INTERNATIONAL STANDARD

**ISO 11228-1**

Second edition
2021-10

# Ergonomics — Manual handling —

## Part 1: Lifting, lowering and carrying

*Ergonomie — Manutention manuelle —*

*Partie 1: Manutention verticale vers le haut, manutention verticale vers le bas et manutention horizontale*



Reference number
ISO 11228-1:2021(E)



ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

# Contents

Page

# 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.



This document was prepared by Technical Committee ISO/TC 159, *Ergonomics*, Subcommittee SC 3, *Anthropometry and biomechanics*.

This second edition cancels and replaces the first edition (ISO 11228-1:2003), which has been technically revised.



The main changes to the previous edition are as follows:

— revision of the scope to include lowering;

— expansion of the risk estimation;

— expansion of Annexes A, B and C;

— addition of Annexes D to I to include updated information; expansions of the RNLE (revised NIOSH lifting equation); more examples for lifting and carrying; detailed information on the scientific background and recommended interpretation of the RNLE.

A list of all parts in the ISO 11228 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

# Introduction

## 0.1 General

The ISO 11228 series establishes ergonomic recommendations for different dynamic manual handling tasks. It provides information for designers, employers, employees and others involved in work, job and product design. The ISO 11228 series provides information on the evaluation of static postures.

Disorders of the musculoskeletal system are common worldwide and one of the most frequent disorders in occupational health. The risk-assessment model in this document allows the estimation of the risk associated with a manual material handling task. It takes into consideration the hazards (unfavourable conditions) related to manual handling tasks and the time spent performing them. Unfavourable conditions can include factors such as the size and mass of the object being handled, working posture (e.g. twisting, bending, overreaching), quality of grip on items, and the frequency and duration of manual handling. Any of these can, alone or in combination, lead to a hazardous handling activity and increase the risk of musculoskeletal disorders. Accordingly, these factors are considered when determining a recommended safe limit of the mass of objects being handled.

The method of determination of safe recommended limits in this document is based on the integration of data derived from four major research approaches, namely the epidemiological, the biomechanical, the physiological and the psychophysical approach.

## 0.2 The ergonomic approach

### 0.2.1 General



Ergonomics pursues the specific goals of optimizing human well-being and overall system performance. This is achieved through contributions to the design and evaluation of tasks, jobs, production, environment and systems in order to make them compatible with the needs, abilities and limitations of people. It strives to design or to modify a work system to accommodate, as far as possible, a broad range of people in order to meet the needs of workers with various characteristics, including people with special requirements. Thus, the development of special solutions for individuals can be minimized. Achieving these goals also contributes to organizational sustainability and social responsibility.



Manual handling tasks in the workplace occur within the context of work systems. Interactions of humans with items, information, environment and other people must be taken into consideration when designing or modifying tasks and work areas. The ergonomics approach can be used to prevent manual-handling-related injuries from occurring by being used proactively in the design of processes, systems or work organization, in addition to when modifications to existing systems are being considered.

The ergonomic approach considers tasks in their entirety, taking into account a range of relevant factors including the nature of the task, the characteristics of objects handled, the working environment and the individuals performing the task. It considers environmental conditions (e.g. lighting, noise, temperature), as well as an individual's characteristics and experiences. An individual's characteristics include physical and mental capabilities, skills, work techniques, behaviour and their perception of the work environment and its social characteristics.

### 0.2.2 Organizational considerations

Work organization (e.g. task duration, job duration, recovery time, shift patterns) is a contributing factor in the prevention or development of musculoskeletal disorders. For example, recovery periods help to mitigate possible muscular fatigue and help to avoid the overuse of similar muscle groups over the duration of the work shift. Job rotation, job diversification and job enlargement are all methods of structuring the work to facilitate variation and recovery within the work period.

Work organization includes appropriate training of workers, including how to safely perform tasks, how to recognize and respond to hazardous conditions in workplaces, and which procedures and communication channels to use to report and correct hazards. Regularly and properly maintained equipment and facilities contribute to safer work, including manual handling tasks. The selection of

equipment and supplies which are appropriate for the workplace and task conditions helps to make work demands safer.

### 0.2.3 Psychological health and safety and the ergonomics approach

The ergonomics approach considers the cognitive or psychological demands on humans, as well as the psychosocial environment in which work takes place. Psychological response to work and workplace conditions (psychosocial factors) has an important influence on mental, physiological and musculoskeletal health. Psychosocial factors in the workplace include the design, organization and management of work, work content, job complexity, job demands (cognitive and physical), job content and the overall social environment (i.e. the context of work).

Undesirable psychosocial aspects of a job can include:

— little or no control over work methods or organization;

— high levels of attention and concentration required;

— poor use of skills;

— little or no involvement in decision-making;

— repetitive, monotonous tasks only;

— machine- or system-paced work;

— work demands perceived as excessive;

— payment systems which encourage working too quickly or without breaks;

— work systems that limit opportunities for social interaction;

— high levels of effort not balanced by sufficient reward (e.g. resources, remuneration, self-esteem, status);

— no training and skill enhancement encouraged or supported;

— poor co-worker or supervisory support.



Many of the effects of these factors on workers occur via stress-related processes, which can in turn have a direct effect on biochemical and physiological responses, which can increase the likelihood of experiencing musculoskeletal injury. Thus, for the prevention of musculoskeletal disorders (MSDs), these psychosocial stressors should be controlled in addition to the biomechanical risk factors. For more information on the effects of the psychosocial stressors on MSDs, see References [63] to [66]. For further information on psychological health and safety in the workplace, see References [1] to [42]

# Ergonomics — Manual handling —

# Part 1: Lifting, lowering and carrying

## 1 Scope

This document specifies recommended limits for manual lifting, lowering and carrying while taking into account the intensity, the frequency and the duration of the task. It is designed to provide requirements and recommendations on the assessment of several task variables, allowing the health risks for the working population to be evaluated.

This document applies to manual handling of objects with a mass of 3 kg or more and to moderate walking speed, i.e. 0,5 m/s to 1,0 m/s on a horizontal level surface.

This document is based on an 8 h working day, but also covers more prolonged working times, up to 12 h. It also addresses the analysis of combined lifting, lowering and carrying tasks in a shift during a day.

This document does not cover the holding of objects (without walking), the pushing or pulling of objects or manual handling while seated. The pushing and pulling of objects are covered in the other parts of the ISO 11228 series.

This document does not cover handling people or animals. (For further information on handling people, refer to ISO/TR 12296.)

This document does not address the manual lifting of objects while using lift-assistive devices such as exoskeletons and does not address the needs of pregnant women or persons with disabilities.



## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

**3.1**
**manual handling**
activity requiring the use of human force to lift, lower, carry or otherwise move or restrain an object

**3.2**
**lifting**
manually (i.e. without using mechanical assistance) moving an object from its initial position

**3.3**
**lowering**
manually (i.e. without using mechanical assistance) moving an object from its initial position downwards

Note 1 to entry: Included in lifting.

**3.4**
**carrying**
manually (i.e. without using mechanical assistance) moving an object which is held with either one or two hands, or positioned on one or two shoulders or on the neck, by walking one metre or more

Note 1 to entry: Does not include the use of backpacks.

**3.5**
**risk assessment**
overall process comprising a risk analysis and risk evaluation

**3.6**
**reference conditions**
set of conditions (environmental, physical, biomechanical and task-design-related) which are considered to be the ideal conditions for safe manual handling to take place

Note 1 to entry: See 4.2.1, 4.2.3.2, A.4 and H.1 for detailed definitions of lifting and carrying conditions.

**3.7**
**repetitive lifting**
lifting an object more than once every 10 min



Note 1 to entry: Infrequent lifting at one lift every 10 min is defined in Reference [57], where a multiplier of 1,0 is applied for all duration scenarios at a frequency of 1 lift per 10 min.

**3.8**
**mid-sagittal plane**
vertical plane in the anterior-posterior direction that divides a person assuming a neutral body posture into equal left and right halves



Note 1 to entry: See Figure C.1

Note 2 to entry: A neutral body posture is an upright standing posture with the arms hanging freely by the side of the body.

**3.9**
**plane of asymmetry**
vertical plane passing through the midpoint of the line between the inner ankle bones and the centre of gravity of the load when the load is at its most extreme displacement from the neutral, mid-sagittal plane

**3.10**
**angle of asymmetry**
angle formed between the lines that result from the intersections of the mid-sagittal plane and the plane of asymmetry

Note 1 to entry: If the feet are repositioned during the lift or lower sequence, the referent planes shall be determined at the point in the action sequence where the largest degree of asymmetrical twist is encountered (see Figure C.1).

**3.11**
**reference mass**
mass considered appropriate for use with an identified user population during the application of the risk-assessment method described herein

**3.12**
**cumulative carried mass**
product of the carried mass and the carrying frequency

Note 1 to entry: The cumulative mass for carrying is defined in kilograms per minute to represent the risk for short-term carrying, in kilograms per hour to represent the risk for medium-term carrying and in kilograms per 8 h to represent the risk for long-term carrying.

**3.13**
**recovery time**
time used for determining the work/recovery pattern, which is the period of light work activity Note 1 to entry: Light work activity can include monitoring activities, light assembly work using the upper limbs, work not involving lifting or lowering or carrying > 3 kg, and work not involving pushing or pulling.

# 4 Risk reduction for manual lifting or carrying tasks

## 4.1 General

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation, the results of which are ultimately used in the effort to reduce risk. The goal in manual materials handling risk reduction is to take measures to improve the design of the task, the object and the working environment relative to the characteristics of the individuals performing the work.

In those cases where manual handling cannot be avoided, a risk assessment shall be completed to determine if, and to what extent, modifications are recommended. The risk assessment takes into account the mass of the object, the grip on the object, the position of the object relative to the position of the body, and the frequency and duration of a specific task.

The risk assessment is accomplished using the step-by-step approach illustrated in Figure 1 (step model). With each successive step, the evaluator analyses the interrelated aspects of the tasks.

If recommended limits are exceeded, the task shall be adapted in such a way that all questions in the step-by-step approach are satisfied.

Employees engaged in manual handling should be provided with adequate information and training on how to perform these tasks safely. The provision of this information and training does not, in isolation, ensure safe manual handling in all cases. However, it is an integral part of the ergonomics approach, and the risk of injury can be reduced by adopting safe ways of manual handling (see A.6).

## 4.2 Risk assessment (step model)

### 4.2.1 Using the step model

The step model illustrated in Figure 1 describes the steps involved in beginning, and working through, a risk assessment of manual handling tasks, including lifting and carrying. Initially, the mass of the object being handled is determined; if it is more than 3 kg, the risk assessment is continued. The task is further analysed to determine if the mass exceeds recommended limits for handling (step 1).

The user shall make modifications where limits are exceeded. In those tasks where lifting and carrying is repetitive, the assessment is continued using the quick assessment procedure (step 2). Based on the outcome of step 2, the task will possibly:

— require immediate modifications for safety (see Annex A for further information);

— be determined to be acceptable; or

— need further, more detailed, risk evaluation (step 3).

Step 3 is also used for evaluating tasks which take place using non-ideal postures.

The reference condition of manual lifting and lowering posture for manual handling is:

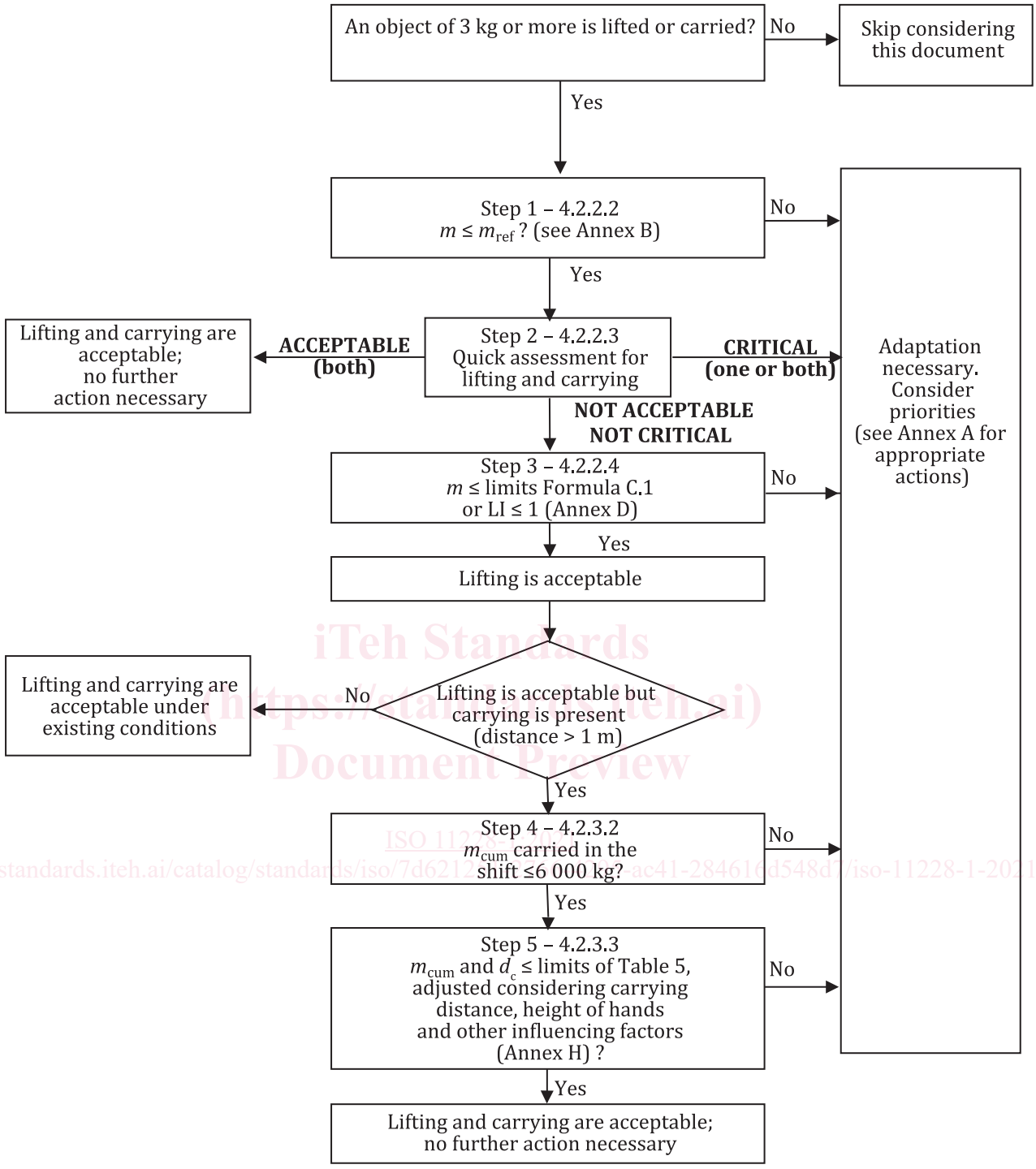
— an upright symmetrical trunk posture (no twisting or lateral bending);

— sagittal trunk inclination of no more than 15° (the minimum inclination observable with the human eye) from the vertical to accommodate the natural posture of the back;

— the horizontal distance between the object being handled and the centre of mass of the worker as close as possible;

— the grip height lying within knuckle and elbow height for lifting or between knuckle and shoulder height for carrying (for anthropometric measurements see ISO 7250-3).

Steps 4 and 5 assist with the further evaluation of the task for cumulative mass for lifting and carrying.




**Key**

| | |
|---|---|
| $m$ | mass of object to be lifted |
| $M_{ref}$ | reference mass for identified user population group |
| $M_{cum}$ | cumulative mass (carried) |
| $d_c$ | duration (of carrying) |
| LI | lifting index |

**Figure 1 — Step model**

### 4.2.2 Recommended limit for manual lifting, lowering and carrying

#### 4.2.2.1 Weight of the object

Whenever an object of 3 kg or more is lifted or carried, a risk assessment shall be performed, beginning with the initial screening, step 1. Note that throughout the text whenever the term “lifting” is used the act of “lowering” is implied.

#### 4.2.2.2 (Step 1) Initial screening

An initial screening of non-repetitive lifting and carrying (performed with reference conditions in place) requires the determination of the object's mass (step 1). The recommended limit for the mass of the object, referred to as the reference mass, $m_{ref}$, and based on population characteristics, is presented in Annex B. For general guidance for designers and additional information related to step 1, see Annex A.

#### 4.2.2.3 (Step 2) Quick assessment of repetitive lifting and carrying

Screening of repetitive lifting and carrying tasks of objects of 3 kg or more is performed using the quick assessment procedure.

The quick assessment procedure aims to identify, without the need for calculation, the presence of two opposite exposure conditions:

— acceptable condition, where unacceptable risk has not been identified;

— critical condition, where unacceptable risk has been identified.



When either of these conditions is met, it is not necessary to perform a more detailed evaluation of the exposure level. Instead, either no further modifications need to be considered (acceptable risk, see Table 1 and Table 2) or modifications should be made immediately (see Annex A for guidance) due to the presence of a critical condition (see Table 3). In either case, Table 4 shall also be referenced to identify the presence of any unfavourable working environment or object circumstances which can further increase the risk of the task (additional factors).

When neither of the two extreme conditions is met, it is necessary to conduct further risk evaluation by methods presented in step 3 (see 4.2.2.4).

Table 1 and Table 2 are used for establishing the acceptable risk condition. If all of the listed conditions are present (yes for each condition), the examined task is acceptable and it is not necessary to continue with a risk evaluation. If any answers are no, then Table 3 shall be used to confirm if there are critical conditions. If any of these conditions is met (a yes response), the task shall not be performed before modifications are made.

In either case, Table 4 shall also be systematically used to identify the presence of any unfavourable working environment or object characteristics which will potentially further increase the risk of the task. These factors can be related to the work environment or to the object characteristics, and they shall be addressed to help reduce risk.

**Table 1 — Lifting and lowering — Quick assessment — Acceptable condition**

| Lifting and lowering | | | |
|---|---|---|---|
| **3 kg to 5 kg** | Asymmetry (e.g. body rotation, trunk twisting) is absent | No | Yes |
| | Load is maintained close to the body (e.g. where space between the body and the item is minimized) | No | Yes |
| | Load vertical displacement is between hips and shoulders | No | Yes |
| | Maximum frequency: less than five lifts per minute | No | Yes |

**Table 1** *(continued)*

| | | | |
|---|---|---|---|
| **> 5 kg to 10 kg** | Asymmetry (e.g. body rotation, trunk twisting) is absent | No | Yes |
| | Load is maintained close to the body (e.g. where space between the body and the item is minimized) | No | Yes |
| | Load vertical displacement is between hips and shoulder | No | Yes |
| | Maximum frequency: less than one lift per minute | No | Yes |
| **More than 10 kg** | Loads of more than 10 kg are absent | No | Yes |
| If all of the questions are answered yes, then the examined lifting task is acceptable and it is not necessary to continue the risk evaluation, except to review Table 4 for other factors to be considered.<br>If at least one of the questions is answered no, the evaluation shall continue (see Table 3 and Table 4). | | | |

**Table 2 — Carrying — Quick assessment — Acceptable condition**

| **Carrying** | | | | |
|---|---|---|---|---|
| Calculate the cumulative mass (total kg carried during the given durations for the given distance below).<br>Is the carried cumulative mass less than or equal to recommended cumulative masses values considering distances (±5 m) and duration (1 min; 1 h; 4 h; 8 h)? | | | | |
| **Duration** | **Distance 1 m to ≤ 5 m per action** | **Distance > 5 m to 10 m per action** | | |
| **6 h to 8 h** | 4 800 kg | 3 600 kg | No | Yes |
| **4 h** | 4 000 kg | 3 000 kg | No | Yes |
| **1 h** | 2 000 kg | 1 500 kg | No | Yes |
| **1 min** | 60 kg | 45 kg | No | Yes |
| | Acceptable conditions for carrying: carry with two hands over a maximum distance of 10 m, picking up and setting down the object at height, where the pick-up and set-down height ranges between 0,75 m and 1,10 m, with the full cycle including returning back to the start point empty-handed over the same distance. The carrying exercise is performed in a comfortable indoor environment, on a hard, flat, non-slip floor, without any obstacles in the way, and in a workspace allowing free body movement and posture. No constraints are placed on the subject. Awkward postures during the carrying are not present. | | No | Yes |
| If all of the questions are answered yes, then the examined carrying task is acceptable and it is not necessary to continue the risk evaluation except to review Table 4 for other factors to be considered.<br>If at least one of the questions is answered no, the evaluation shall continue (see Table 3 and Table 4). | | | | |

**Table 3 — Lifting or carrying— Quick Assessment — Critical condition**

| **Critical condition for lifting: task layout and frequency conditions exceeding the maximum suggested** | | | |
|---|---|---|---|
| **Vertical location** | The hand location at the beginning and end of the lift is higher than 175 cm or lower than the surface at the feet | No | Yes |
| **Vertical displacement** | The vertical distance between the origin and the destination of the lifted object is more than 175 cm | No | Yes |
| **Horizontal distance** | The horizontal distance between the body and load is greater than full arm reach (>63 cm) | No | Yes |
| **Asymmetry** | Extreme body twisting (to either side by more than 45°) without moving the feet | No | Yes |

**Table 3** *(continued)*

| | | | |
|---|---|---|---|
| **Frequency of lifts**[56] | More than 15 lifts per min of short duration (manual handling lasting no more than 60 min consecutively in the shift, followed by at least 60 min of recovery time) | No | Yes |
| | More than 12 lifts per minute of medium duration (manual handling lasting no more than 120 min consecutively in the shift, followed by at least 30 min of recovery time | No | Yes |
| | More than 10 lifts per minute of long duration (manual handling lasting more than 120 min consecutively in the shift) | No | Yes |
| **Critical condition for lifting or carrying: presence of loads exceeding the following limits (see Table B.2 for further information)** | | | |
| **Females** (20 to 45 years) | 20 kg | No | Yes |
| **Females** (<20 or > 45 years) | 15 kg | No | Yes |
| **Males** (20 to 45 years) | 25 kg | No | Yes |
| **Males** (<20 or > 45 years) | 20 kg | No | Yes |
| **Critical condition for carrying: presence of cumulative carried mass greater than those indicated also with acceptable conditions for carrying** | | | |
| **Carrying distance (per action) 1 m to 5 m over a 6 h to 8 h period?** | 6 000 kg in 6 h to 8 h | No | Yes |
| **Carrying distance (per action) 5 m to 10 m over a 6 h to 8 h period?** | 3 600 kg in 6 h to 8 h | No | Yes |
| **Carrying distance (per action) 10 m to 20 m over a 6 h to 8 h period?** | 1 200 kg in 6 h to 8 h | No | Yes |
| **Carrying distance (per action) more than 20 m** | Carrying distance is usually more than 20 m | No | Yes |
| If at least one of the conditions has a yes response, then consider risk as high and a critical condition is present. Proceed with task redesign and continue to Table 4 to identify additional factors to be considered, and then continue to Annex A for identifying urgent corrective actions. | | | |



**Table 4 — Lifting and carrying — Additional factors to be considered**

| | | |
|---|---|---|
| **Is the working environment unfavourable for lifting and carrying?** | | |
| Presence of extreme (low or high) thermal stress (e.g. temperature, humidity, air movement) | No | Yes |
| Presence of slippery, uneven, unstable floor | No | Yes |
| Presence of insufficient space for lifting and carrying | No | Yes |
| **Are there unfavourable object characteristics for lifting and carrying?** | | |
| The size of the object reduces the worker's view and hinders movement | No | Yes |
| The load centre of gravity is not stable (e.g. liquids, items moving around inside of object) | No | Yes |
| The object shape or configuration presents sharp edges, surfaces or protrusions | No | Yes |
| The contact surfaces are too cold or too hot | No | Yes |
| Improper handholds or coupling | | |
| **Does the lifting or carrying task(s) last more than 8 h a day?** | No | Yes |
| If at least one of the questions is answered yes, the specified condition shall be addressed and the risks minimized. | | |

#### 4.2.2.4 (Step 3) Recommended limits for mass, frequency and object position

When none of the two conditions identified in step 2 is met, it is necessary to conduct a risk evaluation (step 3) to determine the recommended limits for the task.