
**Ergonomic procedures for the
improvement of local muscular
workloads —**

**Part 1:
Guidelines for reducing local muscular
workloads**

*Procédures ergonomiques pour l'amélioration des charges de travail
musculaire locales —*

*Partie 1: Lignes directrices pour réduire les charges de travail
musculaire*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

- an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;
- an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 20646-1 was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 3, *Anthropometry and biomechanics*.

ISO/TS 20646 consists of the following parts, under the general title *Ergonomic procedures for the improvement of local muscular workloads*:

- *Part 1: Guidelines for reducing local muscular workloads*
- *Part 2: Practical use of the guidelines given in Part 1*

Introduction

The onset of work-related musculoskeletal disorders, such as lower-back pain and cumulative trauma disorders, is becoming a great ergonomic concern in both industrialised and industrialising countries. The high incidence of work-related musculoskeletal disorders is an important problem to be solved not only to improve workers' health and the quality of working life, but also to improve productivity.

In order to solve the problem of work-related musculoskeletal disorders, it is important to work out primary preventive measures, through improving working conditions and providing adequate health guidance and training, as well as to establish measures for secondary prevention, treatment, and reassignment of the workers after a long sick leave.

Above all, the establishment of primary preventive measures, mainly measures to reduce local muscular workloads (LMWL) is considered the most effective and economic solution, in the context of cost-efficiency as well as a better quality of working life. Various activities to reduce LMWL have already been promoted. In addition, regarding ISO/TC 159/SC 3, new standards are being prepared to improve working conditions relating to the factors causing LMWL. However, in order to reduce LMWL, it is indispensable to take a comprehensive work-related perspective and find a solution, in consideration of the aforementioned factors.

Ergonomic procedures for the improvement of local muscular workloads —

Part 1: Guidelines for reducing local muscular workloads

1 Scope

This part of ISO 20646 provides information and guidelines to properly utilise various ergonomics standards concerning the factors related to local muscular workload (LMWL), and helps develop activities to reduce LMWL in workplaces, in an effective and efficient manner. This part of ISO 20646 is intended primarily for employers, ergonomics and occupational health-related staff in enterprises, and workers. Specific measures to reduce LMWL can be applied to non-professional activities. Although this part of ISO 20646 provides ideas of effective and efficient measures to reduce LMWL, it does not certify the complete prevention of health problems caused by LMWL.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11226, *Ergonomics — Evaluation of static working postures*

ISO 11228-1, *Ergonomics — Manual handling — Part 1: Lifting and carrying*

ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

ISO 14121, *Safety of machinery — Principles of risk assessment*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

local muscular workload

LMWL

loads on the musculoskeletal system required for working motions, maintaining working postures and exerting forces

3.2

harm

physical injury or damage to health

[ISO 12100-1:2003]

3.3

hazard

potential source of harm

[ISO 12100-1:2003]

3.4

risk

combination of the probability of occurrence of harm and the severity of that harm

[ISO 12100-1:2003]

3.5

risk assessment

overall process comprising a risk analysis, risk reduction measure and risk evaluation

NOTE Adapted from ISO 12100-1:2003.

3.6

risk analysis

combination of the specification of work situation, hazard identification and risk estimation

3.7

risk estimation

defining likely severity of harm and probability of its occurrence

[ISO 12100-1:2003]

3.8

risk evaluation

judgement, on the basis of successive risk analysis, of whether the risk reduction objectives have been achieved

[ISO 12100-1:2003]

3.9

work space

volume of space allocated to one or more persons in the work system to complete a work task

[ISO 9241-5:1998]

3.10

workstation

combination of work equipment for a particular person in a work space

[ISO 11064-2:2000]

NOTE It is possible that several persons share a particular workstation, or that several persons alternate between several workstations within any period of time (i.e. hourly, daily, weekly basis).

4 General guiding principles

4.1 Basic principles to reduce LMWL

The management should clarify existing and predicted LMWL, possible health- and productivity-related problems, and publish improvement goals and targets, a basic schedule to achieve the targets, and the organization to implement the improvement, in writing (see Annex A).

4.2 Basic framework and responsibilities of LMWL-reduction activities

As organizations draft, implement and assess LMWL-reduction plans, organizations at the enterprise level and department level, and advisory organizations, should develop activities in a collaborative manner.

4.2.1 Organization at the enterprise level

An organization to manage LMWL problems should be established at the enterprise level, either as part of existing management systems for work design or occupational safety and health, or as a specifically designated project activity. The owner or executive director with overall management authority shall be responsible for the establishment and the conduct of this organization.

4.2.2 Organization at the department level

This refers to an organization within an individual department, for which the departmental manager should be responsible. Its function is to draft, implement and assess the improvement plans for the department.

4.2.3 Advisory organization

This refers to an organization offering advice concerning the validity of drafting, implementation and assessment of improvement plans. The organization can be established inside or outside the enterprise.

4.3 Processes for LMWL risk assessment including implementation of risk reduction activity

An LMWL-reduction plan should not be limited to a few specific factors causing loads. It should be based on LMWL risk analysis in the workplace. On the basis of comprehensive risk assessment using this multi-factorial analysis, specific action targets should be set to eliminate or reduce unacceptable risks. Basic processes in achieving this target are given in 4.3.1 to 4.3.4 (see ISO 12100-1 and ISO 14121).

4.3.1 Risk analysis

To study the necessary activities to reduce the risks of increasing LMWL, risk assessment should be implemented on the basis of risk analysis. Risk analysis should be performed based on the results of specification of work situation, hazard identification and risk estimation.

Risk analysis should be completed by identifying priority risks that should be addressed immediately, so as to reduce risks or reinforce the on-going measures.

4.3.1.1 Specification of work situation

To study the characteristics of the work situation at the workplace, the following items should be specified.

- a) Production process, contents of work and tasks to be performed at the workplace.
- b) Statistics on occupational accidents, incidence of work-related diseases and other diseases, sick leave, etc.
- c) Work organization and shift systems.
- d) Work hours per day, week, month or year.
- e) Operating time per day, continuous operating time and a rest system.
- f) Characteristics of the workers, such as body size, muscle strength, history of injuries and diseases affecting work, work experience, vocational education and training, and age.

4.3.1.2 Hazard identification

The following factors are the main hazards for increasing LMWL (see Annex B).

4.3.1.2.1 Work hours and density

- a) Long work hours.
- b) Frequent and long overtime work.
- c) Long continuous operating time.
- d) Insufficient days off.
- e) Uneven work density in a day, week, month or year.
- f) Uneven work density between the workers.

4.3.1.2.2 Type of work

- a) Lifting and carrying heavy objects (see ISO 11228-1).
- b) Work requiring great physical force.
- c) Repetitive monotonous work.
- d) Work requiring frequent finger, hand or arm motions.
- e) Work using vibrating tools.
- f) Work with a keyboard or other data entry devices.
- g) Precision work/work requiring high mental loads.

4.3.1.2.3 Postures and motions

- a) Awkward postures and motions (see ISO 11226).
- b) Continuous and/or highly frequent change in angle of joint (see ISO 11226).
- c) Long-duration constrained posture (see ISO 11226).
- d) Long-duration and/or long-distance walking (horizontal as well as on an inclining surface).
- e) Frequent stair climbing.

4.3.1.2.4 Characteristics of work space and objects handled

- a) Inadequate work space forcing an awkward posture or limited movement.
- b) Layout of the workstation forcing excessive movement or awkward postures.
- c) Inadequate height and dimensions of the work surface.
- d) Handling work objects above the shoulder or below the knee.
- e) Work space forcing the worker to maintain the same working posture.
- f) Work objects which are heavy and/or require strong force.
- g) Work objects which are difficult to hold or slippery.
- h) Cold work environment and/or objects handled.

4.3.1.2.5 Premises

- a) Slippery and/or uneven floor surface.
- b) Noisy environment.
- c) Whole body vibration.

4.3.1.3 Risk estimation

Risk estimation should take into account the severity of the harm and probability of its occurrence and the number of workers who will be affected.

4.3.2 Specifying risk reduction measures followed by a small trial of the improvement

To study the importance of risk factors and evaluate possible preventive measures for risk reduction, the following factors should be considered.

- Results of the risk analysis.
- Ease of implementation of the risk reduction plan.
- Effect of the improvement after reducing the risk.
- Number of workers who will benefit.
- Cost-efficiency of the plan.

Use of an action-oriented checklist is recommended to perform risk analysis, and to get hints for improvement (see Annex C). The recommended procedure for using the checklist is as follows.

- a) Organize a group to implement a checklist practice. In the group, the owner or executive director with management authority, managers and workers of concerned sections, occupational health and safety personnel should be involved.
- b) Define the workplace to be checked.
- c) Fill out the checklist individually.
- d) Organize small group discussions on the risk factors found at the workplace and the factors with priority of improvement.
- e) Make an action plan to reduce risks for LMWL at the workplace.
- f) Carry out a small trial to ensure the effect of the improvement before implementing the improvement on a large scale.

4.3.3 Implementation of risk reduction measures and monitoring of the effect of the activity

To check the effectiveness or insufficiency of the risk reduction measures, scheduled monitoring of the LMWL level and health problems of the concerned workers should be provided. It is recommended to check the subjective estimation of LMWL levels before and after the implementation, and subjective estimation of the effectiveness of the improvement after the implementation (see Annex D). Statistics of sick leave relating to LMWL and incidence of musculoskeletal diseases are also useful, to evaluate the effectiveness or insufficiency of the risk reduction measures.

4.3.4 Risk evaluation and drafting of new risk reduction plans

To check the effectiveness of risk reduction measures and to find any new or remaining problems, periodic evaluations should be carried out. Evaluations should be performed if changes are made to the product manufactured, the process used or the workstation, or if increased incidence and complaints are noticed (see Annex E).

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Annex A

(informative)

Schedule form for principles, plan and implementation

A.1 Principles

(Enter the management's statement of commitment to improvement of work conditions here.)

A.2 Motivation for improvement

(Describe the present state of the workplace. Specifically, state the overview of the characteristics of works at the workplace, and describe the following points concerning LMWL so that readers can understand the reason why work-conditions improvement should be promoted: "possible hazards that work entails"; "foreseeable problems in the context of health management and productivity"; "severity of problems and extent of their possibilities"; and "the present state of foreseeable problems (including conditions for the onset of the disorder and productivity)".

A.3 Improvement target

(Describe what risk factors should be improved and to what extent they should be reduced as goals, with deadlines clarified.)

A.4 Implementation schedule of improvement projects

(Clarify the schedule of the project, mainly the following actions.)

- a) Identify hazards concerning local muscular workload.
- b) Risk assessment and selection of improvement plan.
- c) Drafting of improvement plan.
- d) Implementation of improvement plan.
- e) Measurement of consequences of implementation of improvement plans.
- f) Records of improvement actions taken and in-house announcement.

A.5 Budget

(Enter the budget amount allocated by the management for this project.)

A.6 Department/section responsible for the project

(Enter the department/section responsible for the project.)

Annex B (informative)

Checklist for hazard identification concerning local muscular workload

This list is intended to identify factors increasing LMWL.

B.1 How to use the checklist

Possible factors causing LMWL are divided into five sections: "work hours and density", "type of work", "postures and motions", "characteristics of work space and objects handled" and "premises". In each section, all factors with the box "Yes" ticked will be examined. Depending on the work, the same factors may be marked with "Yes" in more than one section. Regarding the factors with "Yes", identify the type, magnitude and location of possible muscular load, and work out measures to reduce it, referring to the Notes at the end of this checklist.

B.2 Example of a checklist

Section 1: Work hours and density

Does the condition of work hours and density include any of the following?

	YES	NO
a) Long work hours	☐	☐
b) Frequent and long overtime work	☐	☐
c) Long continuous operating time	☐	☐
d) Insufficient days off	☐	☐
e) Uneven work density in a day, week, month or year	☐	☐
f) Uneven work density between the workers	☐	☐

Section 2: Type of work

Does the work include the following conditions?

	YES	NO
a) Lifting and carrying heavy objects (see NOTE 1)	☐	☐
b) Work requiring high physical force (see NOTE 2)	☐	☐
c) Repetitive monotonous work (see NOTE 3)	☐	☐
d) Work requiring frequent finger, hand or arm motions	☐	☐
e) Work using vibrating tools, etc.	☐	☐
f) Work with a keyboard or other data entry devices [see NOTE 5: 7)]	☐	☐
g) Precision work/work requiring high mental loads (see NOTE 4)	☐	☐

Section 3: Postures and motions**Do postures and movements that the work involves include the following?**

	YES	NO
a) Awkward postures and motions (see NOTE 5)	☐	☐
b) Continuous and/or highly frequent change in angle of joint (see NOTE 6)	☐	☐
c) Long-duration constrained posture (see NOTE 7)	☐	☐
d) Long-duration and/or long-distance walking (horizontal as well as on inclined surfaces) (see NOTE 8)	☐	☐
e) Frequent stair climbing	☐	☐

Section 4: Characteristics of work space and objects handled**Do work space and objects handled correspond to any of the following situations?**

	YES	NO
a) The work space is so insufficient that workers are forced to take an awkward posture or their movement is limited.	☐	☐
b) The layout of the work space or objects handled is so inappropriate that workers are forced to carry out excessive movements or awkward postures.	☐	☐
c) The height and dimensions of the work surface are inadequate for the body and relative location of the worker.	☐	☐
d) The object handled is above the shoulder or below the knee. [see NOTE 5: 2) and 3)]	☐	☐
e) The same posture is maintained due to work. (see NOTE 9)	☐	☐
f) The object handled is heavy, and/or requires strong force.	☐	☐
g) The object is difficult to hold or slippery.	☐	☐
h) Cold work environment and/or object handled.	☐	☐

Section 5: Premises**Do premises include any of the following?**

	YES	NO
a) Floor surface is slippery and/or uneven.	☐	☐
b) The work environment is noisy or there are noise sources in the workplace.	☐	☐
c) The workers are exposed to whole body vibration.	☐	☐

NOTE 1 This work can cause excessive load on the whole body and localised parts of the body, resulting in musculoskeletal disorders, such as lower-back pain. For recommendations and risk assessments concerning mass limits of objects, frequency and distance of moving objects, etc., see ISO 11228-1.

NOTE 2 The work includes pushing, pulling, work requiring power grip, and pedalling. Depending on the type of work, it may cause musculoskeletal disorders in muscles and joints of upper or lower limbs.

NOTE 3 As is the case with assembly work on a plant production line, repetitive monotonous work may cause load on muscles, even if it does not require strong physical force. Moreover, such work can often require long-time constrained posture (see NOTE 7).

NOTE 4 This type of works include precise assembly work, like using a magnifying glass and precise positioning to the target point, work entailing risks of damage or potential for injury. Generally, instead of great force exertion, this type of work may cause static tension in muscles of the neck and upper or lower limbs, and if the tension persists, it may cause muscle strain. Moreover, there is a strong possibility that precise work can cause persisting bow-backed posture because the eyes were brought close to the object handled. A proper hold/rest support for upper limbs (or lower limbs) used can provide effective assistance.

NOTE 5 The following fall under “awkward postures and motions.”

- 1) Frequent stretching up causes load primarily on ankle joints and lower limb muscles.
- 2) Repeated lifting and holding of the upper arms cause greater loads on the neck, shoulders and arms. For acceptable shoulder-joint angles, duration of holding the posture, etc., see ISO 11226.
- 3) Lower-back bending and inclination of the trunk pose strong stress on the lower back, and holding and repeating these postures can increase risks of injuries, such as lower-back pain. Moreover, handling a heavy object and great force exertion while taking such postures remarkably increases risk. For acceptable lower-back bending and trunk inclination, duration of holding the postures, etc., see ISO 11226.
- 4) Sustained or repeated inclination of the head or flexion/extension of the neck may cause loads primarily on the cervical spine and surrounding muscles. For acceptable inclination of the head and flexion/extension of the neck, see ISO 11226.
- 5) Sustained or repeated twisting of the trunk may cause loads primarily on the lower back. In addition, this is often accompanied by movement of upper and lower limbs, possibly resulting in load on associated muscles. For recommendations, see ISO 11226.
- 6) Sustained or repeated twisting of the neck causes loads primarily on the neck. For recommendations, see ISO 11226.
- 7) Sustained or repeated excessive deviation of hand and wrist joints causes loads primarily on hands, wrists and forearms. As is the case with data input with a keyboard, movement of hand joints is often repeated over a long period during work. Such work can cause hand injuries, such as arthritis and entrapment injuries. Particularly, excessive flexion or extension of hand or wrist joints, or radial or ulnar abduction of the wrists, or pronation or supination of the forearms must be avoided as much as possible. For recommendations, see ISO 11226.
- 8) Standing on tiptoe, stretching up of upper limbs (particularly, raising upper arm and hand above the shoulder), knee-flexion posture with no support, or extreme joint positions when reaching for something located at a distance, or difficult to access, also falls under inappropriate working postures and motions.
- 9) Postures or motions requiring great flexion or extension of joints generally cause high loads in joints and surrounding muscles and ligaments, even if the postures and motions do not fall under the conditions mentioned above.

NOTE 6 Keeping part of the body in the same position for a long time, and moving part of the body at high frequency are also included in this factor, even if they are not awkward postures and motions.

NOTE 7 Holding the same posture, even a comfortable one, can cause load. In such work, static tension persists in relevant local muscles in order to stabilise the body position against gravity, possibly resulting in muscular blood stagnation or subcutaneous blood stagnation. It is necessary to introduce enough space to allow continuous slight posture changes, and a break-time is required for frequent significant changes in posture or motion, and exercise.

NOTE 8 Not only moving horizontally but also moving vertically on stairs or using a ladder are included in this factor.

NOTE 9 “No support to the whole body or body segments” and “excessive muscle tension and awkward postures to prevent falling/sliding down” are included in this factor.

Annex C (informative)

Action-oriented checklist

C.1 General

The action-oriented checklist aims at checking overall working conditions relating to LMWL, finding improvement points with priority, and getting hints to improve them. The checklist can be used by a variety of people. It is recommended that all the members of a committee or taskforce responsible for the improvement of LMWL become users of the checklist. The check items shown below are just examples of action-oriented checklist items. Users can delete unnecessary items and add specific items for checking their own workplace. Users can also refer to “Ergonomic checkpoints” and “Higher productivity and a better place to work — Action manual” when they add new check items.

C.2 How to use the checklist

- 1) Organize sub-groups of 5 to 8 members in the committee or taskforce.
- 2) Ask the manager any questions you have. The members should learn about the main products and production methods, the number of workers (male and female), the hours of work (including breaks and overtime) and any important labour problems.
- 3) Define the work area to be checked. In the case of a small enterprise, the whole production area can be checked. In the case of a larger enterprise, particular work areas can be defined for separate checking.
- 4) Each member should read through the checklist and spend a few minutes walking around the work area before starting to check.
- 5) Conduct a walk-through survey and individually apply the checklist. If necessary, ask the manager or workers questions. If the measure has already been applied or it is not needed, mark NO under “Do you propose action?” If the member thinks the improvement measure mentioned in the check items would be worthwhile, mark YES. Use the space for remarks to write a description of users' suggestions or its location.
- 6) After each member has finished the check, choose a few where the benefits seem likely to be the most important. Mark PRIORITY for these items.
- 7) Before finishing, make sure that all the items have been marked either NO or YES, and some items have been marked PRIORITY.
- 8) After the walk-through, organize a group discussion using each member's own checklist as guidance material. In the group discussion, good working conditions and good work practices should be mentioned. Then list the points to be improved and points which have priority for improvement after a walk-through referring to the items marked PRIORITY. Also list good working conditions and good work practices found during the walk-through.
- 9) Based on the results of the small-group discussion, conduct a plenary discussion to make an action plan for the improvement of LMWL.

C.3 Example of an action-oriented checklist

		NO	YES	Priority	Remarks
1	Use carts, hand-trucks and other wheeled devices or rollers, when moving materials. Do you propose action?				
2	Reduce manual handling of materials by using conveyers, hoists and other mechanical means of transport. Do you propose action?				
3	Eliminate tasks that require bending or twisting while handling materials. Do you propose action?				
4	Eliminate or reduce tasks requiring holding of the hands or arms above shoulder level. Do you propose action?				
5	Provide handholds, grips or good handling points for all packages and containers. Do you propose action?				
6	Instead of carrying heavy weights, divide them into smaller lightweight packages, containers or trays. Do you propose action?				
7	Handle a heavy item by two persons. Do you propose action?				
8	Take short pauses between repeated operations of handling heavy items continuously. Do you propose action?				
9	Place frequently used materials and tools within easy reach from the normal working position. Do you propose action?				
10	Provide standing workers with chairs or stools for occasional sitting. Do you propose action?				
11	Provide sitting workers with good adjustable chairs with a backrest. Do you propose action?				
12	Use jigs and fixtures to make machine operation stable, safe and efficient. Do you propose action?				
13	Examine the design of a device or a tool, and make sure that workers can operate or hold it without excessive extension, flexion, or deviation of hand wrists. Do you propose action?				
14	Choose tools that can be operated with minimum force or alternatively suspended or counterbalanced. Do you propose action?				
15	Use a hand tool made of the lightest materials possible and with its gravity centre located near the palm of the hand. Do you propose action?				
16	Adjust the working height for each worker at elbow level or slightly below it. Do you propose action?				
17	Provide hand support when using precision tools. Do you propose action?				
18	Provide short and frequent pauses during continuous visual display work. Do you propose action?				
19	Introduce a work-rotation system to avoid repetition of the same type of work and continuous VDT operation. Do you propose action?				

		NO	YES	Priority	Remarks
20	Protect the workplace from excessive heat and cold. Do you propose action?				
21	Provide sufficient lighting for workers so that they can work efficiently and comfortably at all items. Do you propose action?				
22	Arrange for resting corners or rooms easily accessible during breaks and provided with good furniture and refreshing drinks. Do you propose action?				
23	Involve workers in the improved design of their own workstations, material-handling equipment or chairs. Do you propose action?				
24	Consult workers on improving working-time arrangements. Do you propose action?				
25	Insert short breaks or physical exercise to shorten the time of continuous heavy workloads.				