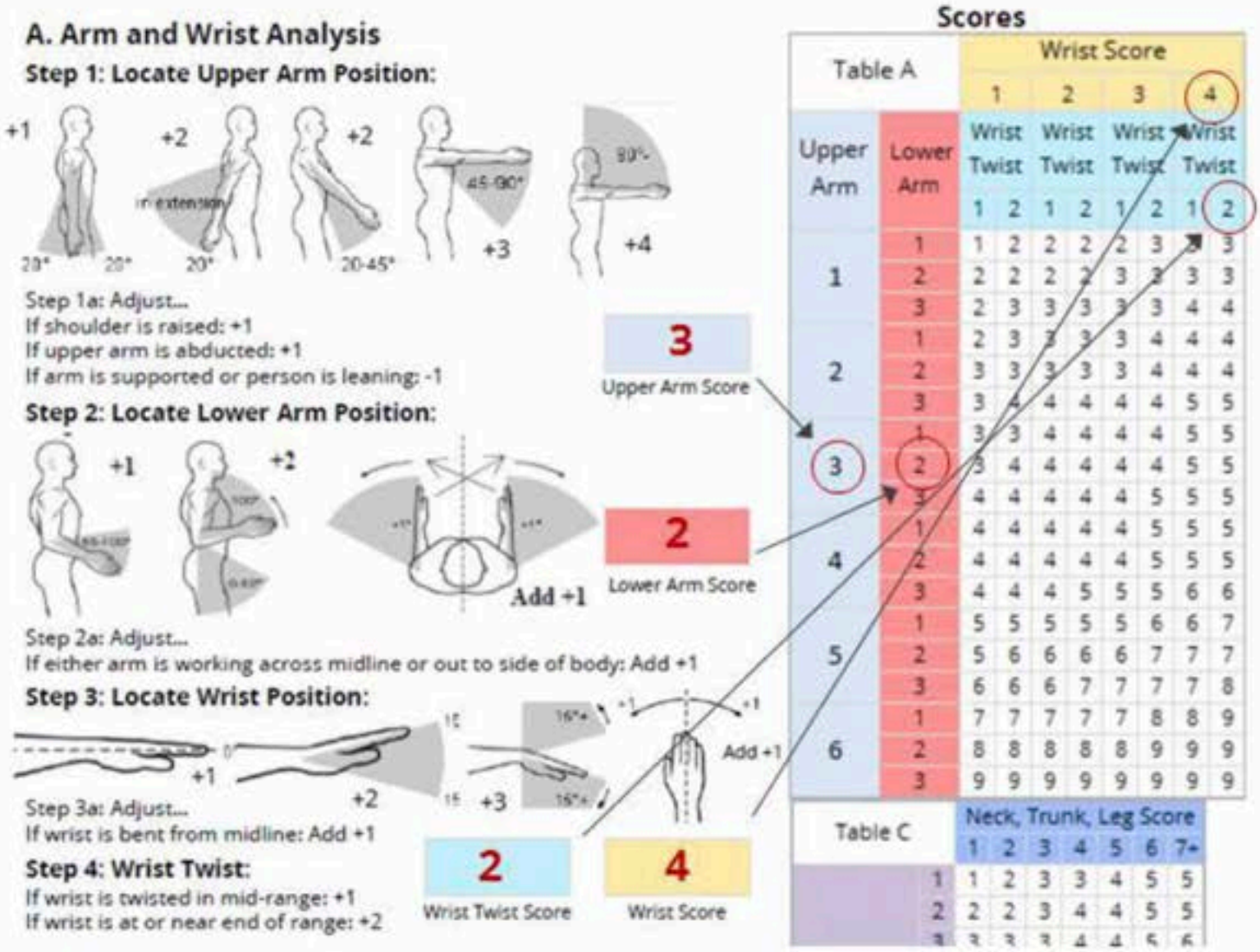
The assessor should score Group A (Arm & Wrist) postures first, then score Group B (Neck, Trunk & Legs) postures for left and right. For each region, there is a posture scoring scale and additional adjustments outlined on the worksheet which need to be considered and accounted for in the score.

Example A – Assessment of Current Work Situation

An example of assessment for an assembly tasks is provided as follow:







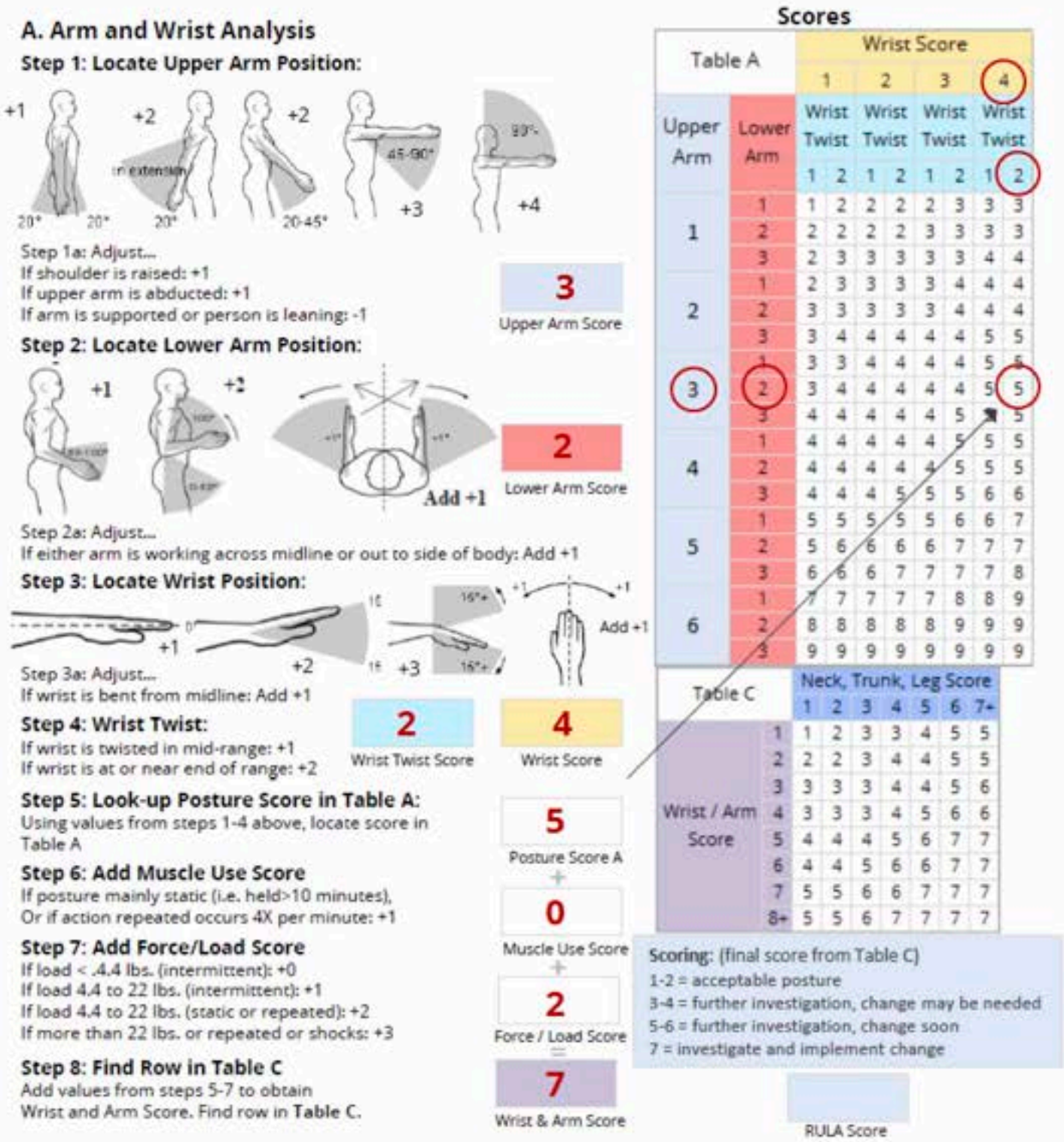
Steps 1-4: Right Arm & Wrist Analysis

Step 1: A +3 score was used for upper arm position (45+ degrees).

Step 2: A +2 score was given for the lower arm position (<60 degrees).

Step 3: Wrist score was +3 for wrist flexion (>15 degrees), and +1 was added for ulnar deviation.

Step 4: Wrist score is +2 because the wrist is twisted near the end range.

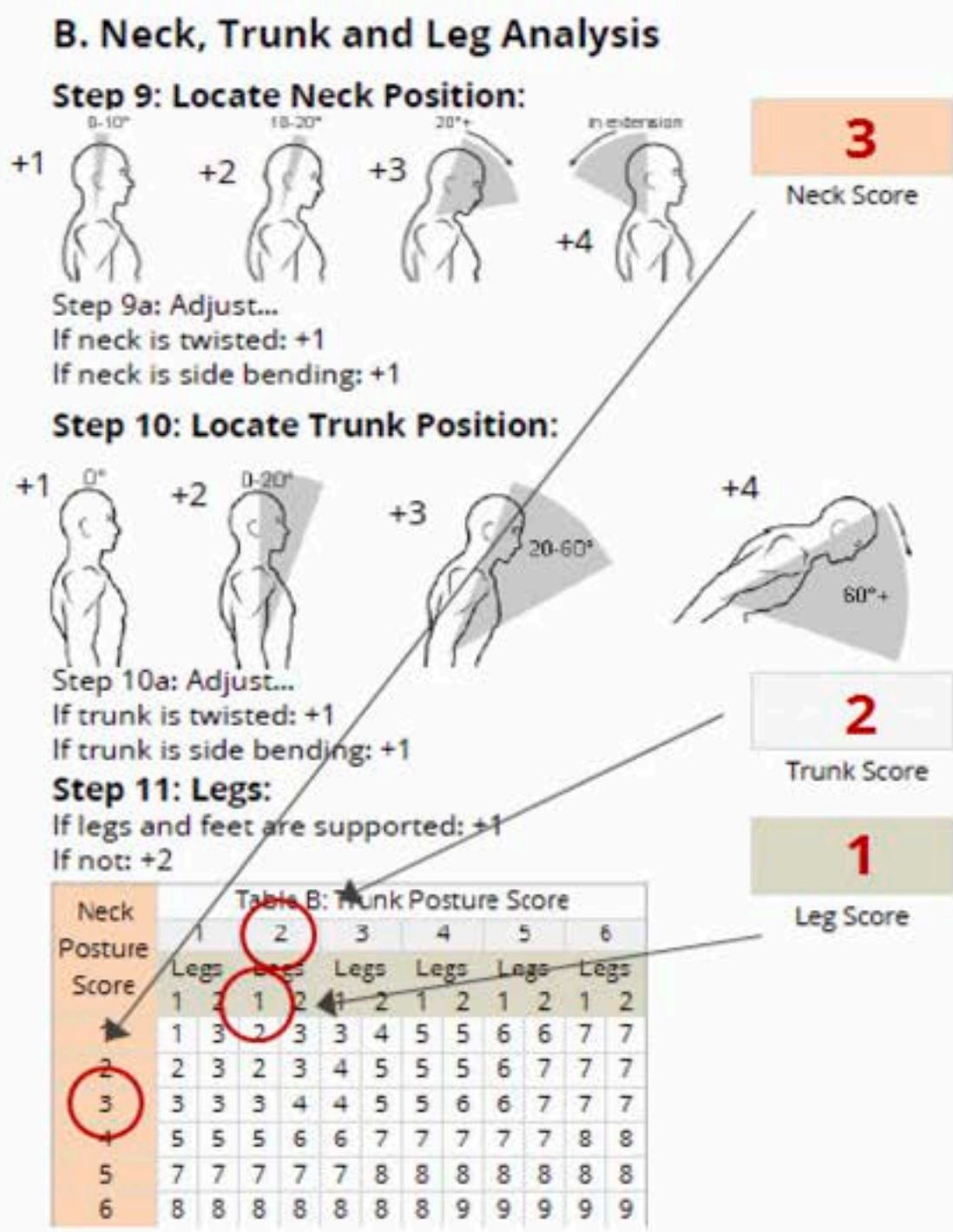


Step 5: Using values from Steps 1-4, summarize the using Table A.

Step 6: Determine the muscle use score.
In this example, the posture is not sustained for more than 10 minutes, and not repeated 4 times per minute. Therefore, the score is 0.

Step 7: Determine the force/load score.
In this example, the load is greater than 4.4 lbs. and repeated.
Therefore, the score is +2.

Step 8: Add the values **from** Steps 5-7 to obtain the Wrist/Arm Score.



Steps 9 – 15: Neck, Trunk and Leg Analysis

Step 9: A +3 score was used for the neck position (>20 degrees).

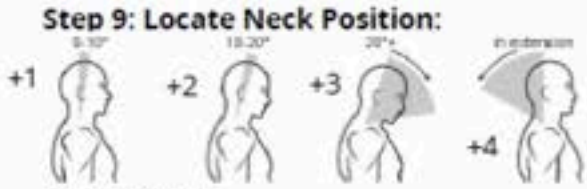
Step 10: A +1 due to trunk position at 0-20 degrees.

Step 11: A +1 score for employees standing on both feet balance.

Step 12: Using values from Steps 9-11, summarize the using Table B.

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:



3
Neck Score

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:

Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

2
Trunk Score

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

1
Leg Score

Table B: Trunk Posture Score

Neck Posture Score	1		2		3		4		5		6	
	Legs		Legs		Legs		Legs		Legs		Legs	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above, locate score in Table B

3
Posture B Score

+

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

0
Muscle Use Score

+

Step 14: Add Force/Load Score
If load < .4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

2
Force / Load Score

=

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C.**

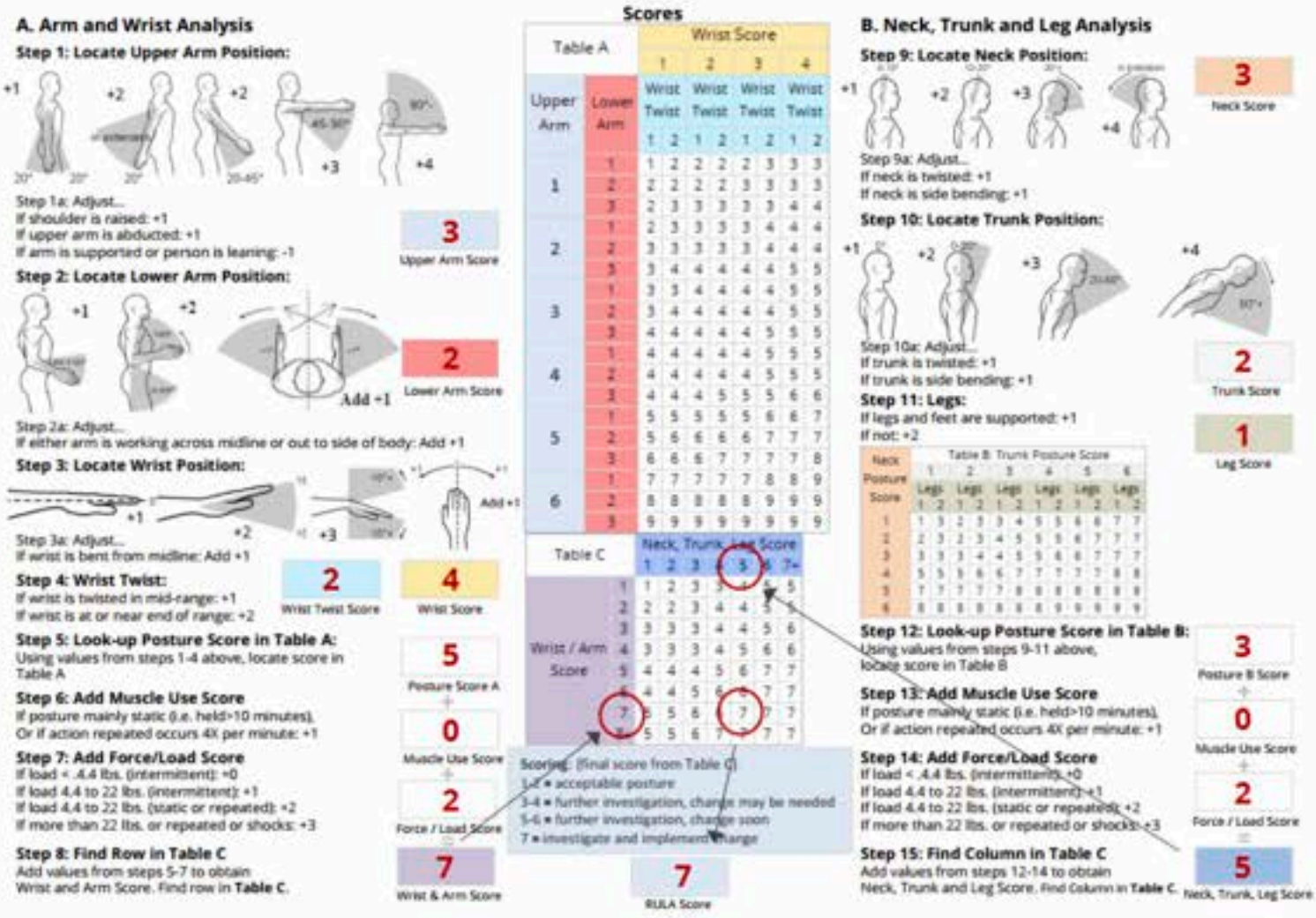
5
Neck, Trunk, Leg Score

Step 13: Add the muscle use score to this box.
In this example, the posture is not sustained for more than 10 minutes, and not repeated 4 times per minute. Therefore, the score is 0.

Step 14: In this example, the load is greater than 4.4 lbs. and repeated.
Therefore, the score is +2.

Step 15: Add the values in Steps 12 – 14 to obtain the Neck, Trunk, & Leg Score.

Determine Final RULA Score:



Step 17: Use Table C to determine the final RULA score using Table C by inserting the score obtained from

i) Wrist and Arm analysis (Step 8) and

ii) Neck, Trunk and Leg analysis (Step 15).

Final RULA Score = 7

In this example, the final RULA score of 7 indicates high risk and calls for engineering and/or work method changes to reduce or eliminate MSD risk.

Example B - Implemented ergonomics improvements:

The assembly process was changed to install the access plate prior to riveting the can together. A fixture was fabricated to hold the can open while the access plate is being installed. A straight or "in-line" pneumatic screw driver (on a tool balancer) is now used to improve upper extremity work postures and eliminate the force required.

A follow-up analysis using the RULA worksheet was performed upon completion of this ergonomic process and tool improvement. When using the new work process and tools, the RULA total score is reduced from 7 to 1.

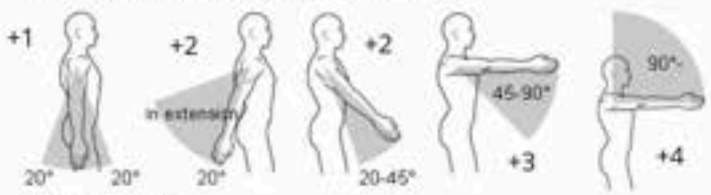
ERGONOMICS PLUS

RULA Employee Assessment Worksheet

Task Name: Date:

A. Arm and Wrist Analysis

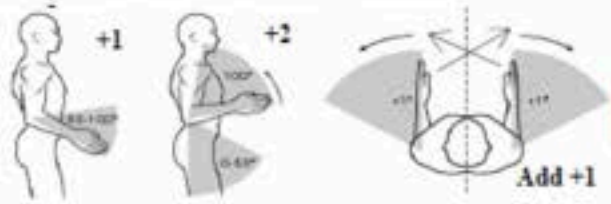
Step 1: Locate Upper Arm Position:



Step 1a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score

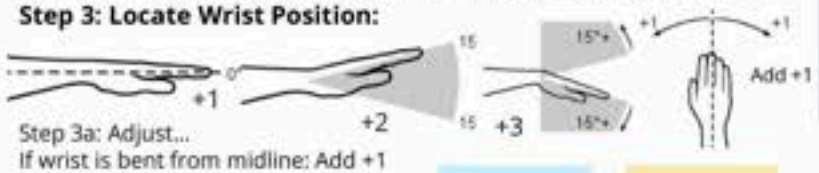
Step 2: Locate Lower Arm Position:



Lower Arm Score

Step 2a: Adjust...
If either arm is working across midline or out to side of body: Add +1

Step 3: Locate Wrist Position:



Step 3a: Adjust...
If wrist is bent from midline: Add +1

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

Wrist Twist Score

Wrist Score

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

Posture Score A

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score

Step 7: Add Force/Load Score
If load < .4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C**.

Wrist & Arm Score

Scores

Table A		Wrist Score							
		1		2		3		4	
Upper Arm	Lower Arm	Wrist Twist		Wrist Twist		Wrist Twist		Wrist Twist	
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C		Neck, Trunk, Leg Score						
		1	2	3	4	5	6	7+
Wrist / Arm Score	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1-2 = acceptable posture
3-4 = further investigation, change may be needed
5-6 = further investigation, change soon
7 = investigate and implement change

RULA Score

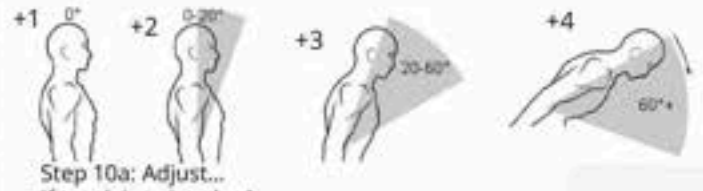
B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:

Neck Score

Step 9a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Step 10: Locate Trunk Position:



Step 10a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

Leg Score

Neck Posture Score	Table B: Trunk Posture Score											
	1		2		3		4		5		6	
	Legs		Legs		Legs		Legs		Legs		Legs	
	1	2	1	2	1	2	1	2	1	2	1	2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above, locate score in Table B

Posture B Score

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

Muscle Use Score

Step 14: Add Force/Load Score
If load < .4.4 lbs. (intermittent): +0
If load 4.4 to 22 lbs. (intermittent): +1
If load 4.4 to 22 lbs. (static or repeated): +2
If more than 22 lbs. or repeated or shocks: +3

Force / Load Score

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C**.

Neck, Trunk, Leg Score

Original Worksheet Developed by Dr. Alan Hedge. Based on RULA: a survey method for the investigation of work-related upper limb disorders, McAtamney & Corlett, Applied Ergonomics 1993, 24(2), 91-99

APPENDIX 5B:
FORCE ANALYSIS/MANUAL HANDLING - MANUAL HANDLING ASSESSMENT CHART

The Manual Handling Assessment Charts (MAC) is a tool aimed at employers, health and safety managers and safety representatives. The tool will help individuals to assess the most common risk factors in lifting (and lowering), carrying and team handling operations and was developed to identify high-risk manual handling. There are three types of assessment that can be carried out with the MAC;

- Lifting operations
- Carrying operations
- Team Handling Operations

It should however be noted that MAC is not appropriate for some manual handling operations, for example those that involve pushing and pulling. Its use does not comprise a full risk assessment as individual and psychosocial risk factors were not considered when completing the score sheet. Besides that, the MAC is also not designed to assess risks from workplace upper limb disorders.

A research has been conducted by HSE UK to benchmark the MAC to the NIOSH Lifting Index. The action categories are as follow:

MAC SCORE	INTERPRETATION
0 – 4	No action required
5 – 12	Action required in the near future
13 – 20	Action required soon
21 – 31	Action required immediately

Guide to use MAC:

a) Observe the task to ensure its representative of normal working procedures. Where several people do the same task, make sure some to have some insight into demands of the job from all employee's perspective. It may help to videotape the task so it can be view it over again if necessary.

b) Select the appropriate type of assessment (i.e: lifting, carrying or team handling). If a task involves lifting and carrying, consider both.

c) Follow the appropriate assessment guide and flow chart to determine the level of risk for each risk factor. The levels of risk are classified as follow:

   i) G = Green – Low level or risk
   ii) A = Amber – Medium level of risk – Examine tasks closely
   iii) R = Red – High level of risk – Prompt action needed
   iv) P = Purple – Very high level of risk

d) Enter the color band and corresponding numerical score on the score sheet. The color bands help determine which elements of the task require attention.

e) Add up the total score. The total scores help prioritize those tasks that need most urgent attention and help check the effectiveness of those improvements.

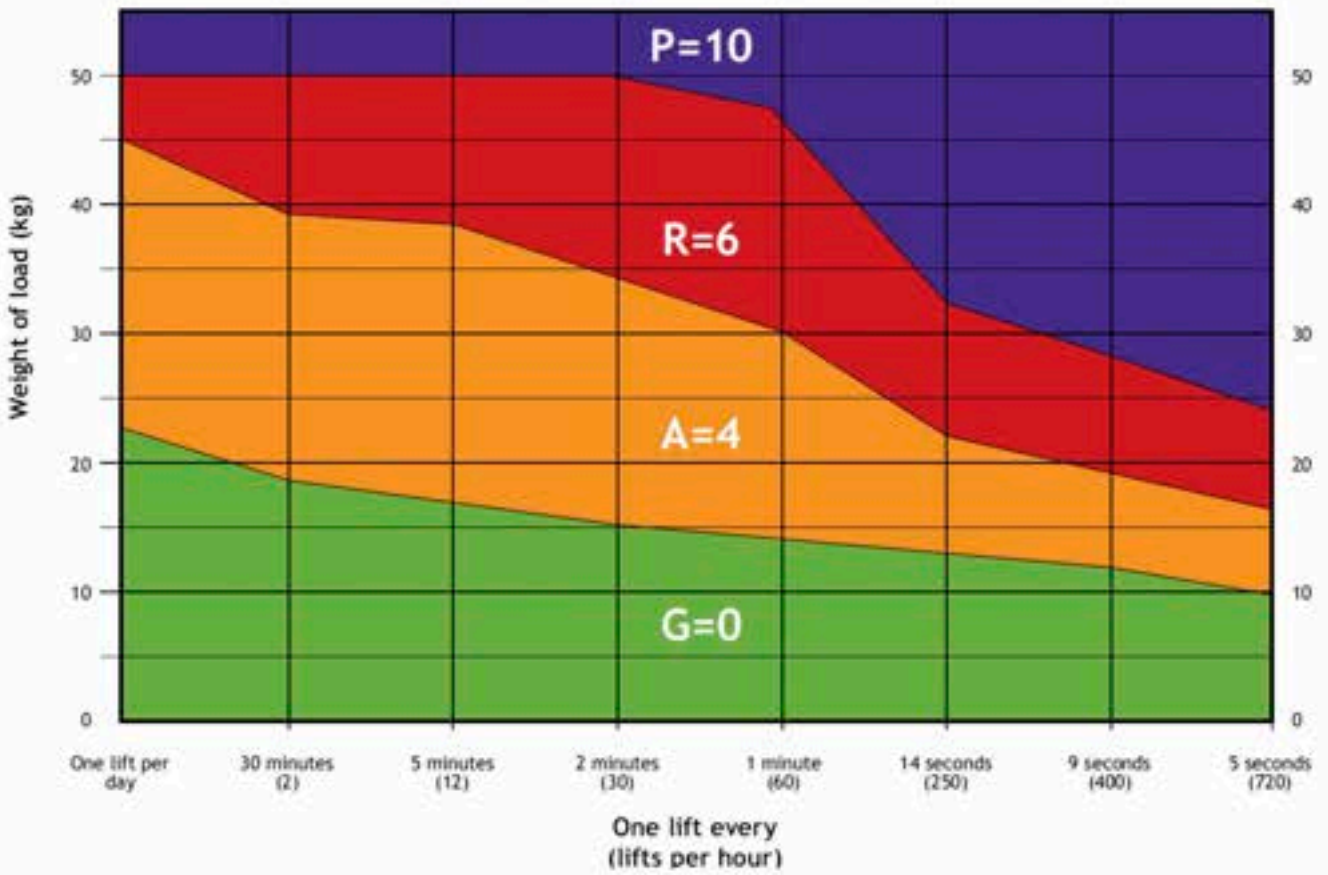
f) Enter the remaining task information asked for on the score sheet.

ASSESSMENT GUIDE FOR LIFTING OPERATIONS

A. Load weight/frequency

Note the weight of the load and the repetition rate of the lifting operation. Read off the risk banding and enter the color band and numerical score on the score sheet. If the color band is purple the task should be examined very closely, such operations may represent a serious risk of injury and should come under close scrutiny, particularly when the entire weight of the load is supported by one person.

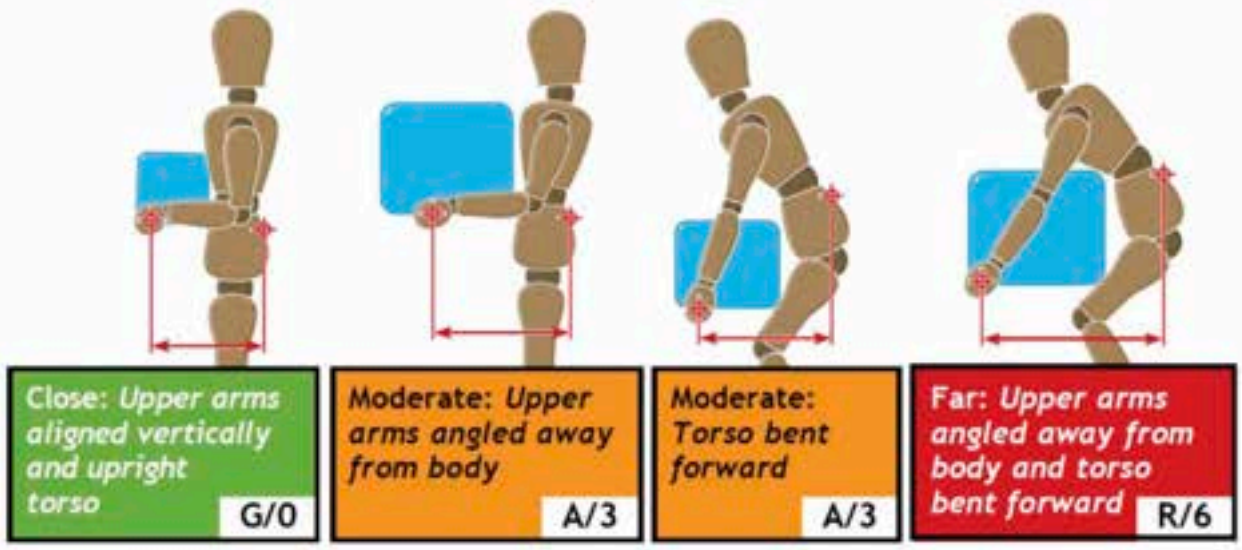
LOAD WEIGHT/FREQUENCY GRAPH FOR LIFTING OPERATIONS



Note*: High frequency handling operations of light weights will fall within the GREEN zone, but may be associated with upper limb problems. Please refer to Upper limb disorders in the workplace.*

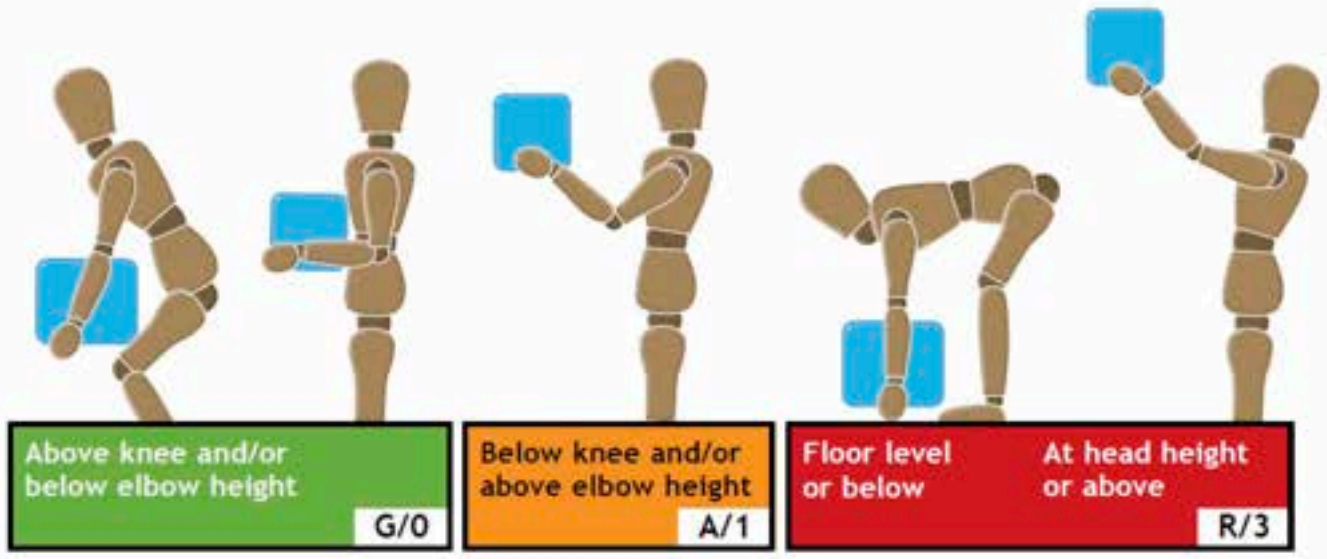
B. Hand distance from the lower back

Observe the task and examine the horizontal distance between the operative's hands and their lower back. Always assess the 'worst case scenario'. Use the following to guide the assessment:



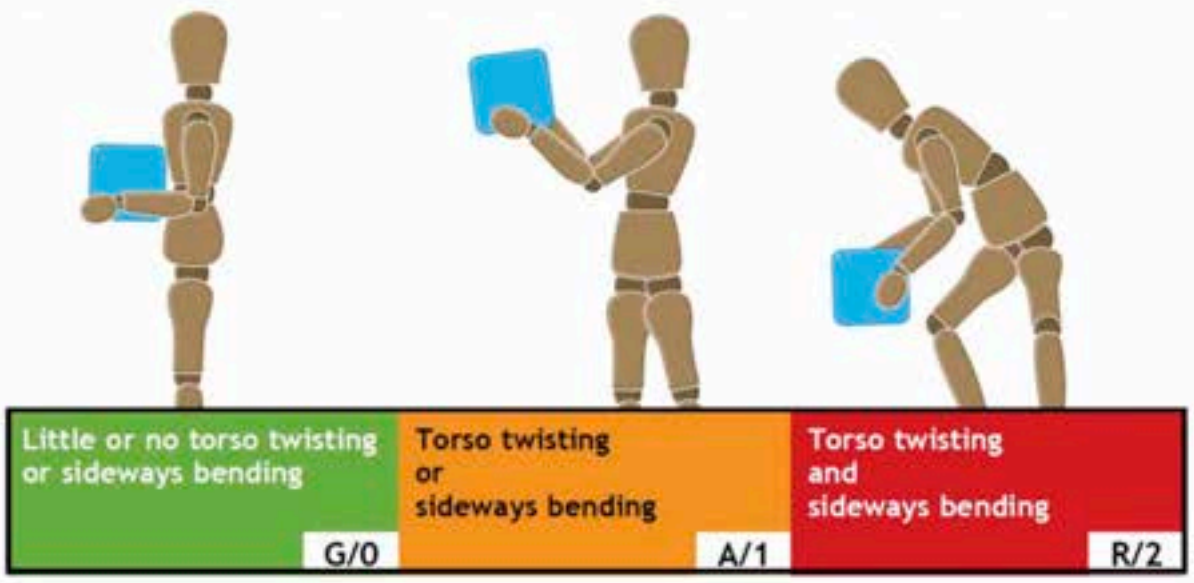
C. Vertical lift region

Observe the position of the operative's hands at the start of the lift and as the lift progresses. Always assess the 'worst case scenario'. Use the following illustrations as a guide:



D. Torso twisting and sideways bending

Observe the operative's trunk as the load is lifted. If the trunk twists in relation to the hips and thighs or the operative leans to one side as the load is lifted, the color band is amber and the numerical score is 1. If the trunk both twists AND bends to the side as the load is lifted the color band is red and the numerical score is 2.



E. Postural constraints

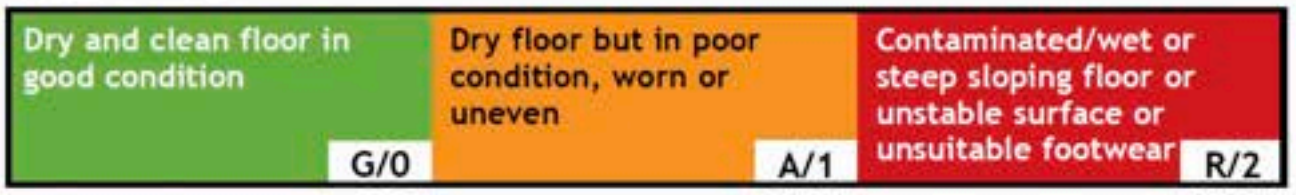
If the movements of the operative are unhindered, the color band is green and the numerical score is 0. If the operative adopts restricted postures during the lift because of the space available (e.g.: a narrow gap between pallet load and hopper) or the workstation design (e.g.: an excessively high monorail conveyor), the color band is amber and the numerical score is 1. If the posture is severely restricted, the color band is red and the numerical score is 3 (e.g.: work in confined areas such as baggage holds).

No postural constraints G/0	Restricted posture A/1	Severely restricted posture R/3

F. Grip on the load

Good grip G/0	Reasonable grip A/1	Poor grip R/2
Containers with well-designed handles or handholds, fit for purpose	Containers with poor handles or handholds	Containers of poor design. Loose parts, irregular objects, bulky or difficult to handle
Loose parts enabling comfortable grip	Fingers to be clamped at 90 degrees under the container	Non-rigid sacks or unpredictable loads

G. Floor surface



H. Other environmental factors

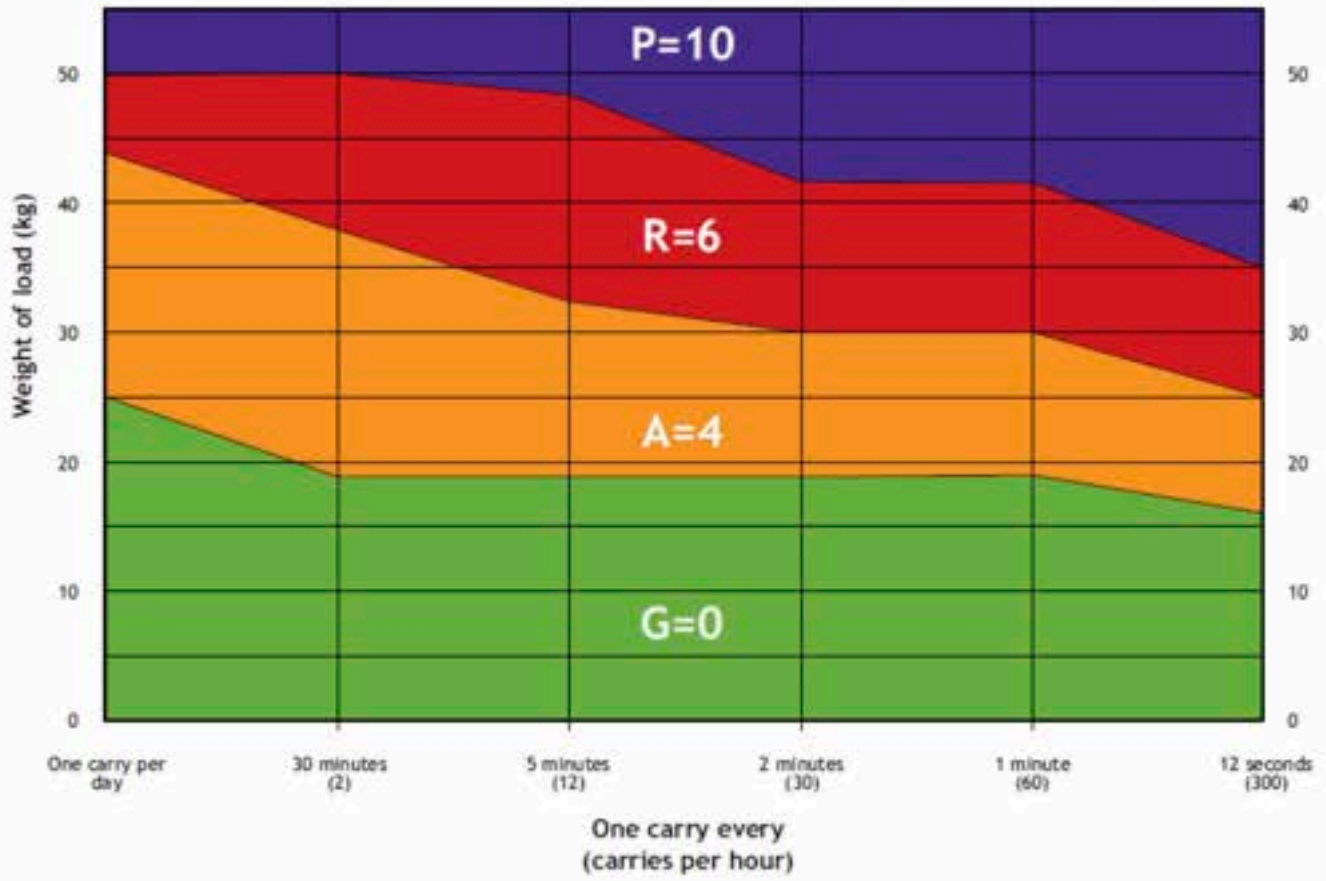
Observe the work environment and score if the lifting operation takes place: in extremes of temperature; with strong air movements; or in extreme lighting conditions (dark, bright or poor contrast). If one of the risk factors are present score 1, if two or more of the risk factors are present score 2.

ASSESSMENT GUIDE FOR CARRYING OPERATIONS

A. Load weight/frequency

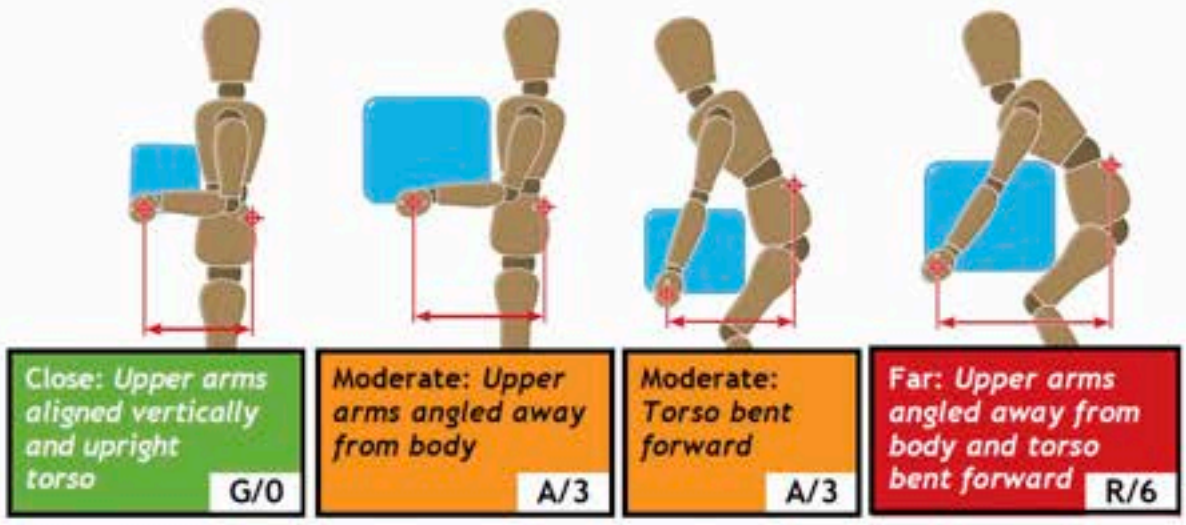
Note the weight of the load and the frequency of the carrying operation. Read off the risk banding on the graph and enter the color band and numerical score on the score sheet. If the colour band is purple the task should be examined very closely, such operations may represent a serious risk of injury and should come under close scrutiny, particularly when the entire weight of the load is carried by one person.

LOAD WEIGHT/FREQUENCY GRAPH FOR CARRYING OPERATIONS



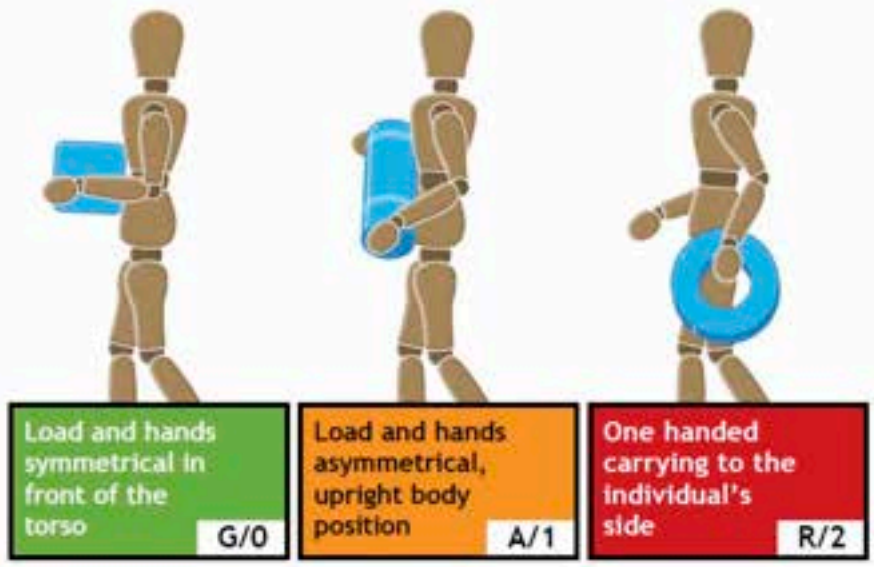
B. Hand distance from the lower back

Observe the task and examine the horizontal distance between the operative's hands and their lower back. Always assess the 'worst case scenario'. Use the following illustrations to guide the assessment:



C. Asymmetrical trunk/load

The operative's posture and the stability of the load are risk factors associated with musculoskeletal injury. The following illustrations should guide the assessment.



D. Postural constraints

If the operative's movements are unhindered, the colour band is green and the numerical score is 0. If the operative adopts restricted postures during the carry (eg a narrow doorway making the operative turn or move the load to get through) the colour band is amber and the numerical score is 1. If the posture is severely restricted, the colour band is red and the numerical score is 3 (eg carrying loads in a forward bent posture in areas with low ceilings such as cellars).

No postural constraints	Restricted posture	Severely restricted posture
G/0	A/1	R/3

E. Grip on load

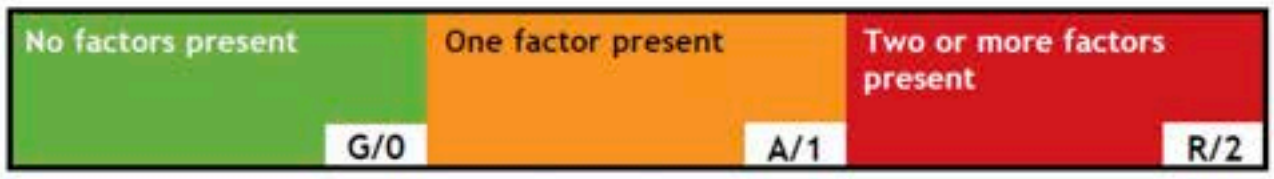
Good grip G/0	Reasonable grip A/1	Poor grip R/2
Containers with well-designed handles or handholds, fit for purpose	Containers with poor handles or handholds	Containers of poor design. Loose parts, irregular objects, bulky or difficult to handle
Loose parts enabling comfortable grip	Fingers to be clamped at 90 degrees under the container	Non-rigid sacks or unpredictable loads

F. Floor surface

Dry and clean floor in good condition	Dry floor but in poor condition, worn or uneven	Contaminated/wet or steep sloping floor or unstable surface or unsuitable footwear
G/0	A/1	R/2

G. Other environmental factors

Observe the work environment and score if the carrying operation takes place: in extremes of temperature; with strong air movements; or in extreme lighting conditions (dark, bright or poor contrast). If one of the risk factors are present score 1, if two or more of the risk factors are present score 2.

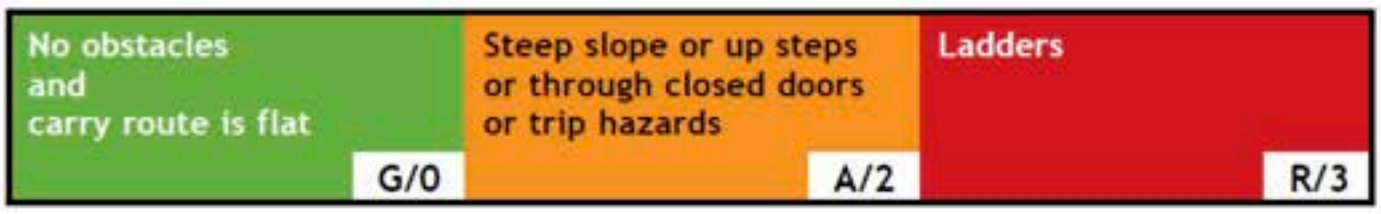


H. Carry distance

Observe the task and estimate the total distance that the load is carried (not the distance 'as the crow flies').

I. Obstacles en route

Observe the route. If the operator has to carry a load up a steep slope, up steps, through closed doors or around tripping hazards, the colored band is amber and the numerical score is 2. If the task involves carrying the load up ladders, enter 'R' (red) for the color band and 3 for the numerical score. If the task involves more than one of the risk factors (i.e.: a steep slope and then up ladders) total the scores on the score sheet. Enter the ladder height data and/or the angle in the task description box on the score sheet.



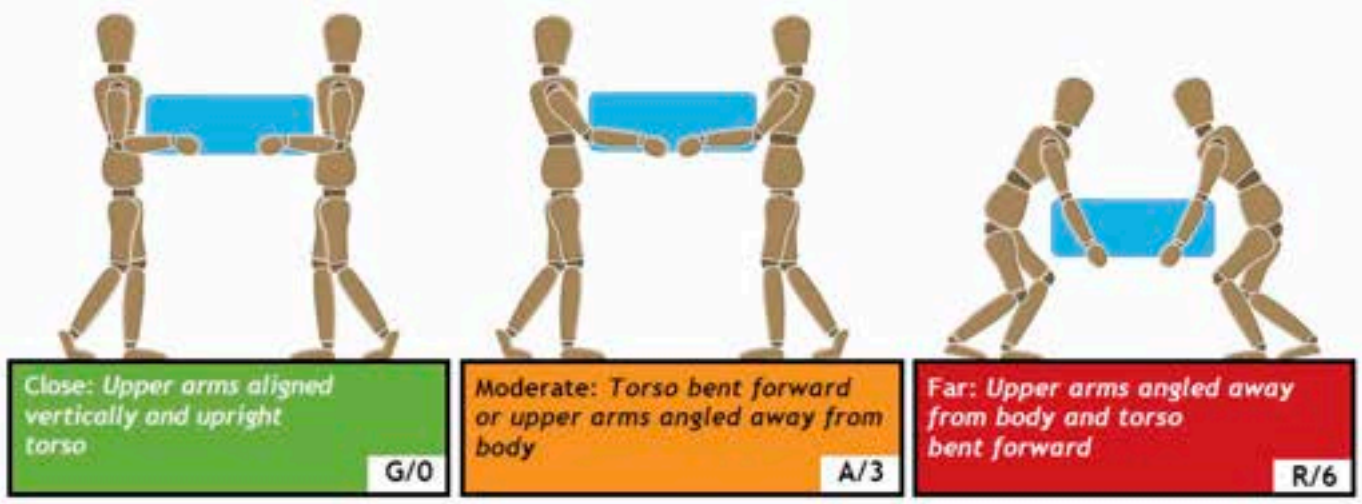
ASSESSMENT GUIDE FOR TEAM HANDLING OPERATIONS

A. Load weight

Note the weight of the load and the number of operatives performing the task. Enter the colour band and numerical score on the score sheet. If the colour band is purple the task should be examined very closely, such operations may represent a serious risk of injury and should come under close scrutiny, particularly when the entire weight of the load is supported by the team.

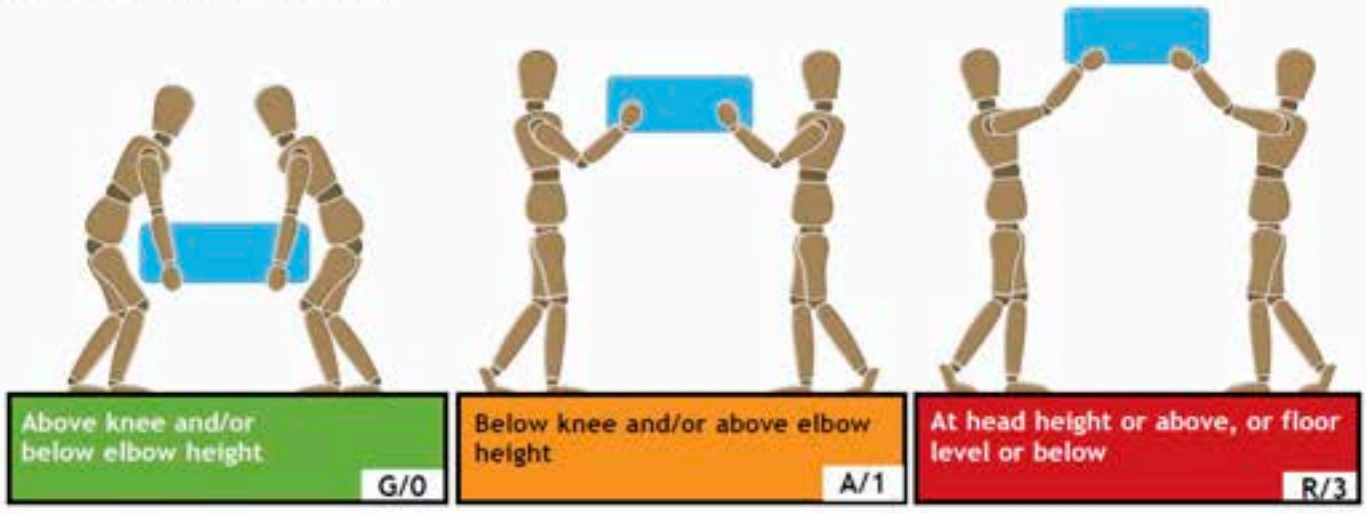
B. Hand distance from the lower back

Observe the task and examine the horizontal distance between each operatives' hands and their lower back. Always assess the 'worst case scenario'. Use the following illustrations to guide the assessment:



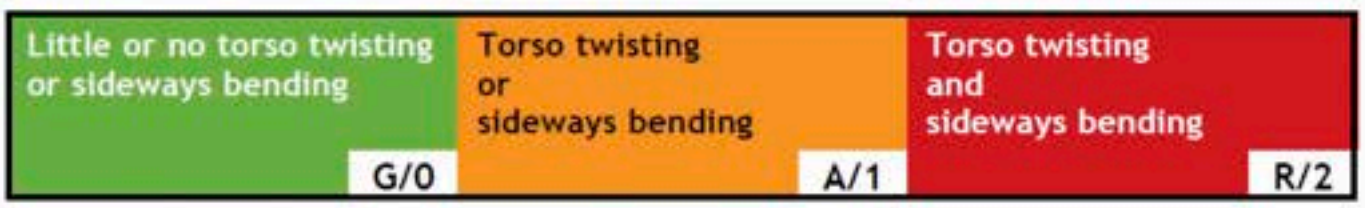
C. Vertical lift region

Observe the position of the operatives' hands at the start of the lift and as the lift progresses. Always assess the 'worst case scenario'. Use the following illustrations as a guide:



D. Trunk twisting and sideways bending

Observe the operatives' trunks as they lift the load. If the trunk twists in relation to the hips and thighs or if the operatives lean to one side as the load is lifted, the colour band is amber and the numerical score is 1. If the trunk both twists AND bends to the side as the load is lifted, the colour band is red and the numerical score is 2.



E. Postural constraints

If the movements of the operatives are unhindered, the colour band is green and the numerical score is 0. If the operatives adopt restricted postures during the lift because of the space available (eg narrow space between team members) or the workstation design (eg an excessively high monorail conveyor), the colour band is amber and the numerical score is 1. If the postures are severely restricted, the colour band is red and the numerical score is 3 (eg work in confined areas such as baggage holds).

No postural constraints	Restricted posture	Severely restricted posture
G/0	A/1	R/3

F. Grip on load

Good grip	Reasonable grip	Poor grip
G/0	A/1	R/2
Containers with well-designed handles or handholds, fit for purpose	Containers with poor handles or handholds	Containers of poor design. Loose parts, irregular objects, bulky or difficult to handle
Loose parts enabling comfortable grip	Fingers to be clamped at 90 degrees under the container	Non-rigid sacks or unpredictable loads

G. Floor surface

Dry and clean floor in good condition	Dry floor but in poor condition, worn or uneven	Contaminated/wet or steep sloping floor or unstable surface or unsuitable footwear
G/0	A/1	R/2

H. Other environmental factors

Observe the work environment and score if the lifting operation takes place: in extremes of temperature; with strong air movements; or in extreme lighting conditions (dark, bright or poor contrast). If one of the risk factors are present score 1, if two or more of the risk factors are present score 2.

No factors present	One factor present	Two or more factors present
G/0	A/1	R/2

I. Communication, co-ordination and control

Communication between the operatives is essential when lifting as part of a team. Examples of good communication would be that you may hear the operatives counting 'one, two, three' etc. prior to the lift. Look to see if the team have control of the load, that it is lifted smoothly, and that all members lift together. An uncoordinated team lift may leave one member of the team bearing the entire weight.

OTHERS RISK FACTORS

1. Individual differences

Individual risk factors may comprise of;

a) difference in competence or skills;

b) new employees may need time to acquire the necessary work skills;

c) employees of varying body sizes, i.e. height, reach etc. This can lead to adopting poor postures when lifting or lowering objects;

d) vulnerable groups, e.g. older employees and new or expectant mothers

e) health status and disability;

f) individual attitudes or characteristics that may affect compliance with safe working practices or reporting of symptoms

2. Psychosocial Risk Factors

Psychosocial risk factors are things that may affect employees' psychological response to their work and workplace conditions (including working relationships with supervisors and colleagues). Examples are:

a) High workloads,

b) Tight deadlines,

c) Lack of control of the work and working methods.

MAC SCORE SHEET

MAC: *Score sheet*
Company name:

Task Description:

Are there indications that the task is high risk?
(Tick the appropriate boxes)

- ☐ Task has a history of manual handling incidents (eg company accident book, RIDDOR reports).
- ☐ Task is known to be hard work or high risk.
- ☐ Employees doing the work show signs that they are finding it hard work (eg breathing heavily, red-faced, sweating).
- ☐ Other indications, if so what? _____

Date: _____

Signature: _____

Insert the colour band and numerical score for each of the risk factors in the boxes below, referring to your assessment, using the tool.

Risk factors	Colour band (G, A, R or P)			Numerical score		
	Lift	Carry	Team	Lift	Carry	Team
Load weight and lift/carry frequency						
Hand distance from the lower back						
Vertical lift region						
Trunk twisting/sideways bending Asymmetrical trunk/load (carrying)						
Postural constraints						
Grip on the load						
Floor surface						
Other environmental factors						
Carry distance						
Obstacles en route (carrying only)						
Communication and co-ordination (team handling only)						
Other risk factors, eg individual factors, psychosocial factors etc (see website - address on page 12)	TOTAL SCORE:					

Appendix 5C: REPETITIVE MOTION ANALYSIS - OCRA Checklist

For first stage assessment, if there is repetitive job or task identified, it is suggested that the second level of OCRA three level systems is used; i.e. the OCRA Checklist. This guideline is to be read together with ISO 11228-3 Manual Handling Part 3 - Handling of low loads at high frequency and Colombini et al. (2013) The Revised OCRA Checklist Method.

The OCRA Checklist has five parts, each devoted to the analysis of a different risk factor. These risk factors are divided into:

- Four main risk factors: lack of recovery time; movement frequency; force; and awkward postures with stereotyped movements.
- Additional risk factors: vibration transmitted to the hand-arm system, ambient temperatures below 0°C, precision work, kickback, use of inadequate gloves, etc.
- In addition to these factors, the final risk estimate also takes into account the net duration of the exposure to repetitive work.

According to ISO 11228-3, the OCRA Checklist applies to repetitive work in which the presence of risk has been detected;

- The work is characterized by cycles (regardless of the duration thereof);
- The work is characterized by a series of virtually identical technical actions that are repeated for more than half the analyzed working time.

The sum of the partial scores thus obtained gives the overall risk exposure score through correlation with the OCRA Index values in accordance with the following ranges:

- 0 – 7.5 : green level or acceptable risk;
- 7.6 – 11 : yellow level or very low risk;
- 11.1 – 14 : light red level or medium-low risk;
- 14.1 – 22.5 : red level or medium risk; and
- 22.5 : purple level or high risk (Occhipinti & Colombini, 2007).

The following show the calculation of the OCRA checklist final score which takes into consideration of risk factors of MSDs for repetitive motion.

$$\left(\text{Frequency} + \text{Force} + \text{Posture} + \frac{\text{Additional}}{\text{factors}}\right) \times \frac{\text{Duration}}{\text{multiplier}} \times \frac{\text{Recovery}}{\text{multiplier}} = \frac{\text{OCRA}}{\text{Checklist}}$$

Guide for assessment

Step 1: Describe the job or task

In order to estimate the intrinsic exposure level of the task or tasks involved, as if the employee would only be performing that job throughout the entire shift. It is thus necessary to identify which jobs at a company, due to their structural and organizational characteristics, entail different levels of risk (none, low, medium or high), regardless of an individual employee's actual exposure time.

Before analyzing the different risk factors, it is essential to estimate the net duration of the repetitive work in order to ensure a precise risk assessment. Table 1 may help analysts to determine this time, which is calculated by subtracting the following times from the total shift time (time for which the employee is paid):

- The real duration of all breaks (official or otherwise);
- The real duration of the lunch break, provided it is included in the duration of the shift and, thus, paid;
- The estimated duration of non-repetitive work.

Table 1. OCRA Checklist: Calculation of the net duration of repetitive work

ORGANISATIONAL DATA: DESCRIPTION		**MINUTES**
DURATION OF SHIFT	Official	(1)
	Real	
OFFICIAL BREAK	By contract	(2)
OTHER BREAKS (Other than the official one)		
LUNCH BREAK	Official	(3)
	Real	
NON-REPETITIVE WORK (e.g., cleaning, stocking, etc.)	Official	(4)
	Real	
NET DURATION OF REPETITIVE WORK: (1) - (2) - (3) - (4) = (5)		(5)

In the absence of a formal break schedule, employees' 'modal behavior' should be analyzed (by consensus with the different company liaisons) in terms of the use of bathroom and other breaks. Once the net duration of the repetitive work has been calculated, the following formula can be used to estimate the net total cycle time or rate in seconds (Table 2):

$$\text{Net total cycle time} = \frac{\text{Net duration of repetitive work x 60}}{\text{No. of pieces (No. of cycles)}}$$

where 'No. of pieces' is the number of real units completed by the employee in a shift.

Table 2: OCRA Checklist: Calculation of net total time of repetitive work cycle

ORGANISATIONAL DATA: DESCRIPTION		**MINUTES**
NET DURATION OF REPETITIVE WORK: (1) - (2) - (3) - (4) = (5)		(5)
No. of pieces (or cycles)	Scheduled	
	Real	(6)
NET TOTAL CYCLE TIME OR RATE (sec.) (5)*60/(6) = (7)		(7)
TOTAL TIME OF OBSERVED CYCLE or OBSERVATION PERIOD (sec.)		(8)
% DIFFERENCE BETWEEN OBSERVED CYCLE TIME AND OFFICIAL CYCLE TIME (7)-(8)| /(7)=(9)		(9)

It should be noted that, where a significant difference is found between the calculated net total cycle time and the total time of the observed cycle (measured through direct observation of the activity or a video thereof), the real content of the shift should be reconsidered in terms of the duration of the breaks, time spent on non-repetitive work, the number of pieces or cycles completed per employee per shift, etc., in order to properly reconstruct the employee's behavior during the shift. A difference of less than 5%, equal to 20 minutes in the workday, is considered acceptable.

Step 2: Determine the duration of exposure factor

In cases in which the net duration of the repetitive work in a shift is less than 420 minutes or greater than 481 minutes, the value of the final OCRA Checklist score should be corrected to reflect the real duration of the task. The objective is to weight the final risk index for the real duration of the repetitive work.

As shown in Table 3, the proposed duration multiplier increases for each additional hour of exposure.

Table 3. Duration multiplier used to calculate the final OCRA Checklist score based on the net duration of the repetitive work.

MULTIPLIER OF THE NET DURATION OF THE REPETITIVE WORK PERFORMED DURING THE SHIFT	
Net duration of repetitive work (minutes)	Duration multiplier
60 – 120	0.5
121 – 180	0.65
181 – 240	0.75
241 – 300	0.85
301 – 360	0.925
361 – 420	0.95
421 – 480	1
Over 480	1.5

Step 3: Determine the recovery time factor

Recovery time is basically resting time for the upper-limb or when it is physically in inactive mode.

Colombini et al. (2005), suggested that the following can be considered as recovery time:

- Breaks (official or otherwise), including the lunch break, provided it is included as part of the paid workday.

- Sufficiently long periods of work activity in which the muscle groups are at rest (e.g., during visual control tasks).

- Periods within the cycle during which the muscle groups are completely at rest. To be considered significant, these periods must last at least 10 consecutive seconds within the cycle and be repeated every cycle, with a 5:1 ratio of work time to recovery time.

Two assessment stages have been defined:

- The first stage consists in identifying the number of work hours without adequate recovery time, which can be determined based on the 6 classic scenarios or, for a more precise result, by determining the exact number of hours without adequate recovery time (as proposed in the OCRA Index).

- The second stage consists in applying a specific multiplier factor, called the recovery multiplier, to the score determined by the OCRA Checklist equation.

If the task has insufficient number of hours our without adequate recovery time in the workday or shift; the more hours there are without adequate recovery time, the higher the recovery multiplier factor will be.

Step 4: Precise calculation of the number of hours without adequate recovery time

Determining the precise number of hours without adequate recovery time is not conceptually easy task, as breaks are often planned not at specific times in the schedule, but rather at specific times of day, without knowing the exact moment in the schedule when the break will begin. Consequently, a calculation procedure has been defined that is relatively immune to such minor changes in the timing of the breaks within the work shift.

First, the distribution of the breaks over the course of the shift should be graphed. Only those rest periods guaranteed to last at least 8-10 minutes should be considered breaks.

Second, the last 60 minutes of the shift and the 60 minutes prior to the lunch break are indicated as hours with adequate recovery time.

To be considered a 'lunch break', the time provided to eat must have a minimum duration of 30 minutes. Periods lasting less than 30 minutes will simply be considered another break in the shift, but not a 'lunch break'. In such cases, the 60 minutes prior to the break will not, by default, be classified as a work hour with adequate recovery time.

The remaining 60-minute periods within the shift are shown, in order, below, indicating whether or not each one includes adequate recovery time. This step has been carried out from right to left in two parts: first, the segment from the end of the shift to the end of the lunch break; second, the segment from the lunch break to the start of the shift.

Any 60-minute period that includes a break, regardless of its timing within the period, will be counted as 1 hour with adequate recovery time. Any 60-minute period that does not include a break will be counted as 1 hour without adequate recovery time.

In this case, the lunch break cannot be counted as recovery time for the work period spanning from 12:30 pm to 1 pm, as it has already been counted as recovery time for the previous work hour.

The number of hours without adequate recovery time can also be determined with a precision of 0.5 hours. To do so, the following criteria should be applied to both the work period following the lunch break and the work period at the start of the shift:

- Work periods with a duration of less than 20 minutes are counted as periods with adequate recovery time.
- Work periods with a duration of greater than or equal to 20 minutes and less than or equal to 40 minutes are counted as 0.5 hours without adequate recovery time.
- Work periods with a duration of greater than 40 minutes but less than 80 minutes are counted as 1 hour without adequate recovery time.

Upon completion of this step, all hours without adequate recovery time in the shift should be added up.

To better illustrate the procedure, this paper will use the example of an organizational structure in which shifts have a total duration of 8 hours (or 480 minutes) and last from 8 am to 4 pm. Employees are given a lunch break to eat outside their work schedule from 12 to 12:30 pm. There are also two 10-minute breaks beginning at 9:20 am and 2 pm. In the below example this procedure results in 3.5 hours without adequate recovery time, as shown in Figure 1.

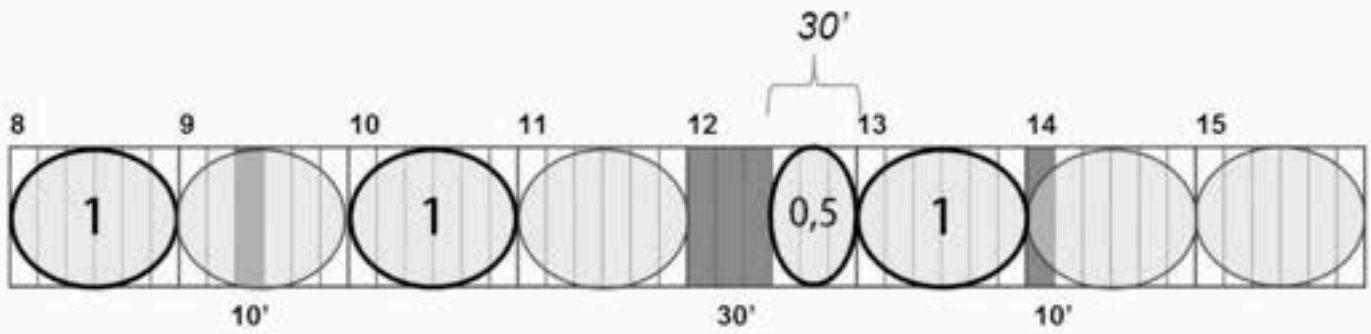


Figure 1: Assessment of work periods without adequate recovery time in the full workday.

Alternatively, the number of hours without adequate recovery time can be estimated based on Table 4.

Table 4: Criteria for estimating the approximate number of hours without adequate recovery time

Duration of shift	No. of hours without recovery	No. of interruptions in the workday considered as recovery: lunch break lasting at least 30 min. and/or No. of (properly distributed) breaks						
		1	2	3	4	5	6	7
480	7	6	5	4	3	2	1	0
460	7	6	5	4	3	2	1	
440	6.5	5.5	4.5	3.5	2.5	1.5	0.5	
420	6	5	4	3	2.5	1.5	0	
390	5.5	4.5	3.5	2.5	1.5	0.5	0	
360	5	4	3	2	1	0		
330	4.5	3.5	2.5	1.5	0.5	0		
300	4	3	2	1	0			
270	3.5	2.5	1.5	0.5	0			
240	3	2	1	0				
210	2.5	1.5	0.5	0				
180	2	1	0					
120	1	0	0					
0	0							

Step 5: Application of the New Recovery Multiplier Factor

The risk factor for lack of recovery time is a multiplier factor applied to the denominator when dividing the number of observed actions by the number of recommended actions. Table 5 shows the multiplier value and its inverse (useful for applying directly to the numerator) for each number of hours without adequate recovery time. The exponential behavior of the data in the table can be seen in Figure 4.

Table 5: OCRA Index – Multiplier for each number of hours without adequate recovery time

No. of hours without adequate recovery time	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**
OCRA INDEX MULTIPLIER FACTOR (applied to the Index denominator)	0.1	0.25	0.45	0.6	0.7	0.8	0.9	1
1 / Multiplier factor	10	4	2.22	1.66	1.428	1.25	1.11	1

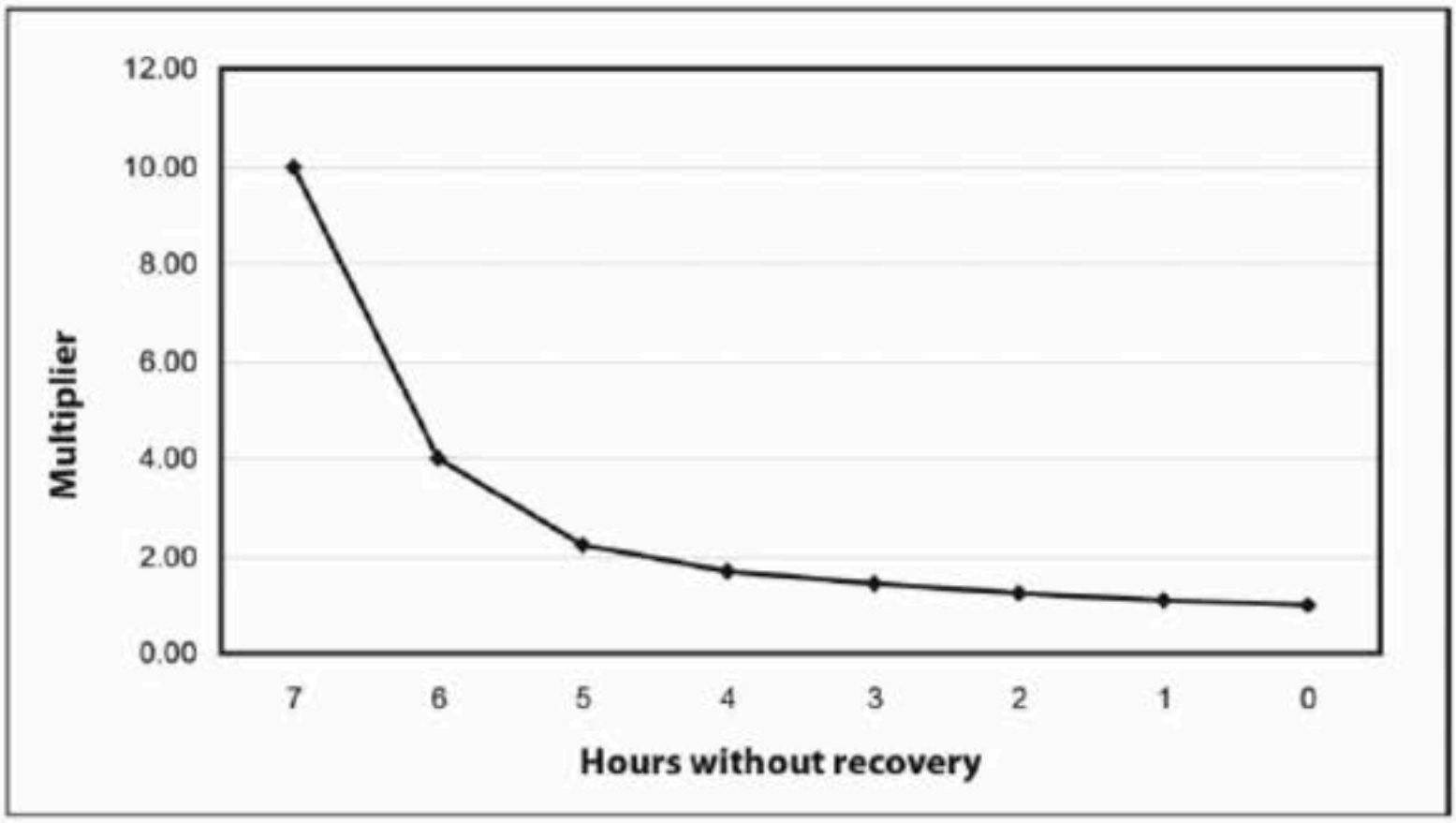


Figure 4: Function of the recovery factor multiplier based on the number of hours without adequate recovery time

To achieve a more logical and effective application of this exponential curve without altering the meaning of the scores currently in use, two restrictions had to be taken into account:

- The sum total of the risk scores for the frequency, posture and additional factors must remain unchanged when all work hours in a shift include adequate recovery time (the recovery multiplier is equal to 1).

- The final score obtained when the recovery score is 4 (in a low-medium risk situation) must be equal to the new multiplier. In fact, in the clinical database correlated to the exposure data on which the OCRA method is based, most cases of exposure have been assigned this recovery score, offering proof of its considerable predictive capacity with regard to the development of work-related musculoskeletal disorders (WMSDs) (Colombini & Occhipinti, 2009). The new curve must be anchored at the point corresponding to the score of 4, and the new multiplier must be modulated based on this restriction.

Table 6 shows the new recovery multiplier thus obtained, as well as the percentage difference (positive or negative) of the final OCRA Checklist score in the case of 4 hours without adequate recovery time.

Figure 6 graphically shows the trend of the revised OCRA Checklist score according to different numbers of hours without adequate recovery time. The new recovery multiplier can be applied according to the following procedure:

- Count the number of hours without adequate recovery time in the shift (as indicated above).

- Identify the multiplier value.

- Apply the multiplier to the sum of the partial scores for the four risk factors (frequency, force, posture and additional factors), as shown in Figure 2.

Table 6: Multiplier values (and intermediate values) for different numbers of hours without adequate recovery time. Also indicated is the positive or negative percentage difference in the case of an 8-hour shift including 4 hours without adequate recovery time.

No. of hours without adequate recovery time	Recovery multiplier	Difference for 4 hours without recovery (%)
0	**1**	-24.8%
0.5	**1.025**	-22.9%
1	**1.05**	-21.1%
1.5	**1.086**	-18.3%
2	**1.12**	-15.8%
2.5	**1.16**	-12.8%
3	**1.2**	-9.8%
3.5	**1.265**	-4.9%
4	**1.33**	0.0%
4.5	**1.4**	5.3%
5	**1.48**	11.3%
5.5	**1.58**	18.8%
6	**1.7**	27.8%
6.5	**1.83**	37.6%
7	**2**	50.4%
7.5	**2.25**	69.2%
8 or more	**2.5**	88.0%

Step 6: Action frequency factor

Because the development of a muscle-tendon disorder is significantly linked to movement frequency, action frequency is an important piece of data to estimate exposure to biomechanical overload.

One way to measure the frequency of mechanical events during the cycle that involve the upper limb in the field is to analytically measure, or to identify and estimate, the number of technical actions in a cycle and then extrapolate this number to the full time unit (number of technical actions/minute = frequency of technical actions) (Colombini et al., 2005) (Occhipinti and Colombini, 2006).

Other criteria for identifying technical actions, such as counting a stage (composed of multiple technical actions) as a single technical action or using the number automatically extrapolated from analytical systems with predetermined methods and times (e.g., MTM, UAS, TMC2, etc.), are not applicable to the OCRA method.

The technical action may be dynamic (characterized by movement) or static (characterized by holding a single posture, such as when a employee must hold an object in his hand). Different methods are used to calculate the scores for dynamic and static technical actions. The higher value should be used for the calculation of the final score, as it will reflect the predominant requirement (dynamic or static).

Step 7: Dynamic Technical Actions factor

The movements carried out in each scenario are qualitatively described in terms of speed (slow, somewhat fast, fast, very fast) and assigned increasing frequency values of between 20 and 70 or more actions per minute at intervals of 10 actions per minute. Once the frequency value of the technical actions has been identified, whether or not the work allows for brief interruptions (at a constant or irregular rate) must be determined.

This second characteristic is used to choose the score for the corresponding scenario, bearing in mind that intermediate values may be used if a more precise result is required. In the case of a technical action frequency of more than 70 actions per minute with the possibility of brief interruptions, the frequency score is 9 rather than 10, to reflect the possibility of the brief interruptions in the cycle.

Experience has shown that analysts often use overly subjective criteria when choosing an intermediate frequency score. To prevent subjective differences in the assignment of intermediate scores, this revised version of the method offers the values in Table 7 as a guide to help analysts ensure proper application.

When brief interruptions are possible, the values in Column A should be used; where they are not, the values in Column B should be used.

Table 7. Intermediate frequency factor scores based on the presence (Column A) or absence (Column B) of brief interruptions.

FREQUENCY	A	B
	Frequency factor score when brief interruptions ARE possible	Frequency factor score when brief interruptions ARE NOT possible
<22.5	0.0	0.0
22.5 to 27.4	0.5	0.5
27.5 to 32.4	1	1
32.5 to 37.4	2	2
37.5 to 42.4	3	4
42.5 to 47.4	4	5
47.5 to 52.4	5	6
52.5 to 57.4	6	7
57.5 to 62.4	7	8
62.5 to 67.4	8	9
67.5 to 72.4	9	10
> 72.4	9	10

Step 8: Static Technical Actions

As described above, static technical actions are actions that require employees to hold an object in their hand for a significant portion of the cycle. The following procedure should be used to calculate the score for static technical actions:

- Identify actions in the cycle requiring employees to hold objects or tools for a time equal to or greater than 5 consecutive seconds.
- Determine the total time spent continuously holding or gripping by taking the sum of the durations of the identified actions.
- Calculate the percentage of the total time spent holding with regard to the net total cycle time (rate).

- Determine the score based on the following relative duration intervals: from 0% to 50%, assign a score of 0; for greater than 50% to 80%, assign a score of 2.5; for greater than 80%, assign a score of 4.5. When both static and dynamic actions occur at the same time (e.g., cutting with a knife, in which the hand is constantly holding the knife handle (static action) as it cuts (dynamic action)), the higher of the two scores (i.e., the score for dynamic actions or the score for static actions) will be taken as the representative frequency factor score.

Step 9: The use of force

Given the difficulty of assessing the internal force exerted without a specific tool, it is suggested that the Borg CR-10 scale be used for both the OCRA Checklist and OCRA Index method by means of interviewing employees and asking them to describe the subjectively perceived muscular effort made when they are carrying out a repetitive task (Colombini et al., 2005) (Occhipinti and Colombini, 2006).

The perceived exertion of the upper limb should be assessed separately for each technical action in the cycle. A practical way to do this is to ignore technical actions requiring a minimal or very light muscular effort (between 0.5 and 2 on the Borg scale) and assess only those technical actions (or groups of actions) requiring at least a 'moderate' effort (score of 3 or higher on the Borg scale).

To complete the assessment, the percentage duration of each level of effort equal to or greater than 3 on the Borg scale should be determined with regard to the total cycle time. Experience has given rise to certain practical suggestions on how best to interview employees in order to obtain reliable information and overcome any doubts with regard to the use of a subjective tool.

To conduct the interview effectively, the following procedure should be followed:

- Ask the employee whether there are any technical actions (the terms 'gestures' or 'movements' may be used instead, as he may not be familiar with the concept of 'technical action') during the cycle that require the use of appreciable muscular force of the upper limb. If the question is not phrased this way, the employee may confuse muscle exertion with the fatigue or exhaustion accumulated over the work shift. The assessment should be made while the indicated technical actions are being performed. Asking an external observer to assess the effort could lead to significant errors. In fact, for actions performed with the fingertips or small joints in certain joint postures (pressing a button, pinch grip, raised arm, etc.), it is difficult for an external observer to perceive the use of force at all, even when the force is significant.

- Once the technical actions requiring the use of force have been identified, ask the employee to attribute one of the labels on the Borg CR-10 scale to each of them using the verbal term, rather than the numerical value (e.g., light, moderate, etc.). Due to the exponential nature of the numerical values of the Borg scale, if numbers are used for the assessment, the employee is more likely to overestimate the effort.

- Subsequently, the analyst should assign a relative duration to each action with regard to the duration of the full cycle.

- Due to the preventive purpose of the assessment procedure, it is important to ask the employee to explain why each of the indicated technical actions requires a physical effort. This information could have immediate practical implications if the presence of force is due to technical defects in the product or to the use of an inefficient tool, whether due to tool failure or the choice of an inadequate tool, as in most cases all such causes can be easily remedied.

The result can be considered more reliable if it is based on interviews with a sufficient number of employees (where possible) who perform the same job: obviously, a larger sample population will significantly reduce the subjectivity of the results. When a group of employees is interviewed, the average will be taken as representative of the employees' opinion.

The opinions of employees who currently suffer or have suffered from upper-limb musculoskeletal disorders in the past should be considered separately, as such employees will likely overestimate the force required for the job.

Table 8 shows the force factor scores, including intermediate values with regard to the previous version of the OCRA Checklist. These values are calculated based on the portion of the cycle during which the force is required (percentage of the duration of the force with regard to the total cycle time) and the value obtained with the Borg scale:

- Extremely heavy, nearly maximal level: score of 8 or more on the Borg scale.

- Heavy level: scores of 5, 6 or 7 on the Borg scale.

- Moderate level: score of 3 or 4 on the Borg scale.

In case of multiple technical actions requiring different levels of force, the final score should be calculated as the sum of the scores assigned to each level.

Table 8: OCRA Checklist: Intermediate Score Used in the High Precision Calculation Model

FORCE OF 3-4		FORCE OF 5-6-7		FORCE OF 8-9-10	
Time as %	Score	Time as %	Score	Time as %	Score
5	0.50	0.33	4.00	0.33	6.00
10	0.50	1.00	8.00	1.00	12.00
18	1.00	1.50	9.00	1.33	13.00
26	1.50	2.00	11.00	1.67	14.00
33	2.00	2.50	11.00	2.00	15.00
37	2.50	3.00	12.00	2.33	16.00
42	3.00	3.50	13.00	2.67	17.00
46	3.50	4.00	14.00	3.00	18.00
50	4.00	4.50	15.00	3.33	19.00
54	4.50	5.00	16.00	3.67	20.00
58	5.00	5.63	17.00	4.00	21.00
63	5.50	6.25	18.00	4.33	22.00
67	6.00	6.88	19.00	4.67	23.00
75	6.50	7.50	20.00	5.00	24.00
83	7.00	8.13	21.00	5.63	25.00
92	7.50	8.75	22.00	6.25	26.00
100	8.00	9.38	23.00	6.88	27.00
		10.0	24.00	7.50	28.00
				8.13	29.00
				8.75	30.00
				9.38	31.00
				10.00	32.00

Step 10: Assessing Awkward Postures in OCRA

A precise description of the main awkward postures and movements required during the activity is helpful in predicting the joint location of work-related muscle-tendon disorders. When assessing the posture factor and quantifying its duration, only those postures and/or movements considered awkward, that is, requiring the joint to work at angles of over 50% of the maximum joint range, should be taken into account (Colombini et al., 2005).

The posture factor is scored using the following steps:

- Separate identification of awkward postures and movements for the scapula-humeral joint (shoulder), elbow, wrist and hand (type of grip and finger movements), for both the left and right sides.

- If the joint must work at an awkward angle, the duration of this work with regard to the full cycle time should be estimated using the values 1/3 (between 25% and 50%), 2/3 (more than 50% and up to 80%) and 3/3 (more than 80%) of the cycle time. Greater precision is required for the shoulder joint, for which intervals of 1/10 of the cycle time are used.

- Use any of the following criteria to determine whether stereotyped movements or static postures are present:

- The presence of identical technical actions or groups of technical actions that are repeated for more than 50% of the cycle time;

- The presence of a static posture that is held unbrokenly for more than 50% of the cycle time (e.g., extended grip of a tool);

- The presence of a very short cycle (lasting less than 15 seconds), provided it includes actions performed with the upper limbs.

The posture conditions for each joint are simple. From a practical standpoint, the following criteria should be used:

- Arm: Determine how long the arm is abducted at an angle of over 80° and/or flexed at an angle of over 80° or extended at an angle of over 20°.

- Elbow: Identify whether movements are made entailing flexion-extension or pronation- supination (nearly complete rotation of the object held in the hand) at angles of over 60°. Assessment of the elbow is an exception as it is the movement, rather than the posture, that is scored as awkward.

- Wrist: Determine how long the wrist remains in an awkward posture (flexed or extended at an angle of over 45° and/or radial deviation of over 15° or clear ulnar deviation of over 20°).

- Hand: Determine whether a non-optimal grip is being used: pinch, palmar grip or hook grip.

Table 9 shows the score values according to the percentage of exposure time to each awkward posture and/or movement.

Table 9: Assessment Scores for awkward shoulder, elbow, wrist and hand postures

Time in awkward posture	Score
Shoulder The arms are kept at about shoulder height, without support, (or in other extreme postures) for	
10% - 24% of the time	2
25% - 50% of the time	6
51% - 80% of the time	12
more than 80% of the time	24
Elbow The elbow executes sudden movements (wide flexion-extension or prono-supination, jerking movements, striking movements) for	
25% - 50% of the time	2
51% - 80% of the time	4
more than 80% of the time	8
Wrist The wrist must bent in an extreme position, or must keep awkward postures (such as wide flexion/extension, or wide lateral deviation) for	
25% - 50% of the time	2
51% - 80% of the time	4
more than 80% of the time	8
Hand The hand take objects or tools in pinch, hook grip, pinch or other different kinds of grasp for	
25% - 50% of the time	2
51% - 80% of the time	4
more than 80% of the time	8

It should be noted that the score for the shoulder takes into consideration the fact that recent studies indicate that there is a significant risk when the arm (or elbow) is held at near shoulder level more than 10% of the time (Punnett et al., 2000).

When a grip is considered optimal, no score should be given. If the grip is not optimal (e.g., when a knife is being used and the employee's index finger is extended forward to guide the tip), the scores shown below, which are lower than those indicated for the hand, may be assigned:

- 1 for 1/3 of the time;
- 2 for 2/3 of the time; and
- 3 for nearly the whole time

Alternatively, if greater precision is required for the assessment of this factor, the intermediate score values shown in Table 10 may be used. Stereotypy can be assessed at two levels:

- High level: A score of 3 is assigned when the cycle time is less than 8 seconds (and, obviously, involves use of the upper limb) or when identical technical actions are performed almost the entire time.
- Intermediate level: A score of 1.5 is assigned when the cycle time is between 8 and 15 seconds or when identical technical actions are performed for 2/3 of the time.

The overall score for the posture factor is the sum of the highest value calculated for a joint segment and the stereotypy value, where applicable.

Table 10: Intermediate scores for calculating the posture factor based on the percentage of time exposed

HAND		SHOULDER		WRIST		ELBOW	
Time (s)	Score	Time (s)	Score	Time (s)	Score	Time (s)	Score
0.05	0.00	0.03	0.50	0.05	0.00	0.05	0.00
0.10	0.50	0.05	1.00	0.10	0.50	0.10	0.50
0.15	1.00	0.08	1.50	0.15	1.00	0.15	1.00
0.20	1.50	0.10	2.00	0.20	1.50	0.20	1.50
0.25	2.00	0.12	2.50	0.25	2.00	0.25	2.00
0.31	2.50	0.14	3.00	0.31	2.50	0.31	2.50
0.37	3.00	0.16	3.50	0.37	3.00	0.37	3.00
0.44	3.50	0.18	4.00	0.44	3.50	0.44	3.50
0.50	4.00	0.20	4.50	0.50	4.00	0.50	4.00
0.54	4.50	0.22	5.00	0.54	4.50	0.54	4.50
0.57	5.00	0.24	5.50	0.57	5.00	0.57	5.00
0.61	5.50	0.25	6.00	0.61	5.50	0.61	5.50
0.65	6.00	0.28	6.50	0.65	6.00	0.65	6.00
0.69	6.50	0.31	7.00	0.69	6.50	0.69	6.50
0.72	7.00	0.34	7.50	0.72	7.00	0.72	7.00
0.76	7.50	0.37	8.00	0.76	7.50	0.76	7.50
0.80	8.00	0.40	9.00	0.80	8.00	0.80	8.00
1.00	8.00	0.43	10.00	1.00	8.00	1.00	8.00
		0.46	11.00				
		0.50	12.00				
		0.54	13.00				
		0.58	14.00				
		0.62	15.00				
		0.66	16.00				
		0.70	17.00				
		0.74	18.00				
		0.78	19.00				
		0.82	20.00				
		0.86	21.00				
		0.90	22.00				
		0.94	23.00				
		1.00	24.00				

Step 11: Additional risk factors

Additional factors are assessed by verifying two blocks of information, as shown in Table 11. The first block refers to additional physico-mechanical factors, while the second block refers to additional socio-organisational factors.

These additional factors have been given these names because they may increase the risk if they are present and should be carefully considered. The maximum score for the additional factor is 5.

Table 11: OCRA Checklist. Assessment of Additional Factor

ADDITIONAL FACTOR	
Choose one answer per block. The final score is the sum of the two partial scores.	
Block A: Physico-mechanical factors	
2	**Inadequate** gloves (uncomfortable, too thick, wrong size) are used more than half the time for the task.
2	Presence of 2 or more sudden, jerky movements per minute.
2	Presence of at least 10 repeated impacts (use of hands as tools to hit) per hour.
2	Contact with cold surfaces (less than 0ºC) or performance of tasks in cold chambers for more than half the time.
2	Use of vibrating tools at least one third of the time. **Assign a score of 4** if these tools involve a high degree of vibration (e.g., pneumatic hammers, etc.).
2	Tools are used that cause compression of muscle and tendon structures (check for the presence of redness, calluses, wounds, etc., on the skin).
2	More than half the time is spent performing precision tasks (tasks on areas of less than 2 or 3 mm), requiring the employee to be physically close to see.
2	More than one additional factor (e.g., ...) is present at the same time for more than half the time.
3	One or more additional factors (e.g., ...) are present almost the entire cycle.
Block B: Socio-organisational factors.	
1	The work rate is determined by the machine, but 'recovery spaces' exist allowing the rate to be sped up or slowed down.
2	The work rate is entirely determined by the machine.

In the first block, which deals exclusively with physico-mechanical factors, a score of 2 is assigned for the duration (more than 50% of the time) or frequency (number of events per minute) of the described circumstance. A score of 3 is assigned when several factors are present at the same time for nearly the entire cycle.

In the second block, which deals with socio-organizational factors, two situations are indicated as risk factors requiring a score:

- A score of 1 is assigned when the work rate is determined by the machine but there is 'breathing room' to partially modulate the rate (e.g., an assembly line in which a certain number of production units can accumulate between the position of one employee and the next).

- A score of 2 is assigned when the work rate is entirely determined by the machine. This is the case when employees must operate on a line (assembly line, conveyor belt, etc.) at a predefined and constant speed.

- Intermediate and lower scores can be used to assess this risk factor, but higher ones cannot.

- A single answer is chosen for each block, and the sum of the partial scores gives the final additional factor score.

Step 12: Calculate the final OCRA Checklist score

The value of the final Revised OCRA Checklist score is the sum of the partial scores for each of the risk factors (frequency, force, posture and additional factors), calculated separately for the right and left upper limbs, multiplied by the values of the recovery factor and the duration factor.

Given that the numerical values obtained with the OCRA Checklist method have been calibrated with the calculation model used for the OCRA exposure index, the final score can be assessed using the same criteria used with the OCRA Index values (Occhipinti & Colombini, 2007).

Table 12: Classification Criteria (according to exposure level) of OCRA index and OCRA Checklist

OCRA CHECKLIST	OCRA INDEX	LEVEL	RISK	Predicted employee population with WMSDs (%)
< 7.5	<2.2	Green	Acceptable risk	< 5.3
7.6 – 11.0	2.3 – 3.5	Yellow	Very low risk	5.3 - 8.4
11.1 – 14.0	3.6 - 4.5	Light red	Medium-low risk	8.5- 10.7
14.1 – 22.5	4.6 – 9.0	Dark red	Medium risk	10.8- 21.5
≥ 22.6	≥ 9.1	Purple	High risk	>21.5

For each level of risk from OCRA Checklist, a range of values of the OCRA Index can be associated, which are shown in Table 12. As proved in the literature (Occhipinti & Colombini, 2007), a mid- to long-term forecasting model based on known OCRA Index values can be used to estimate the possible occurrence of UL-WMSDs.

Worker Exposure Index:

The OCRA Checklist score assigned to a job is also assigned to the worker, providing the workday or shift lasts between 7 and 8 hours and the worker is performing the task in question the entire time. For shorter or longer workdays, the worker's exposure must be weighted based on the real duration.

If, in contrast, the worker rotates between multiple jobs requiring repetitive tasks over the course of an 8-hour workday, the exposure index is calculated using a multitask exposure index.

There are two multitask exposure indexes (Colombini & Occhipinti, 2008) (Occhipinti & Colombini, 2008), depending on whether the worker switches tasks once or more an hour, which we will call hourly rotation, or at intervals of greater than one hour. With hourly rotations, the worker's exposure index is the arithmetic mean of the OCRA Checklist scores for each task weighted by time, as indicated in the following formula:

$$MEI = (\text{point A} \times \%PA) * (\text{point B} \times \%PB)$$

where,

MEI	:	Multitask exposure index
Point A	:	The value of the real exposure index for task A.
%PA	:	Percentage of the duration of the shift spent performing task A.
Point B	:	Is the value of the real exposure index for task B.
%PB	:	Percentage of the duration of the shift spent performing task B.

This formula is applicable, providing the rotation between tasks occurs at least once an hour. For exposures of greater than one hour to a single job, the value is considerably higher. The OCRA system for analyzing exposure to biomechanical overload of the upper limbs

To calculate a worker's exposure index when the worker rotates between jobs or switches between repetitive tasks but nevertheless performs each one for more than 1 consecutive hour, the following calculation model is proposed:

- Step 1: Calculate the Real Exposure Index (REI) for each of the tasks, considering the value of the duration multiplier equivalent to the total duration of the task (total exposure time) within the work shift. The recovery multiplier factor is obviously the same for all tasks.

- Step 2: Order the tasks from highest to lowest REI value. The task with the highest REI value will be called Task 1, its REI OCRA1 and its duration Dum1.

- Step 3: Apply the following formula to calculate the multitask exposure index:

$$MEI = OCRA_{1(Dum1)} + (\Delta ocra_1 \times K)$$

where,

MEI : Multitask exposure index
$OCRA_{1(Dum1)}$: The highest calculated REI value considering the total duration of the task within the shift.

$\Delta ocra_1$: The highest calculated REI value considering the total duration of the repetitive work within the shift (sum of the duration of each of the tasks) less $OCRA_{1(Dum1)}$.

and where

$$K = \frac{\sum_{i=1}^{i=N} Ocra_{imax} \times FT_i}{Ocra_{1max}}$$

where,

i,...N : Repetitive work tasks
$Ocra_{imax}$: The REI of task i calculated taking into consideration the total duration of the repetitive work within the shift.
FT_i : Fraction of the duration of task i (value between 0 and 1) with regard to the total duration of the repetitive work.
$Ocra_{1max}$: The highest calculated REI value for the tasks, calculated taking into consideration the total duration of repetitive work within the shift.

Appendix 5D: WORKSTATION DESIGN - RAPID OFFICE STRAIN ASSESSMENT (ROSA)

Rapid Office Strain Assessment (ROSA)

ROSA is a picture based posture checklist designed to quantify exposure to risk factors in an office work environment. ROSA is modelled after other picture based checklists and chart scoring systems such as RULA and REBA.

The goal of the ROSA process is to serve as a screening tool to identify areas of priority in large office based organizations.

ROSA Results

Research has shown a correlation between discomfort levels and increasing ROSA scores. Inter and intra-rater reliability has also been shown to be good to very good.
Scores of greater than 5 are deemed to be "high risk" and the workstation should be assessed further.

ROSA Methods

The following are instructions on how to select postures using the ROSA checklist.

SECTION A – THE CHAIR

Chair Height and Pan Depth

Select the position of the seat height and chair pan. The first position in the left column indicates the neutral position. This corresponds with a score of "1". The remaining positions are marked with increasing scores. Those sections with scores such as (+1) (ie., Insufficient Space Under Desk) are additive scores. These can be added on to the other scores. For Example, if the chair height is too high (2), and it is non-adjustable (+1), this becomes a score of 3. The score from the Chair Height is then added to the Pan Depth to receive the final score from this section. This score will correspond with the vertical axis along the Section A scoring chart.

seat pan height /depth	Arms / Back rest							
	2	3	4	5	6	7	8	9
2	1	2	3	4	5	6	7	8
3	2	2	3	4	5	6	7	8
4	3	3	3	4	5	7	7	8
5	4	5	4	4	5	7	7	8
6	5	5	5	5	5	8	8	9
7	6	6	6	7	7	8	9	9
8	7	7	7	8	8	9	9	9

Scoring Examples – Chair Height

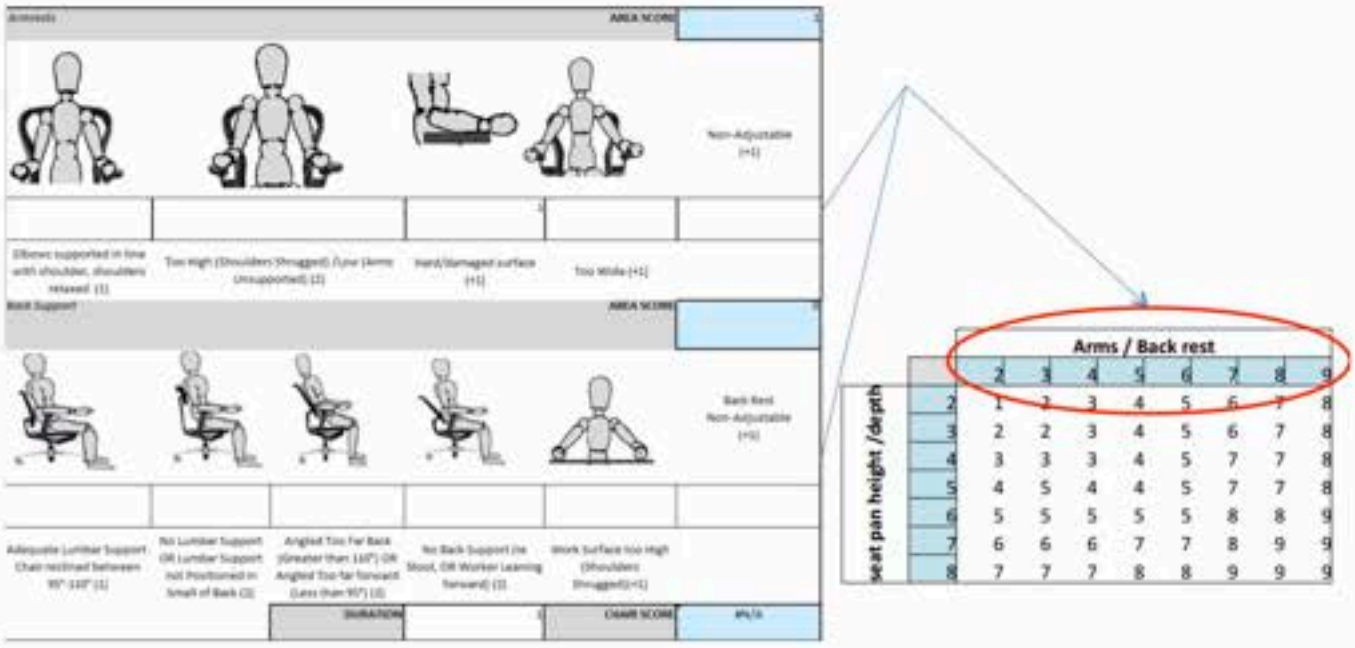
Risk Factor	Example	Picture
Too low	The height adjustment cylinder is set to its lowest height, and the worker is tall.	
Too high	The knee angle is greater than 90 degrees, and there is pressure under the thigh.	
Too high – no foot contact	The worker is using a stool or lab height chair, so the feet cannot physically touch the floor.	
Insufficient space under the desk	The keyboard tray or a computer tower blocks the legs from moving freely under the desk.	

Scoring Examples – Chair Depth

Risk Factor	Example	Picture
Seat pan depth – too long	There is less than 2-3" of space behind the knee when the person sits back in the chair.	
Seat pan depth – too short	There is more than 2-3" of space behind the knee when the person sits back in the chair. This may focus pressure on the underside of the thigh, and the thigh will not be supported.	

Arm Rests, Back Support and Duration of Sitting

Select the position of the arm rests. Once again, the scores that can be added on to postures are indicated by a (+) in front of the number. The scores from both the arm rest section and the backrest section combined will amount to the score across the top axis on the scoring chart.



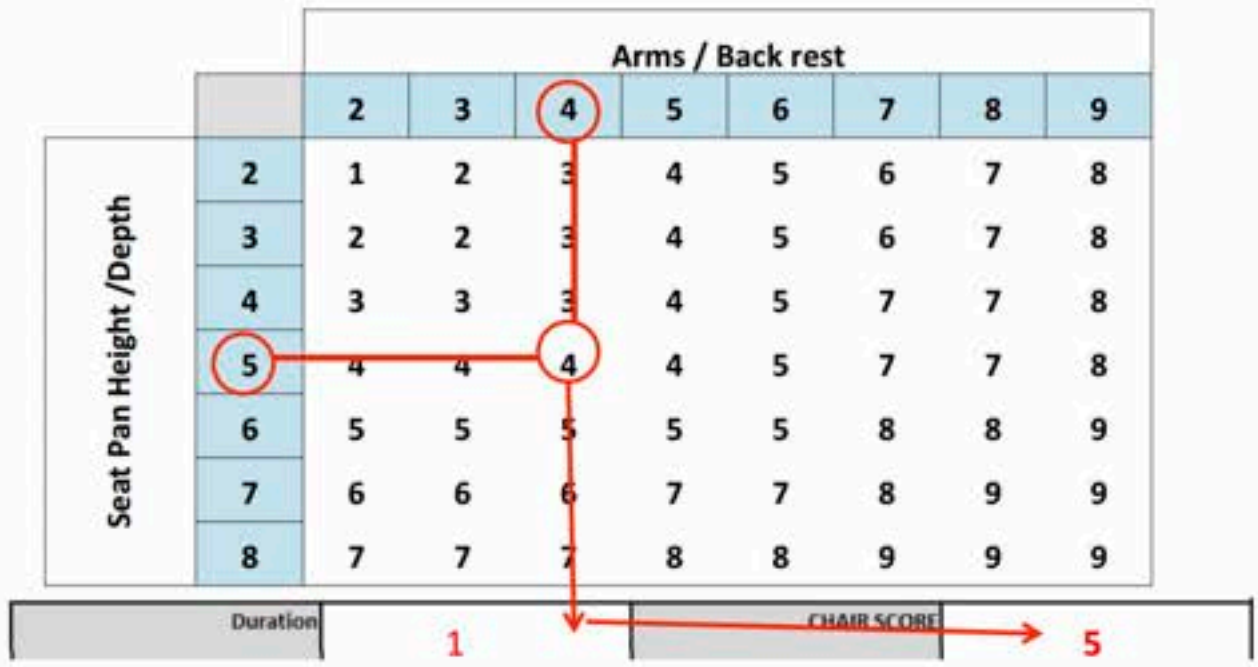
	2	3	4	5	6	7	8	9
2	1	2	3	4	5	6	7	8
3	2	2	3	4	5	6	7	8
4	3	3	3	4	5	7	7	8
5	4	5	4	4	5	7	7	8
6	5	5	5	5	5	8	8	9
7	6	6	6	7	7	8	9	9
8	7	7	7	8	8	9	9	9

Scoring Examples – Armrest

Risk Factor	Example	Picture
Armrests too low	There armrests do not support the forearms with the elbows bent to 90 degrees	
Armrests too high	The shoulders are shrugged when the forearm is on the armrest and the elbow is at 90 degrees.	
Hard or Damaged Surface	The armrest is made of a hard plastic/wood or metal, and this creates a pressure point on the forearm.	

Scoring Examples – Backrest

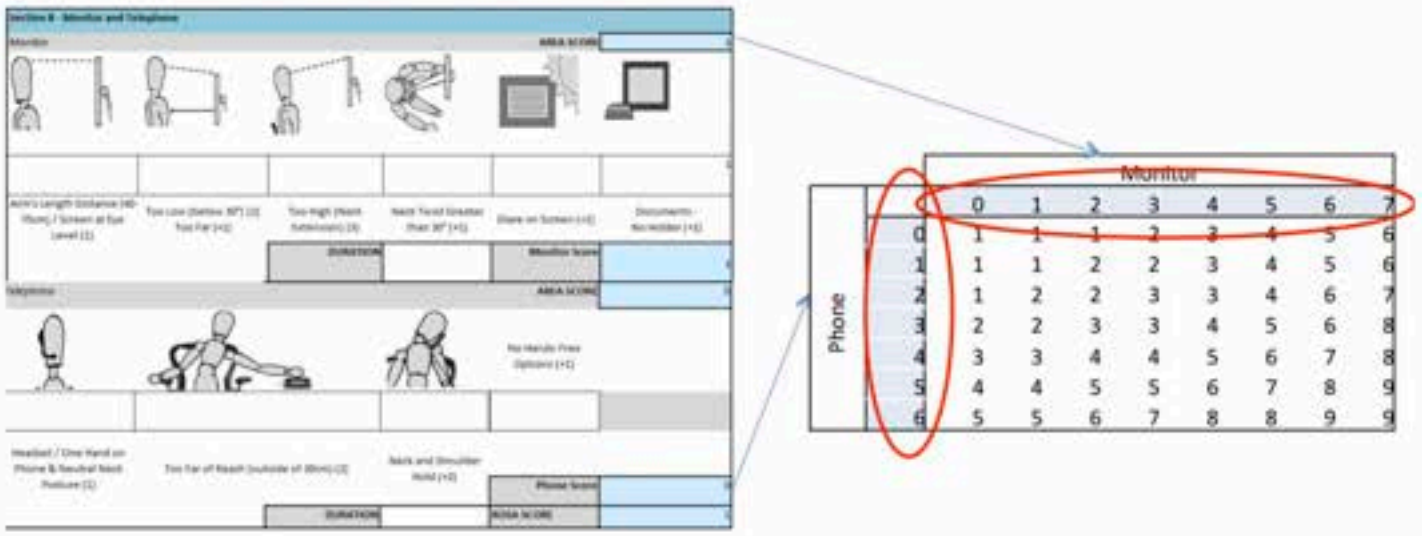
Risk factor	Example	Picture
No lumbar support	The chair has a flat backrest, possibly a plastic or board room chair. This is usually seen in less expensive models. The chair may have lumbar support and it is not positioned correctly in the lower back	 
Angled too far back	The backrest recline is too far back, causing the person to either sit forward, or reach to the keyboard.	
No Back Support	The worker is using a stool or the backrest is not positioned against the back	



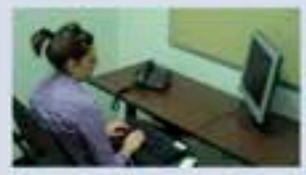
The combined score from the arm and back rest section will then be compared on the horizontal axis against the seat pan depth and height on the vertical axis. The square in which the scores land will then be the score for the chair. To account for the duration that the worker spends in the chair per day, a score of -1 will be assigned if the worker spends less than 1 hour a day in the chair throughout the day, or for less than 30 minutes consecutively. If the worker spends 1-4 hours a day intermittently, or between 30 minutes to 1 hour continuously in the chair, the duration score is 0. If the worker spends more than 4 hours a day in the chair intermittently, or greater than 1 hour consecutively, the duration score will be +1. Add the duration score to the chair score to receive your final chair score. This will represent your score for section A, which will be used later to achieve a final score for the office.

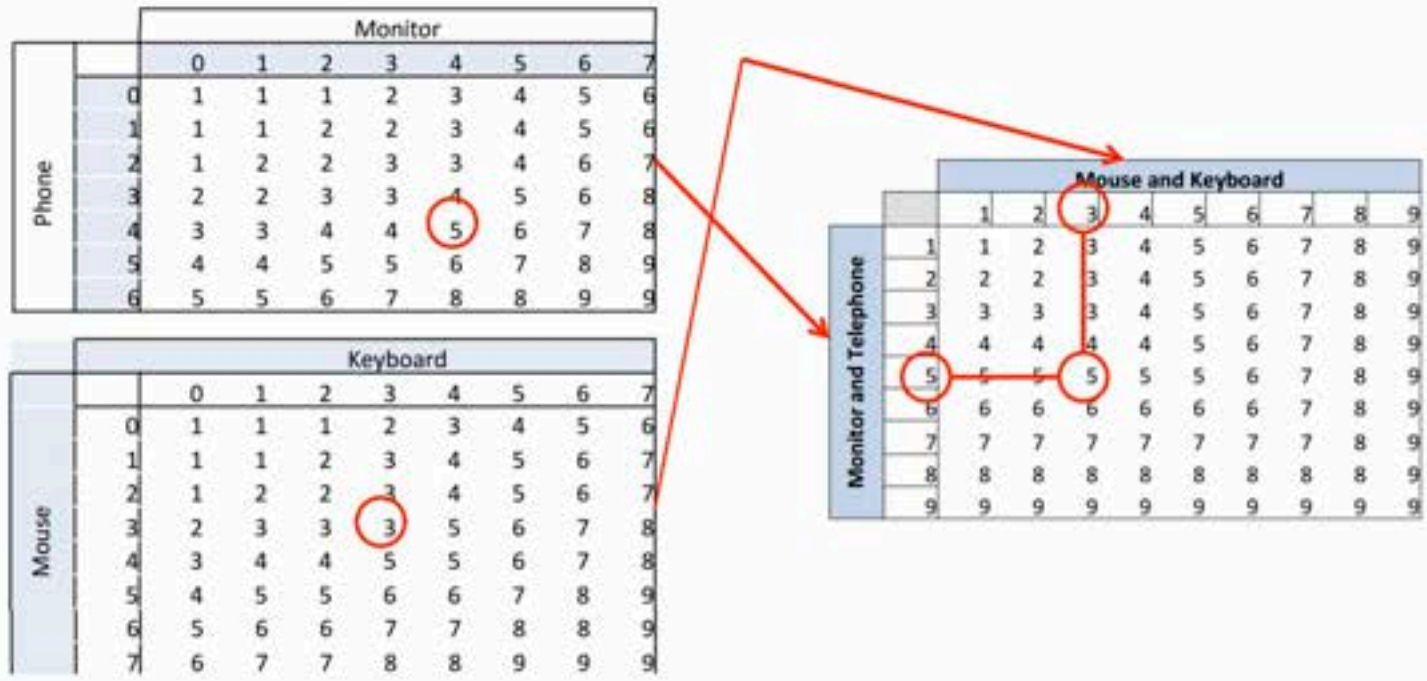
SECTION B – TELEPHONE AND MONITOR

Select the scores as present related to the monitor position for the worker. With this score, add 1 for use of the monitor of greater than 4 hours per day intermittently, or 1 hour consecutively. Add a duration score of 0 if the work is between 1-4 hours intermittently, or 30minutes to 1 hour consecutively. Subtract 1 if there is less than 1 hour of work done per day intermittently, or less than 30 minutes consecutively. This score is then to be used along the horizontal axis Select a score related to the position and usage of the telephone. Add in a duration factor of +1, 0 or -1 based on the amount of time the worker spends on the phone per day. This score is then to be used along the vertical axis. Compare the score between the horizontal and vertical axis as done with the chair score. This score becomes the Section B ROSA score, which will be used again later to receive the grand score.

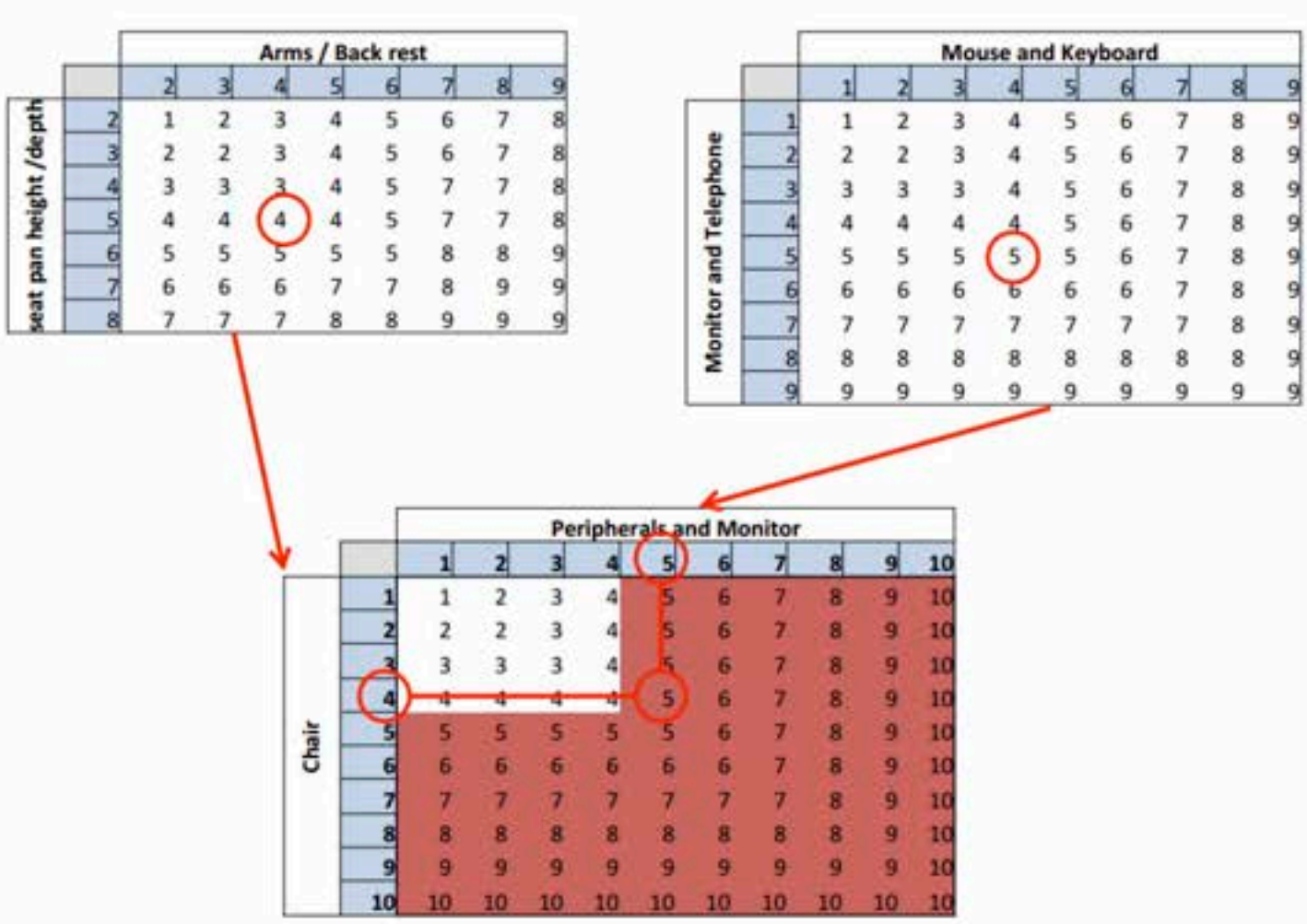


Scoring examples – Monitor

Risk Factor	Example	Picture
Monitor too low	The top of the screen is 30 degrees below the sitting eye height causing neck flexion	
Monitor too high	The top of the screen is above eye level, causing the neck to be extended while viewing the screen.	
Neck twist	The monitor is positioned to the side of the worker, or dual screens may cause the worker to rotate the head back and forth.	
Documents used – no document holder	The worker has to flex and twist the neck in order to view papers positioned on the desk	



The score from Section A is seen along the vertical axis, and the score from section B and C is seen along the horizontal axis. These scores are then combined through this final scoring chart to receive the ROSA final score from the office. The ROSA final score is broken into two areas: further assessment not immediately required, and further assessment required as soon as possible.

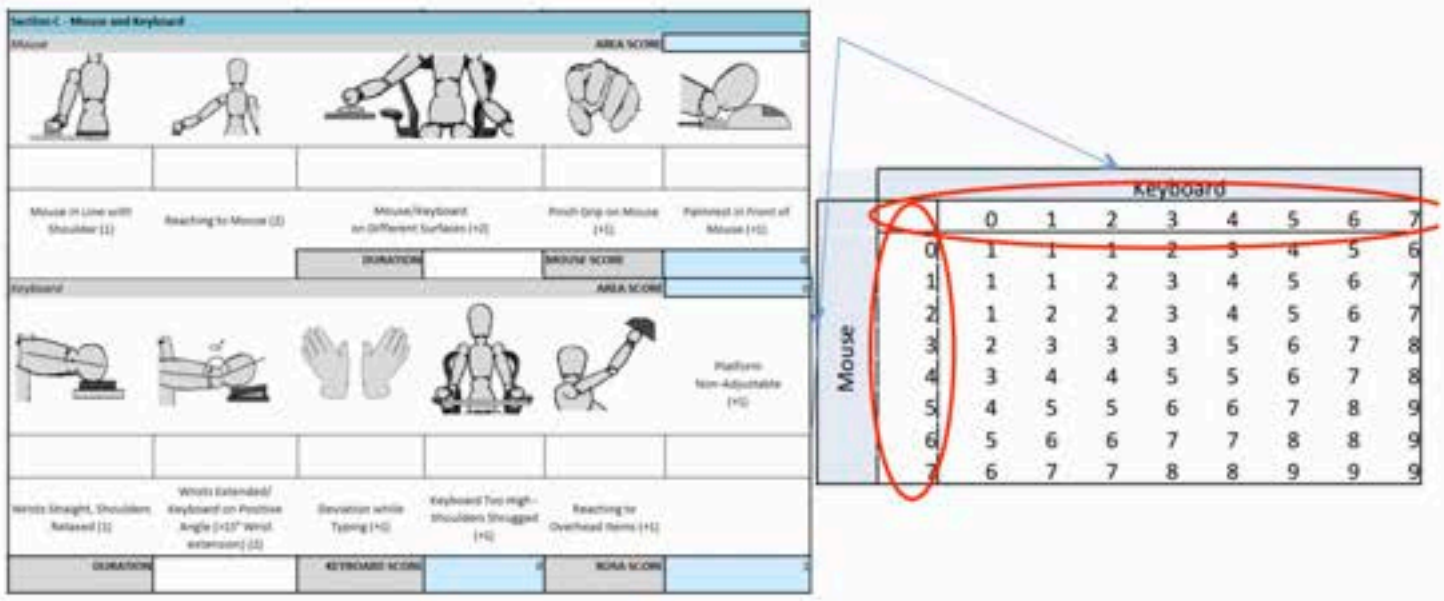


Scoring Examples – Telephone

Risk factor	Example	Picture
Too far – reach	The phone is positioned at the back of the desk, and when it rings, the worker has to extend and bend over the surface to grab the handset.	
Neck and Shoulder hold	The worker has to use the phone and computer at the same time, and in order to type, they will pinch the handset between the neck and the shoulder.	

SECTION C – KEYBOARD AND MOUSE

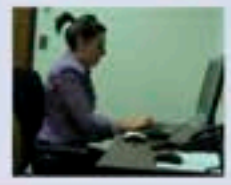
Select a score based on the position of the keyboard. If the keyboard is used for greater than 4 hours per day intermittently, or 1 hour consecutively, use a duration score of +1. For between 1-4 hours intermittently, or 30minutes to 1 hour consecutively, use a score of 0. For 1 hour or less intermittently, or less than 30 minutes consecutively, use a score of -1. Select a score based on the mouse position. If the mouse is used for greater than 4 hours per day intermittently, or 1 hour consecutively, use a duration score of +1. For between 1-4 hours intermittently, or 30minutes to 1 hour consecutively, use a score of 0. For 1 hour or less intermittently, or less than 30 minutes consecutively, use a score of -1. Select a score by finding the intersection between the keyboard and mouse scores. This score will now be used to retrieve a score for the peripherals, monitor and telephone.



Scoring Examples – Mouse

Risk Factor	Example	Picture
Pinch grip on mouse	The mouse is small (such as a notebook mouse) leading to a pinching of the mouse.	
Reach to mouse	The mouse is out to the side of the keyboard, causing abduction of the arm. This may because the person is small through the shoulders, and the numeric keypad causes further mouse position.	
Different surfaces	Mouse reach may also be cause if the keyboard tray is too small, and the mouse is on a separate surface.	

Scoring Examples – Keyboard

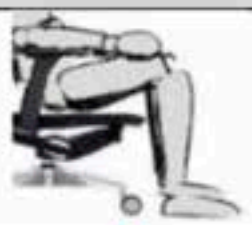
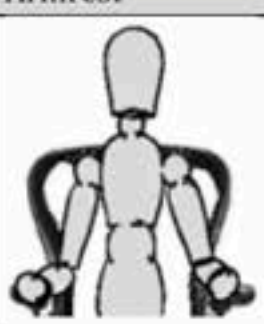
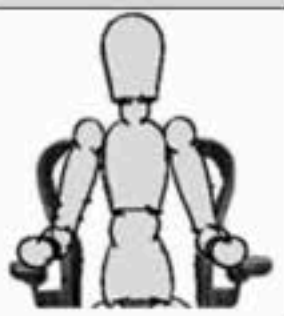
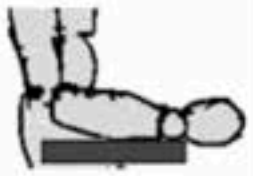
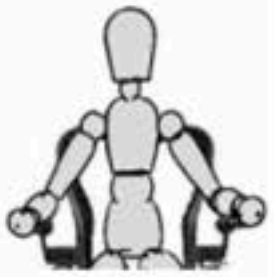
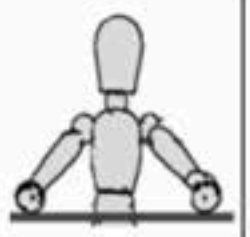
Risk Factor	Example	Picture
Wrists extended	The tray may be angled, or the legs on the back of the keyboard may be up causing the wrists to be extended while typing.	
Deviation while typing	A small keyboard can cause wrist deviation while typing (ie, laptop keyboards)	
Keyboard tray too high	When typing, the shoulders are shrugged in order to rest the arms or hands on the appropriate desk surface.	

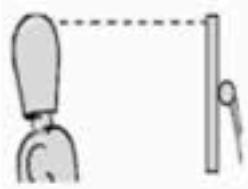
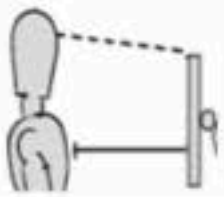
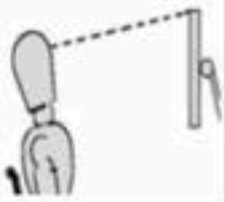
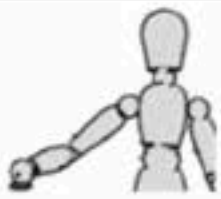
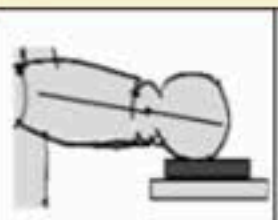
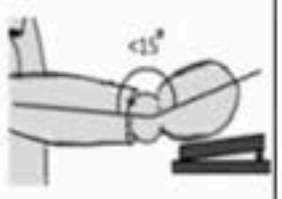
PERIPHERALS AND MONITOR/PHONE SCORE

Using the score retrieved from the Monitor and Phone score in Section B, highlight the correct number on the horizontal axis. Using the correct score retrieved from the monitor and telephone section, highlight the correct number on the vertical axis. Find the corresponding value within the scoring chart.

The value found from this scoring chart will now be used to find a final score by comparing it against the value retrieved from Section A – The Chair.

Example 1:

Section A - Chair					
Chair Height				Area Score	2
					Non-Adjustable (+1)
	2				
Knees at 90°(1)	Too low- Knee Angle < 90°(2)	Too High – Knee Angle >90°(2)	No foot contact on ground (3)	Insufficient Space Under Desk – Ability to Cross Legs (+1)	
Pan Depth				Area Score	3
			Non-Adjustable (+1)		
	2			1	
Approximately 3 inches of space between knee and edge of seat (1)	Too Long – Less Than 3°of space (2)	Too Short – More than 3°of space (2)			
Armrest				Area Score	3
				Non-Adjustable (+1)	
	2			1	
Elbows supported in line with shoulder, shoulders relaxed (1)	Too high (shoulders shrugged) / Low (Arms Unsupported) (2)	Hard/damaged surface (+1)	Too wide (+1)		
Back support				Area Score	3
					Back rest non-adjustable (+1)
	2				1
Adequate lumbar support – Chair reclined between 95°-110°(1)	No lumbar support OR Lumbar support not positioned in small of back (2)	Angled too far back (greater than 110°) OR Angled too far forward (less than 95°) (2)	No back support (i.e: stool OR worker leaning forward) (2)	Work surface too high (shoulders shrugged) (+1)	
		Duration	1	Chair Score	

Section B – Monitor and Telephone					
Monitor				Area Score	
					
	2				
Arm's length distance (40 -75 cm)/screen at eye level (1)	Too low (below 30°) (2) Too far (+1)	Too high (neck extension (3)	Neck twist greater than 30°(+1)	Glare on screen (+1)	Documents no holder (+1)
			Duration 1	Monitor Score	
Telephone				Area Score	
				No hands free options (+1)	
			2		
Headset/One hand on phone & Neutral neck posture	Too far of reach (outside of 30 cm) (2)		Neck and shoulder hold (+2)		
				Phone score	
			Duration -1	ROSA Score	
Section C – Mouse and Keyboard					
Mouse				Area Score	
					
	2				
Mouse in line with shoulder (1)	Reaching to mouse (2)	Mouse/Keyboard on different surfaces (+2)		Pinch grip on mouse (+1)	Palm rest in front of mouse (+1)
			Duration 1		
					Platform non-adjustable
	2				1
Wrists straight, shoulders relaxed (1)	Wrists extended/keyboard on positive angle (> 15° wrist extension) (2)	Deviation while typing (+1)	Keyboard tray too high (+1)	Reaching to overhead items (+1)	
			Duration 1	ROSA Score	

Example 1

seat par height /depth \ Arms / Back rest	2	3	4	5	6	7	8	9
2	1	2	3	4	5	6	7	8
3	2	2	3	4	5	6	7	8
4	3	3	3	4	5	7	7	8
5	4	4	4	4	5	7	7	8
6	5	5	5	5	5	8	8	9
7	6	6	6	7	7	8	9	9
8	7	7	7	8	8	9	9	9

Chair Score = 5 +1 FOR DURATION = 6

Mouse = 2 + 1 = 3

Keyboard = 3 +1 = 4

Mouse \ Keyboard	0	1	2	3	4	5	6	7
0	1	1	1	2	3	4	5	6
1	1	1	2	3	4	5	6	7
2	1	2	2	3	4	5	6	7
3	2	3	3	3	5	6	7	8
4	3	4	4	5	5	6	7	8
5	4	5	5	6	6	7	8	9
6	5	6	6	7	7	8	8	9
7	6	7	7	8	8	9	9	9

Monitor = 2 +1 = 3

Phone \ SCORE Monitor	0	1	2	3	4	5	6	7
0	1	1	1	2	3	4	5	6
1	1	1	2	2	3	4	5	6
2	1	2	2	3	3	4	6	7
3	2	2	3	3	4	5	6	8
4	3	3	4	4	5	6	7	8
5	4	4	5	5	6	7	8	9
6	5	5	6	7	8	8	9	9

Phone = 2 -1 = 1

Monitor and Telephone \ Mouse and Keyboard	1	2	3	4	5	6	7	8	9
1	1	2	3	4	5	6	7	8	9
2	2	2	3	4	5	6	7	8	9
3	3	3	3	4	5	6	7	8	9
4	4	4	4	4	5	6	7	8	9
5	5	5	5	5	5	6	7	8	9
6	6	6	6	6	6	6	7	8	9
7	7	7	7	7	7	7	7	8	9
8	8	8	8	8	8	8	8	8	9
9	9	9	9	9	9	9	9	9	9

Example 1

Chair Score = 5 +1 FOR DURATION = 6

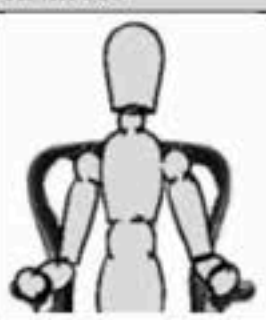
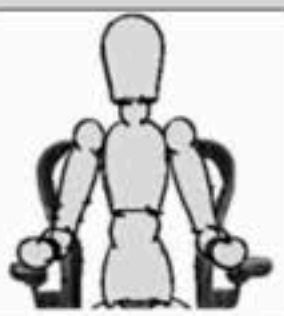
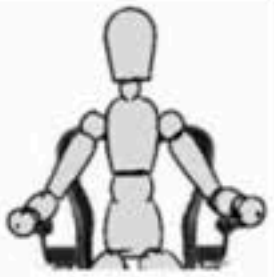
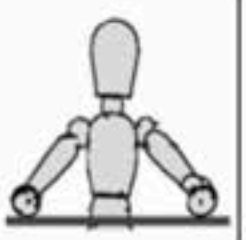
seat pan height /depth \ Arms / Back rest	2	3	4	5	6	7	8	9
2	1	2	3	4	5	6	7	8
3	2	2	3	4	5	6	7	8
4	3	3	3	4	5	6	7	8
5	4	4	4	4	5	6	7	8
6	5	5	5	5	6	7	8	9
7	6	6	6	7	7	8	8	9
8	7	7	7	8	8	9	9	9

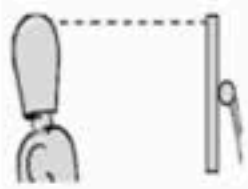
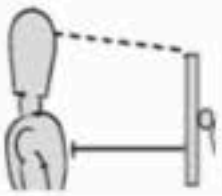
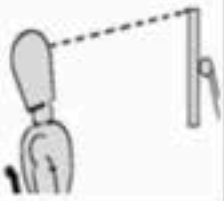
Monitor and Telephone \ Mouse and Keyboard	1	2	3	4	5	6	7	8	9
1	1	2	3	4	5	6	7	8	9
2	2	2	3	4	5	6	7	8	9
3	3	3	3	4	5	6	7	8	9
4	4	4	4	4	5	6	7	8	9
5	5	5	5	5	5	6	7	8	9
6	6	6	6	6	6	6	7	8	9
7	7	7	7	7	7	7	7	8	9
8	8	8	8	8	8	8	8	8	9
9	9	9	9	9	9	9	9	9	9

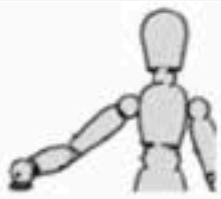
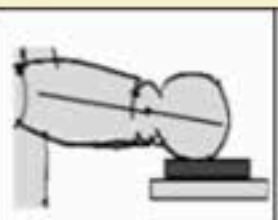
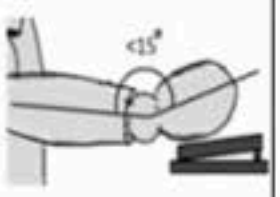
Chair \ Peripherals and Monitor	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	2	2	3	4	5	6	7	8	9	10
3	3	3	3	4	5	6	7	8	9	10
4	4	4	4	4	5	6	7	8	9	10
5	5	5	5	5	5	6	7	8	9	10
6	6	6	6	6	6	6	7	8	9	10
7	7	7	7	7	7	7	7	8	9	10
8	8	8	8	8	8	8	8	8	9	10
9	9	9	9	9	9	9	9	9	9	10
10	10	10	10	10	10	10	10	10	10	10

The Grand ROSA score for Example 1 is 6.

ROSA Form

Section A - Chair					
Chair Height				Area Score	
					Non-Adjustable (+1)
Knees at 90°(1)	Too low- Knee Angle < 90°(2)	Too High – Knee Angle >90°(2)	No foot contact on ground (3)	Insufficient Space Under Desk – Ability to Cross Legs (+1)	
Pan Depth				Area Score	
				Non-Adjustable (+1)	
Approximately 3 inches of space between knee and edge of seat (1)		Too Long – Less Than 3°of space (2)	Too Short – More than 3°of space (2)		
Armrest				Area Score	
				Non-Adjustable (+1)	
Elbows supported in line with shoulder, shoulders relaxed (1)	Too high (shoulders shrugged) / Low (Arms Unsupported) (2)	Hard/damaged surface (+1)	Too wide (+1)		
Back support				Area Score	
					Back rest non-adjustable (+1)
Adequate lumbar support – Chair reclined between 95°-110°(1)	No lumbar support OR Lumbar support not positioned in small of back (2)	Angled too far back (greater than 110°) OR Angled too far forward (less than 95°) (2)	No back support (i.e: stool OR worker leaning forward) (2)	Work surface too high (shoulders shrugged) (+1)	
		Duration		Chair Score	

Section B – Monitor and Telephone					
Monitor				Area Score	
					
Arm's length distance (40 -75 cm)/screen at eye level (1)	Too low (below 30°) (2) Too far (+1)	Too high (neck extension (3)	Neck twist greater than 30°(+1)	Glare on screen (+1)	Documents no holder (+1)
		Duration		Monitor Score	
Telephone				Area Score	
				No hands free options (+1)	
Headset/One hand on phone & Neutral neck posture	Too far of reach (outside of 30 cm) (2)		Neck and shoulder hold (+2)		
				Phone score	
		Duration		ROSA Score	

Section C – Mouse and Keyboard					
Mouse				Area Score	
					
Mouse in line with shoulder (1)	Reaching to mouse (2)	Mouse/Keyboard on different surfaces (+2)		Pinch grip on mouse (+1)	Palm rest in front of mouse (+1)
		Duration			
					Platform non-adjustable
Wrists straight, shoulders relaxed (1)	Wrists extended/keyboard on positive angle (> 15° wrist extension) (2)	Deviation while typing (+1)	Keyboard tray too high (+1)	Reaching to overhead items (+1)	
		Duration		ROSA Score	

Appendix 5E: VIBRATION ANALYSIS - Measurement, Evaluation and Assessment of Human Response to Vibration

A. WHOLE BODY VIBRATION

1. Introduction

Vibration is transmitted through the several contact surfaces to the human body when one rides on vehicles. The contact surfaces of body during transmission are:

- Hip (in contact with the seat surface)
- Back (in contact with the seat back
- Foot (in contact with the foot rest / floor)

2. Possibility of WBV exposure

- Road transport: Cars, vans, trucks, buses, coaches, carriages, motorcycles, and pedal cycles
- Off-road vehicles: Tractors, earth-moving machinery, forest machines, tanks, and animal riding
- Marine systems: Ships, boats, hovercrafts, hydrofoil, submarines, swimmers, and divers
- Railway transport: Trains, monorails, ski lifts, and cable cars
- Aerospace systems: Fixed-wing aircraft, rotary-wing aircraft, and spacecraft
- Building: Houses, offices, workshops, off-shore structures, lifts and escalators
- Industrial equipment: Cranes, fork-lift trucks, and equipment control stations

3. Whole-body vibration syndrome

Disorders caused by WBV is called WBV syndrome, which includes

- Low back pain and other back disorder
- Neck and shoulder disorders
- Digestive circulatory disorders
- Cochleo-vestibular and reproductive effects

4. Evaluation of Risk

The risk assessment should:

- Identify where there may be a health or safety risk for which whole-body vibration is either the cause or a contributory factor;
- Estimate workers' exposures and compare them with the exposure action value and exposure limit value;
- Identify the available risk controls;
- Identify the steps taken to control and monitor whole-body vibration risks;
- Record the assessment, the steps that have been taken and their effective
- In addition, non-vibration factors
- Poor posture while driving/operating plant;

- Sitting for long periods without being able to change position;
- Poorly placed control operations, which require the driver/operator to stretch or twist;
- Poor visibility of the operation, which requires twisting and stretching to get an adequate view;
- Manual lifting and carrying of heavy or awkward loads;
- Repeatedly climbing into or jumping out of a high or difficult access cab

5. Determining exposure duration

Before the daily vibration exposure ($A(8)$ or VDV) can be estimated, the total daily duration of exposure to the vibration from the vehicles machines used must be observed. Be careful to use data that is compatible with the vibration magnitude data, for example, if the vibration magnitude data is based on measurements when the machine was working, then count only the time that the worker is exposed to vibration.

6. Measurement of WBV and Determining Vibration Magnitude

a) ISO standard

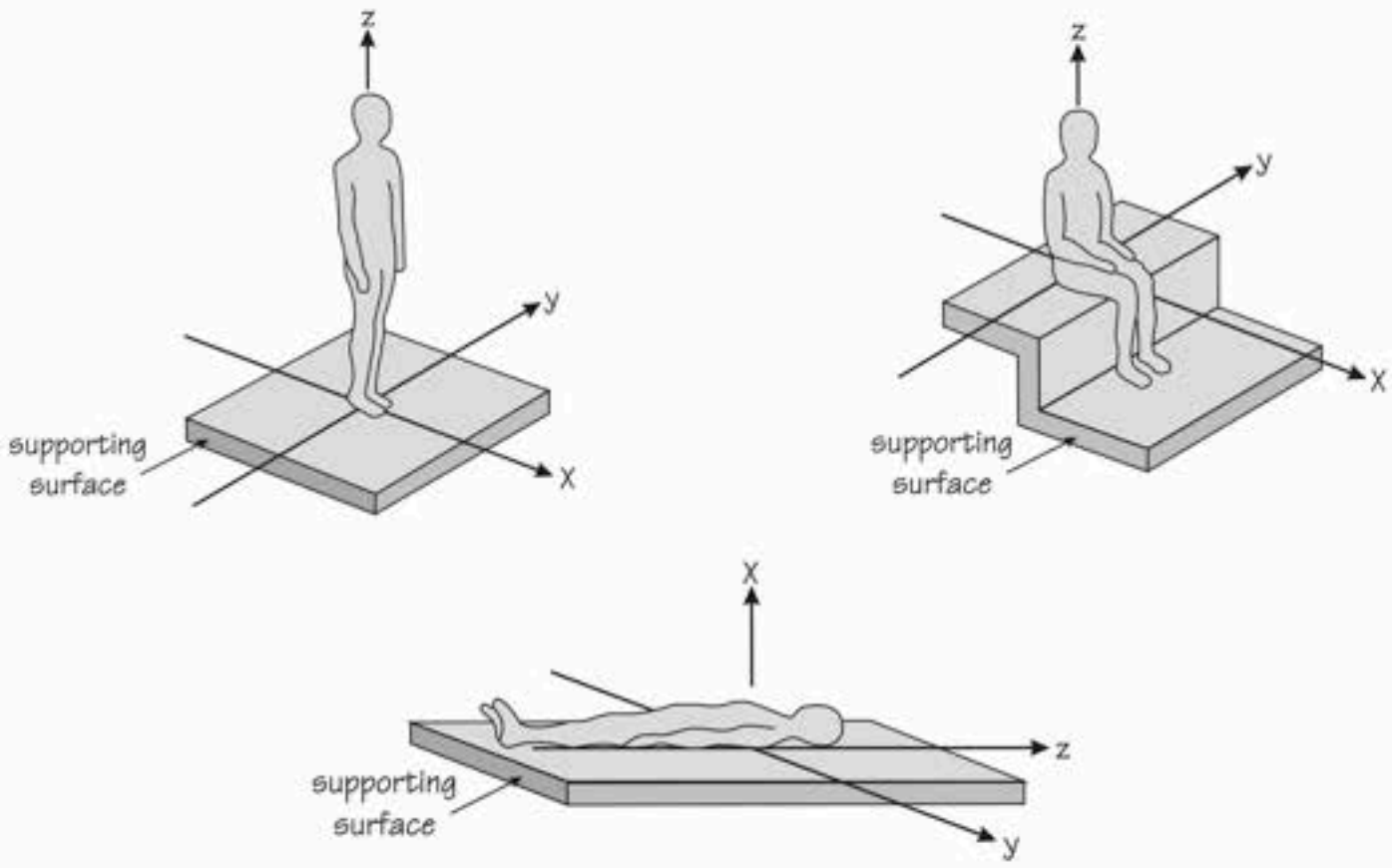
A series of International standards ISO 2631: Part 1 – Part 5 define measurement and evaluation of human exposure to WBV. This standard includes assessment of WBV for:

- health effects
- ride comfort
- motion sickness

The number of acceleration values to be measured depends on the type of assessment.

b) Typical postures

- Standing posture
- Seated posture
- Recumbent posture



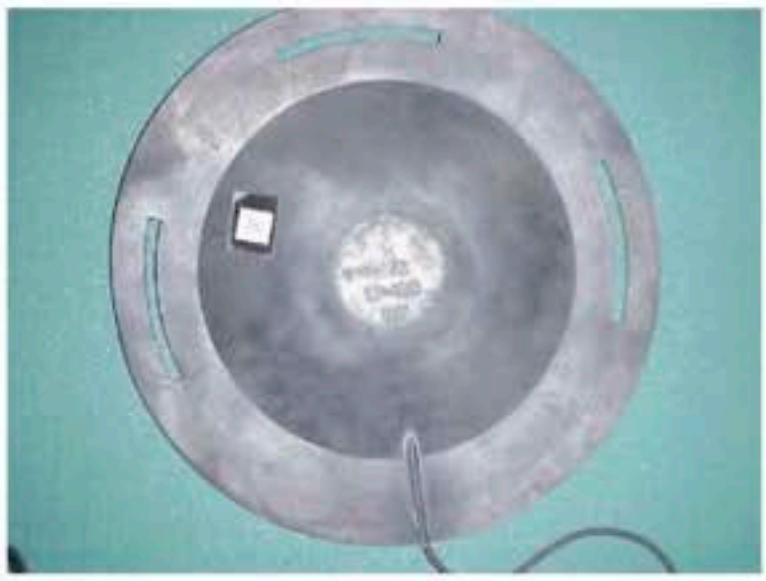
c) Measuring points

Acceleration values are measured at points where the human body contacts with vibrating objects.

- Standing posture: foot
- Recumbent posture: back
- Seated posture: back, hip, foot

d) Accelerometers

- Tri-axial seat transducer
- The requirements for tri-axial seat transducers to be used for measurement based on ISO2631-1 have been defined in ISO5008.



Acceleration measurement for health effect assessment

- Measuring point
- Hip (seat surface)
- Three transitional acceleration components
- Measured simultaneously

7. Measurement of vibration

- It is recommended that wherever practical, measurements should be made over periods of at least 20 minutes

- Where shorter measurements are unavoidable they should normally be at least three minutes long and, if possible, they should be repeated to give a total measurement time of more than 20 minutes

- Longer measurements, of 2 hours or more are preferable (half or full working day measurements are sometimes possible)

8. Evaluation of WBV

a) How to get the overall total acceleration value

$a(t)$ — Raw data (in the x, y and z axis)

$a_w(t)$ — Frequency weighted acceleration (in the x, y and z axis)

$$a_w = \sqrt{\frac{1}{T}\int_0^T a_w^2(t)dt}$$ — R.M.S acceleration (in the x, y and z axis)

$$a_{bv} = \sqrt{1.4a_{wx}^2 + 1.4a_{wy}^2 + a_{wz}^2}$$ — Acceleration value

b) Evaluation of WBV with A(8)

- 8-Hour energy equivalent acceleration A(8)
- T (hour): Vibration exposure time

$$a_{bv} = \sqrt{1.4a_{wx}^2 + 1.4a_{wy}^2 + a_{wz}^2}$$

$$A(8) = a_{bv}\sqrt{\frac{T}{8}}$$

9. What is A(8) ?

- A(8) : 8-Hour energy equivalent acceleration
- A(8) is defined as acceleration of vibration (r.m.s.) to which workers can be exposed for 8 hours in a day.

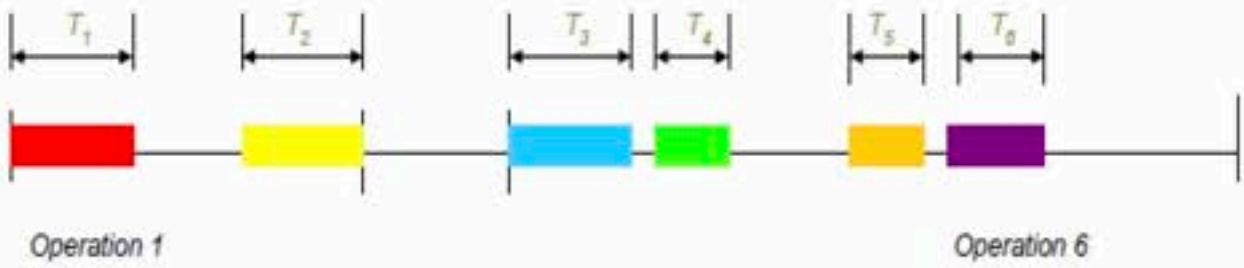
$$A(8) = a_{bv}\sqrt{\frac{T}{8}}$$

a) How to calculate A(8)

- N: number of operations in one day
- T 8hour(hour): daily working hours (8 hour)

$$[A(8)]^2 \cdot T_{8hour} = sum\{a_{bvi}^2 \cdot T_i \big| 1 \le i \le N\}$$

$$= a_{bv1}^2 \cdot T_1 + a_{bv2}^2 \cdot T_2 + \cdots + a_{bvN}^2 \cdot T_N$$



b) Evaluation of WBV with A(8)

- 8-Hour energy equivalent acceleration A(8)
- If the daily exposure consists of several vibration exposures,

$$A(8) = \sqrt{\frac{1}{8}\sum_{j=1}^{N} a_{bvj}^2 T_j}$$

$$= \sqrt{\frac{1}{8}(a_{bv1}^2 T_1 + a_{bv2}^2 T_2 + \cdots + a_{bvN}^2 T_N)}$$

10. Assessment of WBV

Assessment of WBV based on A(8) - EU Directive –

a) Exposure Action Value: A(8) > 0.5m/s^2
Action must be taken to monitor and control worker's exposure to WBV.

b) Exposure Limit Value: A(8) > 1.15m/s^2
The process creating the worker exposure to vibration must be stopped.

Permissible time of driving

a) Permissible time of driving a vehicle in one day can be obtained from the following equation.

$$A(8) = a_{hw}\sqrt{\frac{T}{8}} \leftrightarrow T = 8 \cdot \left(\frac{A(8)}{a_{hw}}\right)^2$$

b) Substituting 1.15 into A(8) yields permissible time of driving a vehicle.

$$T = 8 \cdot \left(\frac{1.15}{a_{hw}}\right)^2$$

B. HAND-ARM VIBRATION (HAV)

1. Introduction

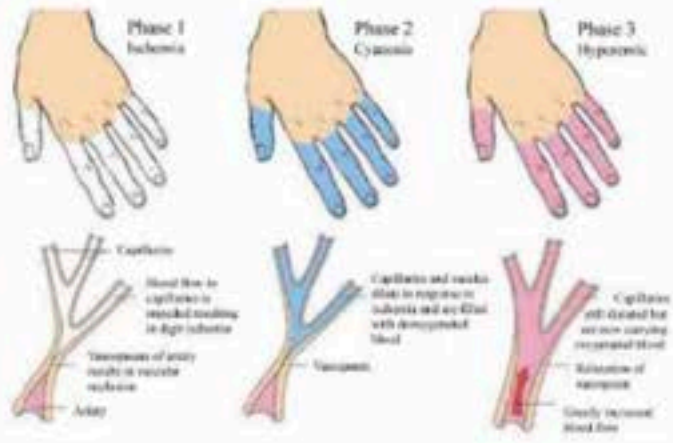
Vibration transmitted through the hand to the human hand-arm system when one use hand-held power tools.

2. Common industrial tools and processes that lead HAV

- Road Breakers
- Pedestal Grinder
- Hand-held Grinders
- Needle Guns
- Riveting Hammers
- Bucking Bars
- Chipping Hammers

3. Hand-arm vibration syndrome (HAVS)

Hand-arm vibration syndrome (HAVS) is a disease that involves vascular, neurological, and musculoskeletal disorders at the hand.



4. Measurement of HAV

How to set up the instrument

- A tri-axial accelerometer is embedded in a adapter.
- The adapter is attached to the tool handle and tool users grasp the handle with the adapter.

a) ISO5349-1

- Measurement, evaluation and assessment of HAV have been defined in ISO5349-1.
- The vibration dose during a real operation of tools can be used as a parameter in the evaluation of the health risk and damage.

b) Evaluation of HAV

How to get the overall total acceleration value

$a(t)$ — Raw data (in the x, y and z axis)

$a_w(t)$ — Frequency weighted acceleration (in the x, y, and z axis)

$$a_w = \sqrt{\frac{1}{T}\int_0^T a_w^2(t)dt}$$ — R.M.S acceleration (in the x, y, and z axis)

$$a_{hw} = \sqrt{a_{wx}^2 + a_{wy}^2 + a_{wz}^2}$$ — Overall total acceleration value

c) Evaluation of HAV with A(8)

- 8-Hour energy equivalent acceleration A(8)
- T (hour): Vibration exposure time

$$a_{hw} = \sqrt{a_{wx}^2 + a_{wy}^2 + a_{wz}^2}$$

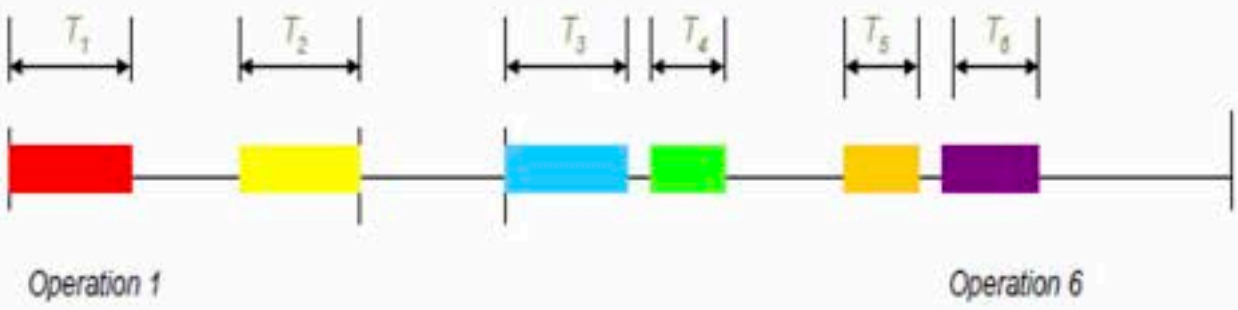
$$A(8) = a_{hw}\sqrt{\frac{T}{8}}$$

d) How to calculate A(8)

- N: number of tool operations in one day
- T_{8hour}(hour): daily working hours (8 hour)

$$[A(8)]^2 \cdot T_{8hour} = sum\{a_{bvi}^2 \cdot T_i | 1 \leq i \leq N\}$$

$$= a_{bv1}^2 \cdot T_1 + a_{bv2}^2 \cdot T_2 + \cdots + a_{bvn}^2 \cdot T_N$$



e) Evaluation of HAV with A(8)

- 8-Hour energy equivalent acceleration A(8)
- If the daily exposure consists of several vibration exposures,

$$A(8) = \sqrt{\frac{1}{8}\sum_{j=1}^{N} a_{hw1}^2 T_j}$$

$$= \sqrt{\frac{1}{8}(a_{hw1}^2 T_1 + a_{hw2}^2 T_2 + \cdots + a_{hwN}^2 T_N)}$$

5. Assessment of HAV

Assessment of HAV based on A(8) - EU Directive -

a) <u>Exposure Action Value: A(8) > 2.5m/s^2</u>
Action must be taken to monitor and control worker's exposure to WBV.

b) <u>Exposure Limit Value: A(8) > 5.0m/s^2</u>
The process creating the worker exposure to vibration must be stopped.

Permissible time of usage

a) Permissible time of usage for a tool in one day can be obtained from the following equation.

$$A(8) = a_{hw}\sqrt{\frac{T}{8}} \leftrightarrow T = 8 \cdot \left(\frac{A(8)}{a_{hw}}\right)^2$$

b) Substituting 2.5 into A(8) yields permissible time of usage for a tool.

$$T = 8 \cdot \left(\frac{2.5}{a_{hw}}\right)^2$$

Appendix 6: INITIAL ERGONOMICS RISK ASSESSMENT CHECKLIST

(Refer Part 3)

Ergonomics risk factors: awkward posture

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)	
			Yes	No
Shoulders	Working with hand above the head OR the elbow above the shoulder	More than 2 hours per day		
	Working with shoulder raised	More than 2 hours per day		
	Work repetitively by raising the hand above the head OR the elbow above the shoulder more than once per minute	More than 2 hours per day		
Head	Working with head bent downwards more than 45 degrees	More than 2 hours per day		
	Working with head bent backwards	More than 2 hours per day		
	Working with head bent sideways	More than 2 hours per day		
Back	Working with back bent forward more than 30 degrees OR bent sideways	More than 2 hours per day		
	Working with body twisted	More than 2 hours per day		
Hand/Elbow/Wrist	Working with wrist flexion OR extension OR radial deviation more than 15 degrees	More than 2 hours per day		
	Working with arm abduction sideways	More than 4 hours per day		
	Working with arm extended forward more than 45 degrees OR arm extended backward more than 20 degrees.	More than 2 hours per day		
Leg/Knees	Work in a squat position.	More than 2 hours total per day		
	Work in a kneeling position	More than 2 hours per day		
Sub Total (Number of tick(s))				

Ergonomics risk factors: static and sustained work posture

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)	
			Yes	No
Trunk/ Head/ Neck/ Arm/ Wrist	Work in a static awkward position as in Table 3.1	Duration as per Table 3.1		
Leg/Knees	Work in a standing position with minimal leg movement	More than 2 hours continuously		
	Work in seated position with minimal movement.	More than 30 minutes continuously		
Sub Total (Number of tick(s))				

Ergonomics risk factors: forceful exertion (manual handling)

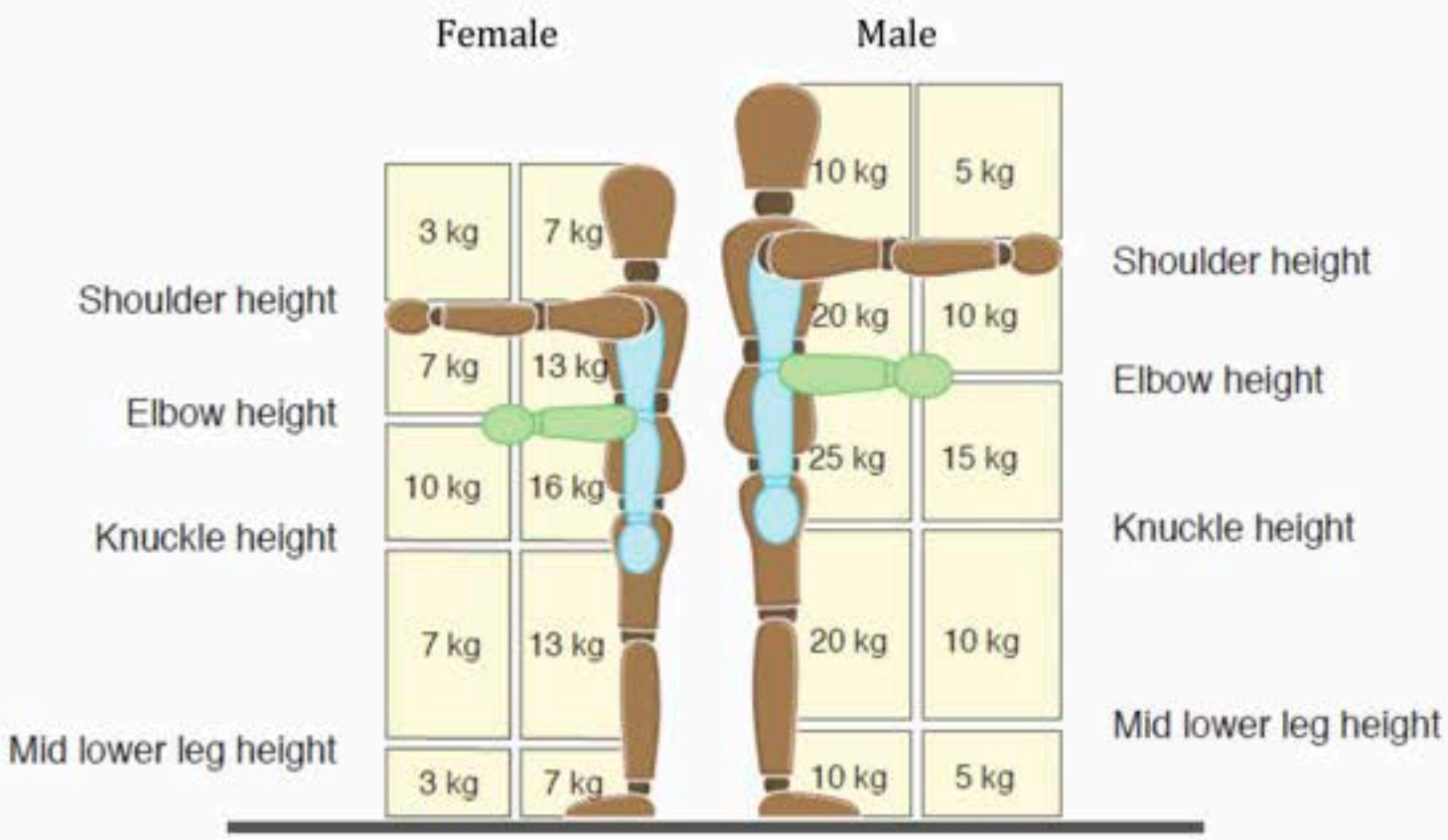


Figure 3.1 Recommended weight

Ergonomics risk factors: forceful exertion
(Manual handling – Lifting and/or lowering)

Working height (where force is applied)	Recommended weight limit (male or female)	Current weight handled	Exceed limit?	
			Yes	No
Between floor to mid-lower leg				
Between mid-lower leg to knuckle				
Between knuckle height and elbow				
Between elbow and shoulder				
Above the shoulder				

Ergonomics risk factors: forceful exertion
(Manual handling – Lifting and/or lowering with repetitive operation)

If employee repeats operations	Weight* should be reduced by
Once or twice per minutes	30%
Five to eight times per minute	50%
More than 12 times per minute	80%

Ergonomics risk factors: forceful exertion
(Manual handling – Lifting and/or lowering with twisted body posture)

If employee twists body from forward facing to the side	Weight* should be reduced by
45 degrees	10%
90 degrees	20%

Ergonomics risk factors: forceful exertion
(Pushing and/or pulling)

Activity	Recommended weight	
	Male	Female
Stopping or starting a load	approximately 1000kg load (equivalent to 200N pushing or pulling force) on smooth level surface using well maintained handling aid	approximately 750kg load (equivalent to 150N pushing or pulling force) on smooth level surface using well maintained handling aid
Keeping the load in motion	approximately 100kg load (equivalent to 100N pushing or pulling force) on uneven level surface using well-maintained handling aid	approximately 70kg load (equivalent to 70N pushing or pulling force) on uneven level surface using well-maintained handling aid

Ergonomics risk factors: forceful exertion
(Handling in seated position)

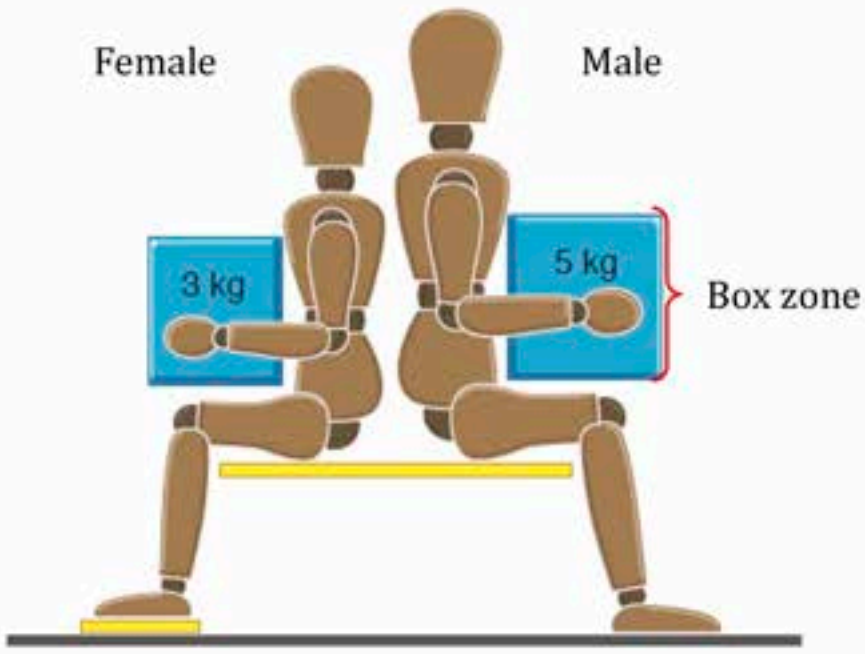


Figure 3.2 Recommended weight for seated position

Summary for carrying activity

Factor	Condition	Outcome
Floor Surface	Dry and clean floor in good condition	Acceptable
	Dry floor but in poor condition, worn or uneven	Conduct advanced ERA
	Contaminated/wet or steep sloping floor or unstable surface or unsuitable footwear	
Other environmental factors	No factors present	Acceptable
	One or more factor present (i.e. poor lighting condition, extreme temperature)	Conduct advanced ERA
Carry distance	2 m—10 m	Acceptable
	More than 10 m	Conduct advanced ERA
Obstacles en route	No obstacles and carry route is flat	Acceptable
	Steep slope or up steps or through closed doors or trip hazards or using ladders	Conduct advanced ERA

Summary of single manual handling activity (forceful exertion)

Activity (where applicable)	Recommended weight limit	Exceed limit?	
		Yes	No
Lifting and lowering only; or	based on Figure 3.1 and Table 3.3		
Repetitive lifting and lowering; or	based on Figure 3.1 and Table 3.4		
Twisted body posture while lifting and lowering; or	based on Figure 3.1 and Table 3.5		
Repetitive lifting and lowering with twisted body posture; or	based on Figure 3.1, Table 3.4 and Table 3.5		
Pushing and pulling; or	based on Table 3.6		
Handling in seated position; or	based on Figure 3.2		
Carrying	based on Table 3.7		

Ergonomics risk factors: repetitive motion

Body Part	Physical Risk Factor	Max. Exposure Duration	Please tick (/)	
			Yes	No
Neck, shoulders, elbows, wrists, hands, knee	Work involving repetitive sequence of movement more than twice per minute	More than 3 hours on a "normal" workday OR More than 1 hour continuously without a break		
	Work involving intensive use of the fingers, hands or wrist or work involving intensive data entry (key-in)			
	Work involving repetitive shoulder/arm movement with some pauses OR continuous shoulder/arm movement			
	Work using the heel/base of palm as a "hammer" more than once per minute	More than 2 hours per day		
	Work using the knee as a "hammer" more than once per minute.	More than 2 hours per day		
Sub Total (Number of tick(s))				

Ergonomics risk factors: vibration

Body parts	Physical Risk Factor	Max. Exposure Duration	Please tick (/)	
			Yes	No
Hand-Arm (segmental vibration)	Work using power tools (e.g. battery powered/ electrical pneumatic/hydraulic) without PPE	More than 50 minutes in an hour		
	Work using power tools (ie: battery powered/electrical pneumatic/hydraulic) with PPE	More than 5 hours in 8 hours shift work		
Whole body vibration	Work involving exposure to whole body vibration	More than 5 hours in 8 hours shift work		
	Work involving exposure to whole body vibration combined employee complaint of excessive body shaking	More than 3 hours in 8 hours shift work		
Sub Total (Number of tick(s))				

Ergonomics risk factors: environmental factors

Physical Risk Factor	Please tick (/)	
	Yes	No
Inadequate lighting		
Extreme temperature (hot/cold)		
Inadequate air ventilation		
Noise exposure above PEL (based on previous reports or measurement)		
Exposed to annoying noise more than 8 hours		
Sub Total (Number of tick(s))		

Initial ERA Form

<table>
<tr><th>Risk factors</th><th>Total Score</th><th>Minimum requirement for advanced assessment</th><th>Result of Initial ERA</th><th>Any Pain or Discomfort due to risk factors as found in Musculoskeletal Assessment (refer Part 3.1) (Yes/No)</th><th>Need Advanced ERA? (Yes/No)</th></tr>
<tr><td>Awkward Postures</td><td>13</td><td>≥ 6</td><td></td><td rowspan="10">YES / NO

If YES, please tick (√) which part of the body
<table><tr><td>Neck</td><td></td></tr><tr><td>Shoulder</td><td></td></tr><tr><td>Upper back</td><td></td></tr><tr><td>Upper arm</td><td></td></tr><tr><td>Lower back</td><td></td></tr><tr><td>Forearm</td><td></td></tr><tr><td>Wrist</td><td></td></tr><tr><td>Hand</td><td></td></tr><tr><td>Hip/buttocks</td><td></td></tr><tr><td>Thigh</td><td></td></tr><tr><td>Knee</td><td></td></tr><tr><td>Lower leg</td><td></td></tr><tr><td>Feet</td><td></td></tr></table></td><td></td></tr>
<tr><td>Static and Sustained Work Posture</td><td>3</td><td>≥ 1</td><td></td><td></td></tr>
<tr><td>Forceful Exertion</td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td>Repetitive Motion</td><td>5</td><td>≥ 1</td><td></td><td></td></tr>
<tr><td>Vibration</td><td>4</td><td>≥ 1</td><td></td><td></td></tr>
<tr><td>Lighting</td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td>Temperature</td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td>Ventilation</td><td>1</td><td>1</td><td></td><td></td></tr>
<tr><td>Noise</td><td>2</td><td>≥ 1</td><td></td><td></td></tr>
</table>

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MINISTRY OF HUMAN RESOURCES
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