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Ergonomics — Application of ISO 11226, the ISO 11228 series and ISO/TR 12295 in the agricultural sector

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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.

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*.

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

Agriculture is by far the biggest working sector in the world. It is estimated that 2,6 billion people or 40 % of the world's population are farmers. Agriculture is one of the most hazardous sectors in both the developing and the developed worlds. Work-related musculoskeletal disorders (WMSDs) are the most common work-related diseases in farmers. In Europe more than 50 % of farmers report disorders of their lower back or limbs related to their working conditions. WMSDs are caused mainly by manual handling, heavy physical work, awkward postures and repetitive movements. Increasing attention is being drawn to the application of practical actions in agricultural settings to help reduce work-related accidents and illness and WMSDs in particular. ISO 11226, the ISO 11228 series and, more recently, ISO/TR 12295 are useful for this specific scope.

Experiences in the application of these standards have been acquired in different parts of the world, but rarely in agriculture. This document extends the scope and methods included in existing standards to different agricultural contexts (e.g. smallholdings, industrialized farms) based on emerging application experiences. Special attention is devoted to rendering this document accessible also to non-experts. Reference is made to easily applicable, non-commercial online tools (simple tools in spreadsheets) that may be useful for the purposes of this document, making possible the application of the criteria provided here and therefore the real numerical estimate of the biomechanical overload risks.

The ISO 11228 series, ISO 11226 and ISO/TR 12295 establish ergonomic recommendations for different manual handling tasks, repetitive movements and working postures. All their parts apply to occupational and non-occupational activities. The standards provide information for designers, employers, employees and others involved in work, job and product design, such as occupational health and safety professionals.

ISO 11228 series consists of the following parts, under the general title *Ergonomics — Manual handling*:

— Part 1: Lifting and carrying;

— Part 2: Pushing and pulling;

— Part 3: Handling of low loads at high frequency.

ISO 11226 provides recommended limits for static working postures with no or minimal external force exertion, while taking into account body angles and duration.

ISO/TR 12295 serves as an application guide of the ISO 11228 series and ISO 11226. It offers a simple risk assessment methodology for small and medium enterprises and for non-professional active.

This document is intended to be used alongside ISO/TR 12295, ISO 11226 and the ISO 11228 series in the agricultural sector, where the risk from biomechanical work overload from repetitive movements, from manual handling of loads, from towing and pushing carts and awkward postures is universally present.

In addition to having deeply used the standards previously mentioned, an extensive review of the literature on methods for risk assessment of biomechanical overload applied in the agricultural setting for the prevention of musculoskeletal disorders (MSDs) has been conducted, of which the most salient data are reported.

Regarding crop production (not cattle), the assessment of biomechanical exposures at work results in 800 studies where 58 studies were selected on the basis of title and abstract. Only studies regarding crop production and reporting on risk assessment of biomechanical exposures at work were included in the analysis.

The design of the selected studies was mostly cross-sectional (70 %) and Asia was the world region from where the majority of the studies came (41 %). In addition, 10 studies were carried out in South America, 13 in North America (Canada and the USA), 10 in Europe and two in Africa. Most of the selected studies were field studies (68 %); only 8 % were carried out in a laboratory and seven studies were classified as surveys.

Regarding the applied methods, 14 studies used direct measurements (e.g. electromyography, accelerometer) and 12 studies used different types of questionnaires (self-compiled or filled in by an Ergonomist).

Six studies used the RULA (Rapid Upper Limb Assessment)[45] method.

OWAS (Ovako Working Posture Analysing System)[42] was used as a risk assessment method in five studies.

The OCRA (Occupational Repetitive Actions[21],[22]) checklist, the REBA (Rapid Entire Body Assessment)[39] method and the QEC (Quick Exposure Check)[29] method were used in nine studies (three studies).

Most of the applied methods are observational and attention is drawn to the problems related to their reliability, especially when the movements are fast.

These studies represent a summary of the papers published in the last decade in the agriculture sector. The available research has shown a lack of high-quality studies (generally using statistical "prospective" studies) to evaluate the dose-response relationship between the level of biomechanical exposure at work and the outcome (MSDs). It is necessary to consider in fact that, given the lack of results of clinical studies in agriculture (due to the widespread difficulty in subjecting workers to health surveillance), occupational exposure limits connected with the probability of generating MSDs in the agricultural setting are not available.

The OCRA checklist method, in its multi-day cycle risk assessment version,[22] is currently the only risk assessment method available in literature capable of offering criteria and application experiences to address multitask analysis (supported by a specific simple tool in the form of free download spreadsheets for final risk calculation).

ISO/TR 12295 had already adopted this multitask method of exposure analysis.

Clinical evaluation of exposed workers, conducted in multitask studies in agriculture with the OCRA method and with other methods, are still limited to few longitudinal studies due to great difficulty in having case studies subjected to health control, as there are rarely fixed-term workers, but more often seasonal workers, with high turnover, without regular work contracts and underpaid. For this reason, the prospective studies are difficult and very rarely can be concluded.

After all, the development of a method capable of predicting the appearance of pathologies (real risk assessment method) can be conquered only after years of use and improvement. The development of a new TR which, offering evaluation solutions for biomechanical overload study in agriculture, can stimulate many more valid epidemiological studies in the future, is therefore desirable. The concept of doing nothing, while waiting for sufficient and perfect published methods, means not doing prevention.

The NIOSH itself, due to the formula for calculating the lifting index (LI), changed the maximum limit value of its first formula several times over the years, through years of application experience. Recently the NIOSH added the formula for calculating the variable lifting index (VLI) for the evaluation of manual lifting tasks of complex loads, with many different weights and geometries[20],[63]. The gained experience in this type of analysis was introduced in ISO/TR 12295 and ISO 11228-1.

For the study of working postures it is important to point out the new TACOS (Timing Assessment Computerized Strategy for posture)[24] strategy, which adds to all the experience gained from the RULA and REBA methods and from ISO 11226, a more adequate timing assessment (therefore not only qualitative studies of work postures, but also studies of their real duration).

The mathematical criterion for the extension of the calculation of any risk factors for the study of biomechanical overload, not only for the working day cycle but also for cycles different in duration (e.g. annual cultivation cycles) was also discussed within a specifically activated writing group of experts for the preparation of this document. The transition is indispensable for the extension of the evaluation models already present in the specific International Standards (all used in this document) to the risk evaluation in multitask exposition with annual turnover needed for risk studies in agriculture (see Annex B).

Any other risk assessment methods that include a multitask analysis procedure can adopt the criteria here proposed, extending multitask annual exposure risk study, for instance to:

— repetitive movements (e.g. strain index, method present in ISO 11228-3);

— manual handling of loads (NIOSH formula in ISO 11228-1).

Ergonomics — Application of ISO 11226, the ISO 11228 series and ISO/TR 12295 in the agricultural sector

1 Scope

This document is intended to be used alongside ISO/TR 12295, ISO 11226 and the ISO 11228 series in the agricultural sector. This document gives information on how existing standards can be used in a global sector such as agriculture where, albeit with different characteristics, biomechanical overload is a relevant aspect, WMSDs are common and specific preventive actions are needed.

The proposed project aims to:

1) define the user(s) and fields for its application (including non-experts in ergonomics);

2) provide examples of procedures for hazard identification, risk estimation or evaluation and risk reduction in different agricultural settings, through:

   — more synthetic procedural schemes (main test);

   — more analytical explanations of the procedures, through mathematical models and application examples, also with the use of specific free simple tools, in:

      — Annex A (pre-mapping with ERGOCHECK);

      — Annex B (evaluation of Multitask risk of biomechanical overload on typical agricultural macro-cycles, considering upper limbs repetitive movements, manual lifting and carrying, pushing-pulling);

      — Annex C (study of awkward postures with criteria derived from the actual standards and scientific literature as TACOS method).

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

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/

4 General outline of work processes in an annual multi-task analysis in agriculture

4.1 General structure of a multi-task analysis

Specifically, this document provides additional information to aid the user in the selection and use of the appropriate standards. Depending upon whether specific risks are present, it is intended to help the user to decide which standards to apply. It will include three levels of approach (Figure 1):

— First level: the "participatory approach" for pre-mapping of danger and discomfort provides all users, particularly those who are not experts in ergonomics, with criteria and procedures to identify situations in which they may apply the ISO 11228 series, ISO 11226 and ISO/TR 12295 in different agricultural settings (key-enter and key-questions level). Only in the early analytical stage is the opportunity offered to map, even if only using subjective data obtained by interviewing the workers (through the identification of groups of workers, homogeneous for exposure to occupational risks), all the occupational hazards and not just the risk of biomechanical overload.

— Second level: provides a "quick assessment method" (according to the criteria provided in ISO/TR 12295) for easily recognizing activities that are "definitely acceptable or definitely critical". If an activity is "neither definitely acceptable nor definitely critical", it is necessary to complete a detailed risk-assessment as set out in the standards, continuing with the necessary subsequent preventive actions.

— Third level: refer to detailed methods for risk assessment set out in the relevant standards when the quick assessment method shows that the activity risk falls between the two exposure conditions (definitely acceptable or definitely critical).

The above approaches and scopes are illustrated in the flowchart in Figure 1 and are described in the main text of ISO/TR 12295.

At first the user is required to answer a short series of practical questions present in the first and second level. It is emphasized that the quick-assessment method is best implemented using a participatory approach involving workers in the enterprise (homogeneous groups of workers).

This involvement is deemed to be essential for effectively setting priorities for dealing with the different hazard and risk conditions and, where necessary, identifying effective risk reduction measures.

In agriculture evaluation it can be possible to limit the study to the first and second levels, obtaining sufficient data about occupational risk priorities.

The analytical risk assessment approach (third level) provides all users, especially those experienced in ergonomics, or familiar with the ISO 11228 series, with details and criteria for applying the risk assessment methods proposed in the original standards also to agriculture.

This analytical risk assessment approach is fully consistent with the methods proposed in the standards and does not introduce any changes in the criteria (mathematical model) for risk calculations, defined in the existing standards (as well expressed in ISO/TR 12295) but only adapts the proposed methodology to the risk assessment in agriculture.

The proposed additional analyses aim to facilitate the use of the actual standards, making it possible to extend them to risk assessment in agriculture (Annexes A, B and C).

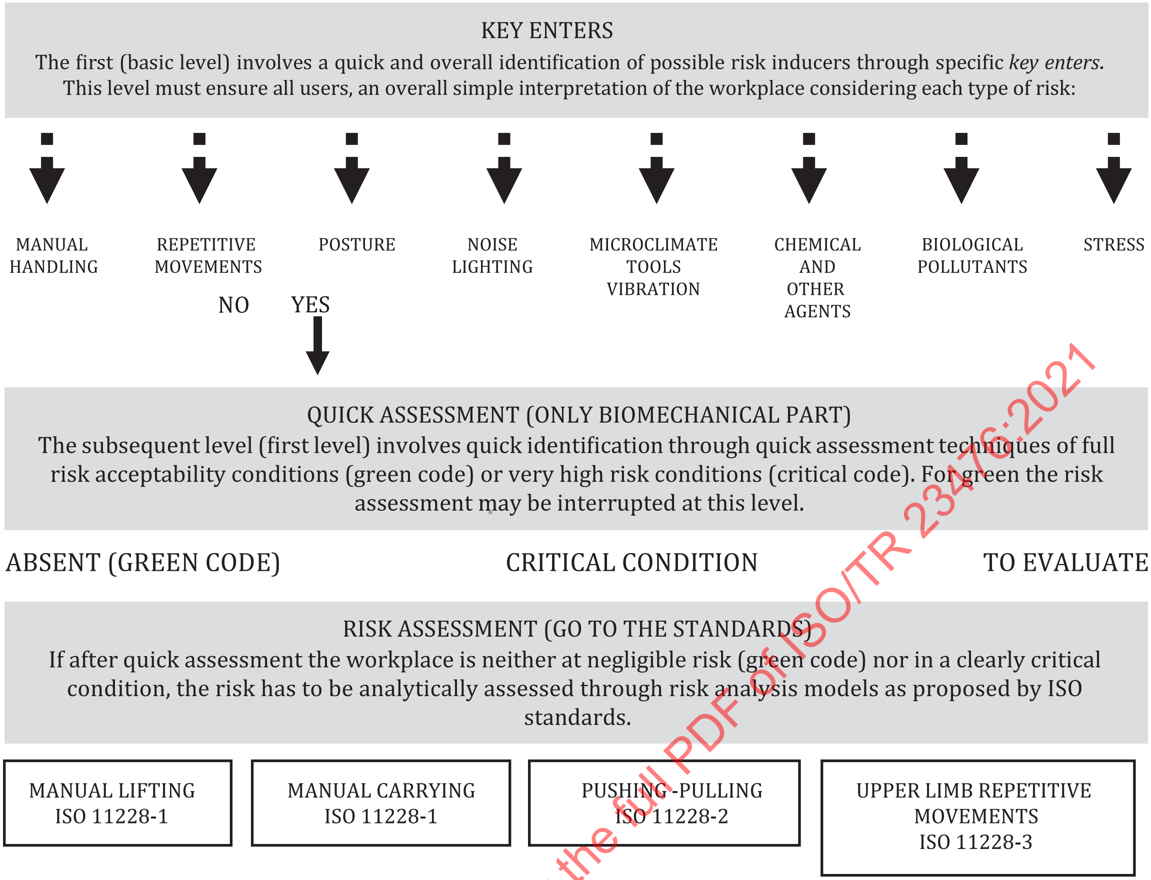


Figure 1 — Different risk assessment levels according to ISO/TR 12295 for biomechanical overload estimation

4.2 Study of tasks distribution over the year and search for groups of workers who are homogeneous in terms of risk exposure

4.2.1 General

In a setting such as agriculture, before starting a risk analysis, it is necessary to define a set of procedures and criteria for estimating risk in complex situations where workers perform multiple tasks, variously distributed in qualitative and quantitative terms over the year (annual cycle).

The general risk evaluation process entails a certain number of steps, beginning with:

a) identification of the macrocycle of the many different tasks;

b) analysis of farming tasks to identify tasks performed within the period and obtain a qualitative definition of the work during each month of the year;

c) identification of one or more homogeneous groups.

4.2.2 Macrocycle duration

Task rotation is when a worker alternates between two or more tasks during a certain period of time; this situation occurs quite often in modern work organizations and, if properly designed, can represent one of the most effective strategies for reducing the risk of biomechanical overload.

In special situations, such as in agriculture, where the worker has to perform a large number of tasks and the tasks are distributed “asymmetrically” over the shift, risk assessments can become extremely complex. This is why it is necessary to carry out a thorough preliminary study of how the work is organized. At any rate, the risk analysis process involves different steps, listed further on.

The first step consists in defining the time required to complete the task rotation schedule; this is the macro-cycle time, which may be daily, weekly, monthly or yearly.

The types of macrocycles durations are infinite, but if there are no simplification criteria that allow us to estimate the risk, every risk assessment stops and nobody does anything (the excuse being that the mission is impossible).

The modal macro-cycle periods appear to be, at least in the sectors of agriculture, building construction and services, accurately representative of job cycles. In agriculture, task rotations are typically annual, but one can use annual cycles even when multiple cycles of fewer months in each year are repeated identically (e.g. multiple harvests per year of the same product). In the construction sector there is generally a yearly cycle for large construction sites, but a monthly cycle (modal) is more frequent in smaller-scale constructions and civil renovation projects. In other sectors (e.g. logistics for retail chains, cleaning services, food preparation facilities), the most common rotation scenario is monthly, while in yet other situations (e.g. supermarkets) tasks can be rotated on a weekly or, occasionally, a monthly basis.

In summary, some practical suggestions are provided here for using the predefined macro-cycle (weekly, monthly, yearly), thus certainly simplifying subsequent evaluations:

— If several identical sub-macro-cycles are repeated over the year, use the annual macro-cycle.

— If several identical sub-macro-cycles (e.g. week, fortnight) are repeated within the month and if the following months are similarly repeated, use the monthly macro-cycle.

Whichever macro-cycle duration is chosen, the criteria and procedures for dealing with the biomechanical overload risk analysis are the same. Given the extreme activity variability, the recommendation is, however, to identify and evaluate representative modal scenarios.

4.2.3 Phases and tasks identification

It is not simple to identify farming tasks, which may be very numerous and performed by different workers or groups of workers. At the outset, therefore, it is necessary to:

a) identify the specific cultivation or crop;

a) break down the crop-growing activities into phases; all relevant tasks must be identified inside each phase.

The same activity can be carried out in several different ways; each operating method is intended to be viewed as a separate task and listed accordingly (e.g. pruning with manual tool or pruning with pneumatic tool).

It is important to note that all the tasks performed at the farm over the year have to be evidenced, including preparing the soil, applying fertilizers and disinfectants and other seemingly ancillary activities, regardless of who performs them.

As it is so inherently difficult to identify phases and tasks in the crop growing or cultivation process,[21],[22],[25] a kind of universal cultivation system has been developed that will enable even beginners to conduct a preliminary organizational analysis in an agricultural setting.

It consists of phases (soil preparation, treatment, disinfection and fertilization, planting, intermediate processes, harvesting) that include a certain number of typical tasks broken down by type, technique and tools (Table 1).

Table 1 — Principal tasks characterizing a generic cultivation: the universal cultivation system

Preparation and treatment of soil, mechanical weeding	with tractor
	with animals
	with manual tools
	manual carrying (weight up to max. 3 kg)
	manual carrying (weight 3 kg)
	with manual tool and pulling or pushing
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)
Disinfection, disinfestation, fertilizing, chemical weeding	with tractor
	manual with machinery
	manual with tools
	with manual tools and pulling or pushing
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)
Planting	automatic with tractor
	semi-automatic with tools or machinery
	manual with manual tool (product weight up to max. 3 kg)
	manual without tools (product weight up to max. 3 kg)
	manual with manual tool (product weight over 3 kg)
	manual without tools (product weight over 3 kg)
	manual carrying (product weight up to max. 3 kg)
	manual carrying (product weight over 3 kg)
	with manual tool and pulling or pushing
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)
Intermediate farm work (e.g. pruning, binding, thinning)	pruning with manual tools
	pruning with pneumatic or electric tools
	pruning with chainsaws
	manual pruning without tools
	manual carrying (weight up to max. 3 kg)
	manual carrying (weight 3 kg)
	with manual tool and pulling or pushing
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)

Table 1 *(continued)*

Harvesting of crops	automatic with tractor
	semi-automatic with tools or machinery
	manual with manual tool
	manual with pneumatic or electric tools
	manual without tools
	manual carrying (weight up to max. 3 kg)
	manual carrying (weight 3 kg)
	with manual tool and pulling or pushing
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)

4.2.4 Identification of the different homogeneous groups

The next step is to assign tasks to an individual worker or group of workers exposed to the same risk, to identify homogeneous groups. Since the focus of the analysis is the exposure of workers to a set of conditions determined by the tasks they are assigned to perform, it is first necessary to identify which homogeneous group of workers are present that need to be examined.

The homogeneous group of workers for risk exposure (as groups of workers homogeneous for working risks are being defined, not groups of people homogeneous for other factors, such as weight, age, culture or gender) is the group of workers that performs the same tasks, in the same workplace and with similar durations (or time patterns) during the selected period (macro-cycle).

Note that a homogeneous group may sometimes be made up of just one person, if no other workers perform the same tasks qualitatively and quantitatively.

Moreover, if two groups of workers perform the same tasks in the same workplaces but with different durations or time patterns (e.g. one group works full-time and the other works part-time) the two groups must be analysed separately.

For instance, typically (as presented in Table 2), a single group of workers may be assigned the job of actually growing a crop (tasks may include pruning and harvesting) (homogeneous group 1), while other workers prepare and disinfect the soil, apply fertilizers and so on (homogeneous group 2), as presented in Table 3.

Homogeneous groups of seasonal workers can also be present, who are called to work only in the harvesting phase (Table 4).

The assignment of the tasks to a homogeneous group (or individual worker) even just from the qualitative standpoint (or semiquantitative as here), is not difficult but it is absolutely essential before conducting the first levels of risk evaluation (key questions and quick assessment level).

To determine the real risk exposure (risk assessment level) it is necessary to study a quantitative description of all active tasks.

Only after this organizational analysis, can the different risk levels be assessed in terms of repetitive movements, manual load handling, awkward postures and pushing-pulling.

Table 2 — Example of description of tasks (pruning and harvesting) performed monthly by homogeneous group 1

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plowing (tractor)												
Installing irrigation system												

Table 2 *(continued)*

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Planting (manual)											40 %	10 %
Planting (mechanical)											20 %	90 %
Pruning large branches with chainsaws												
Pruning with manual shears										50 %	5 %	
MMH of large branches										40 %	30 %	
Pruning with manual shears		70 %	70 %	60 %	60 %	60 %						
MMH of small branches		20 %	20 %	30 %	30 %	30 %						
Manual harvesting on ground							45 %	45 %	45 %			
Manual harvesting on ladder							35 %	35 %	35 %			
MMH of ladder							10 %	10 %	10 %			
Preparing machine to apply fertilizer												
Driving tractor												
Composting (manual)												
Disinfection (manual)												
Disinfection (tractor)												
Push/pull trolley-large branches		5 %	5 %	5 %	5 %	5 %				5 %	5 %	
Push/pull trolley-small branches		5 %	5 %	5 %	5 %	5 %				5 %		
Push/pull trolley-fruit boxes							10 %	10 %	10 %			
	0	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

Table 3 — Example of description of tasks (workers prepare and disinfect the soil, apply fertilizers) performed monthly by homogeneous group

Task	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plowing (tractor)	40 %	20 %	20 %	20 %	40 %	30 %	30 %	30 %		100 %	20 %	20 %
Installing irrigation system	20 %											
Planting (manual)												
Planting (mechanical)											20 %	20 %
Pruning large branches with chainsaws												
Pruning with manual shears												
MMH of large branches												
Pruning with manual shears												
MMH of small branches												
Manual harvesting on ground												
Manual harvesting on ladder												
MMH of ladder						70 %	70 %	70 %				
Preparing machine to apply fertilizer		10 %	10 %	10 %							20 %	20 %
Driving tractor		40 %	40 %	40 %							20 %	20 %
Composting (manual)		10 %	10 %	10 %							20 %	20 %
Disinfection (manual)	20 %	10 %	10 %	10 %	30 %							
Disinfection (tractor)	20 %	10 %	10 %	10 %	30 %							
	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	0	100 %	100 %	100 %

Table 4 — Example of description of tasks (harvesting) performed by a seasonal homogeneous group

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plowing (tractor)												

Table 4 *(continued)*

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Installing irrigation system												
Planting (manual)											40 %	10 %
Planting (mechanical)											20 %	90 %
Pruning large branches with chainsaws												
Pruning with manual shears										50 %	5 %	
MMH of large branches										40 %	30 %	
Pruning with manual shears												
MMH of small branches												
Manual harvesting on ground							45 %	45 %	45 %			
Manual harvesting on ladder							35 %	35 %	35 %			
MMH of ladder							10 %	10 %	10 %			
Preparing machine to apply ferti-lizer												
Driving tractor												
Composting (manual)												
Disinfection (manual)												
Disinfection (tractor)												
Push/pull trolley-large branches										5 %	5 %	
Push/pull trolley-small branches										5 %		
Push/pull trolley-fruit boxes							10 %	10 %	10 %			
							100 %	100 %	100 %			

5 First levels: pre-mapping of danger and discomfort through key questions and quick assessment

5.1 Foreword

One of the latest developments being pursued by the World Health Organization (WHO) and other international organizations (ILO, ISO), in relation to preventing work-related diseases and disorders concerns the creation of toolkits[8],[9],[17],[19],[26],[27].

The main aim is to rapidly but accurately identify the presence of possible sources of risk, using instruments that can easily be used by accident prevention officers, occupational physicians, business owners, workers, trade union representatives and security services.

However, this objective also reflects the criteria set forth in ISO/TR 12295 with respect to the risk of biomechanical overload, as mentioned in Annex A. In Annex A, all the criteria and methods used for the pre-mapping are presented again but in greater detail and through real examples. The presented results have been obtained with specifically prepared simple tools. Against this backdrop, the "problem of WMSDs" can be considered together with "other occupational hazards" (e.g. physical, chemical), for the more general purposes of prevention.

The aim here is to suggest a methodology and some simple tools (free downloadable calculation sheets[64]) to undertake a preliminary mapping of discomfort or danger (i.e. to identify risk sources in the work cycle), especially in small and very small businesses. The simple tool is not designed to replace the standard risk evaluation process, but to support such a process in order to identify hazardous situations in the workplace, to single out emerging problems that need to be submitted to a full risk assessment, in the appropriate order of priority. The simple tool is primarily designed to be used by employers and work safety officers, but it may also be useful for:

— medical staff conducting periodical inspections and drafting health surveillance protocols;

— work safety officers periodically monitoring hazardous situations in the workplace;

— supervisory bodies (labour inspectors) conducting inspections in the workplace, needing to rapidly detect potentially dangerous situations requiring specific preventive interventions;

— trade union representatives.

The procedure presented here demands a cooperative approach towards assessing and managing risk, as it also entails interviews with workers.

In accordance with the recommendations of the WHO, three main criteria underpin the methodology:

— globality: a global approach towards assessing the worker's discomfort, due to either the task or the workplace;

— simplicity: the methodology consists in an easy-to-use model for collecting data;

— priority setting: the results obtained automatically via dedicated software and depicted clearly in bar graphs will not only help to identify problems but also offer a scale of priorities for conducting subsequent assessments and ergonomic redesign.

5.2 The pre-mapping model

Please note that the pre-mapping model (presented in greater detail in Annex A) has to be used through the interview of workers of each homogeneous group (i.e. groups of workers exposed to the same occupational hazards).

This step entails two levels of intervention (Figure 1):

— level one: a rapid and general identification of possible risk inducers via the use of specific "key-enters and key questions".

The first level is broken down into several "boxes" relating to the main types of risks, for example handling loads, repetitive movements of the upper limbs, postures, noise, microclimate, chemicals, organization of work and stress. This preliminary level ensures that anyone can simply and generally observe the workplace and respond to the expected closed-ended questions by interviewing the workers. The main highlights of the model are described in Annex A.

— level two: quick assessment (only for studying biomechanical overload).

Quick assessment consists in a rapid identification of acceptable risk (using the traffic light colours), indicated as green when risk is absent, red when very high and purple when critical. Quick assessment procedure produces the following information:

a) if the situation is code green (green light) the quick risk assessment process can stop here because it means that there is no meaningful occupational risk;

b) if a critical code (purple light) is detected, then there is definitely a significant occupational risk and immediate corrective action is required;

c) if the quick assessment finds that the risk level at the work station is neither acceptable (green light) nor critical (purple light), and therefore the situation is intermediate (potentially code yellow or red), then the risk assessment has to be carried out, using the analytical methods suggested by International Standards or the accredited literature (third level).

To simplify as far as possible this kind of approach, the criteria and methodology were included in an easy-to-use computer-based model (the first specific simple tool) for allowing users to collect data in the correct way through close questions and to obtain an automatic evaluation of them.

The spreadsheet "EPMIES-agriERGOCHECKprecultivoENG ( )" can be downloaded free of charge from http://www.epmresearch.org/a57_free-software-in-english.html[64].

The compilation has to be done through the answers provided by the workers involved in each homogeneous group, homogeneous by occupational exposure (one spreadsheet, one homogeneous group). It is a matter of drawing information on work-related distress through their "collective subjectivity". The study of the results of the collective hardships provides the priorities, emerging from the level with which the various problems were indicated, useful for the subsequent real evaluative interventions.

Compared to the concern of not taking into account the different anthropometric parameters[35] that characterize the different agricultural populations of the world (e.g. body weights, heights, body structures from thin to muscular), at this stage of pre-mapping, the reported discomfort for exposure to the various risk factors is estimated through the study of the collective subjectivity of the homogeneous working group.

As an example, in a group of workers (homogeneous for risk exposure), both people with small and lean anthropometric parameters and more robust workers may be present. Only the smaller and leaner workers report greater discomfort during the lifting of the same load, but not the more robust workers. The result of the collective subjective study will confirm manual material handling (MMH) as a priority risk factor, based on the smaller and leaner worker.

In this way, through the subjective verification of collective distress, the effect of anthropometric parameters on the work performed is taken into great consideration in determining the priorities for subsequent improvement interventions.

The results of the pre-mapping exercises carried out via "key-enters, key questions and quick assessments" is also summarized graphically to more comprehensively define the "pre-mapping" and corrective action priorities. The programmed spreadsheet, described previously, generates this summary automatically.

Figure 2 shows an example of a summary of the results obtained from the "pre-mapping" of homogeneous group 1 (full-time and part-time 4 hours a day) and Figure 3 shows the results for homogeneous group 2 (full-time), whose job organizations are described in Table 2 and Table 3, respectively. Figures 2 and 3 show the final summary generated automatically by the software, depicting histograms for all possible risks. The height of each histogram corresponds to the percentages resulting from Formula (1).

$$(P_{Li}/P_{Mi}\times 100\times W) \quad (1)$$

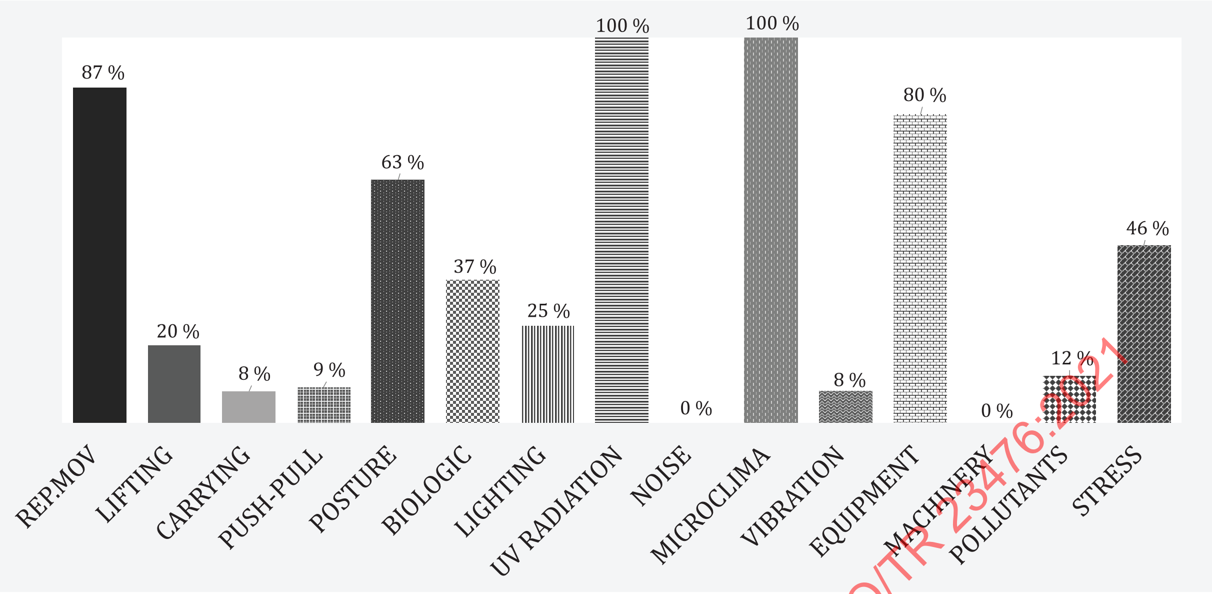
where:

P_{Li} is the score for each risk inducer,

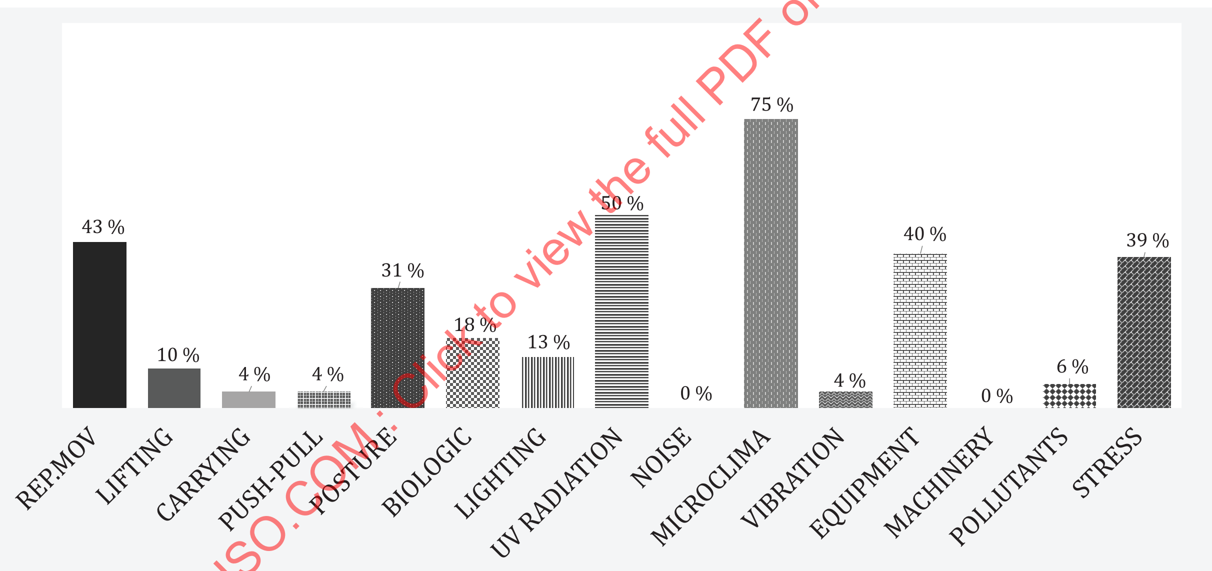
P_{Mi} is the predefined maximum inducer score,

W is the time-weighted percentage as a proportional time length to estimate the real risk factor duration in the year compared to a predefined constant. (W = 100 % when the risk factor is present for 11 months per year, 7 h to 8 h per day, 5 or 6 working days per week).

These are merely descriptive scores, to be used to "rank" events from the best to the worst. The scores do not define the risk; they are simply descriptive scales designed to help not only to identify problems but also to set priorities for the analyses and evaluations that have to be undertaken to adopt immediate measures to reduce risk, especially for conditions defined as "critical".



a) Homogeneous group 1 — full-time (data from Table 2)



b) Homogeneous group 1 — part-time only (4 h a day)

Figure 2 — Final summary of results depicting histograms for all possible risks for homogeneous group 1

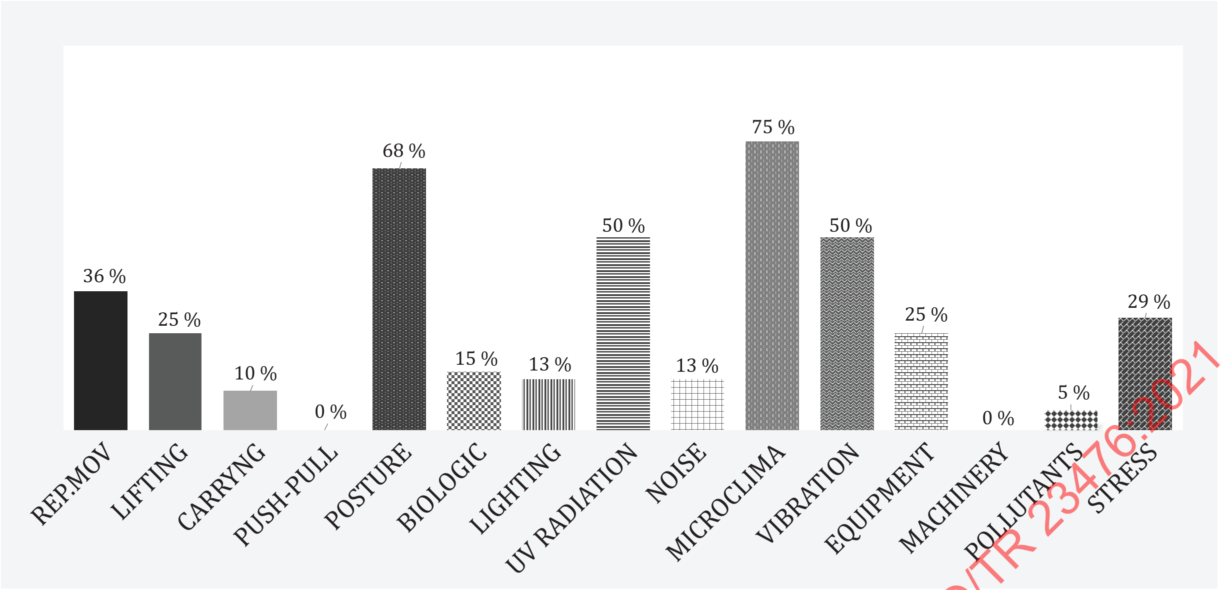


Figure 3 — Final summary of results, depicting histograms for all possible risks for homogeneous group 2 (see example in Table 3)

6 Analytical study of work processes in annual multi-task analysis: description of a typical working day for each month and quantitative task distribution over the year

6.1 General

To switch from the pre-mapping of discomfort and dangers (first and second levels) to the actual risk assessment phase (third level) for all risks, it is necessary to undertake in-depth organizational studies, utilizing not only qualitative data but also quantitative data.

In this clause all the procedures necessary for the evaluation of the most typical biomechanical overload risks (repetitive movements and manual lifting) are explained through the use of a not real but representative example of agricultural cultivation, made up of few tasks (the same homogeneous group 1 presented in Table 2). In the Annex B, all the criteria and methods, mathematical formulas used for the risk assessment of repetitive movements and manual lifting are presented in greater detail,[20],[22],[31],[32],[33],[34],[46],[47][59],[60],[61],[62],[63] also through real examples derived from viticulture.

The results presented have been obtained with specifically prepared simple tool, which is discussed in this clause. In fact, considering the amount of data to be collected and written in an orderly manner and the number of calculations to be done with the use of complex formulas, another specific simple tool was built to make reliably easy and possible such risk assessments and overcome the inherent difficulties mentioned: “ERGOepmVINCIocraNIOSHpushTAeng (..)”[64], available as a free download.

After all, IEA and WHO have been recommending for years to offer those who do prevention, not only evaluation criteria but also simple tools to simplify the final risk evaluation.

To complete the risk assessment as level third, three phases are necessary.

6.2 Phase A – Description of a typical working day

The description of a representative typical or modal working day, representative of each month, is required to start the analysis (Table 5). It is obvious that in farming, the net duration of a shift may vary depending on the weather. This is why the organizational structure of a modal day (i.e. the one that appears most frequently during each month of the year) has to be described. The analysis records, for example, the duration of shifts and the number and duration of pauses in order to obtain the net duration of work (net duration of work in the shift).

Table 5 — Description of a typical working day representative of each month to study the modal net duration of repetitive movements (homogeneous group 1)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shift duration		420	420	420	420	420	420	420	420	420	420	420
No. official breaks (excluding lunch break)												
No. actual breaks duration of more than 8 min (excluding lunch break)		3	3	3	3	3	3	3	3	3	3	3
Actual duration of the pause (excluding lunch break)		30	30	30	30	30	30	30	30	30	30	30
Duration lunch break if this is inside the shift (the technical name is "paid lunch"; to calculate the net time of repetitive work, its duration must be subtracted from the shift time)												
Shift is held consecutively (i.e. without interruptions, for example due to a change of workplace)												
If the shift is not consecutively because of breaks for change of working site (or for unpaid lunch break) mark the number of interruptions only if the duration is equal to or higher than half an hour		1	1	1	1	1	1	1	1	1	1	1
Total actual pause duration present in working time	0	30	30	30	30	30	30	30	30	30	30	30
Non-repetitive tasks												
Putting on or taking off uniforms (protective gear)		10	10	10	10	10	10	10	10	10	10	10
Cleaning		10	10	10	10	10	10	10	10	10	10	10
Other: time to reach workstation		10	10	10	10	10	10	10	10	10	10	10
Other:												
Total minutes of non-repetitive tasks in shift	0	30	30	30	30	30	30	30	30	30	30	30
Net repetitive working time (in minutes)	0	**360**	**360**	**360**	**360**	**360**	**360**	**360**	**360**	**360**	**360**	**360**

6.3 Phase B – Estimation of total number of hours worked every month of the year

In order to make this estimation, the following information is necessary (Table 6): the number of hours worked every month by the entire homogeneous group for the total number of tasks. This information is readily available on the farm as it is required to calculate the cost of the active workforce.

Since the aim is to obtain the number of hours worked by each member of the homogeneous group, the number of workers present in the whole homogeneous group has to be described. Figure 4 provides a graphic depiction of the hourly distribution of work over the various months of the year.

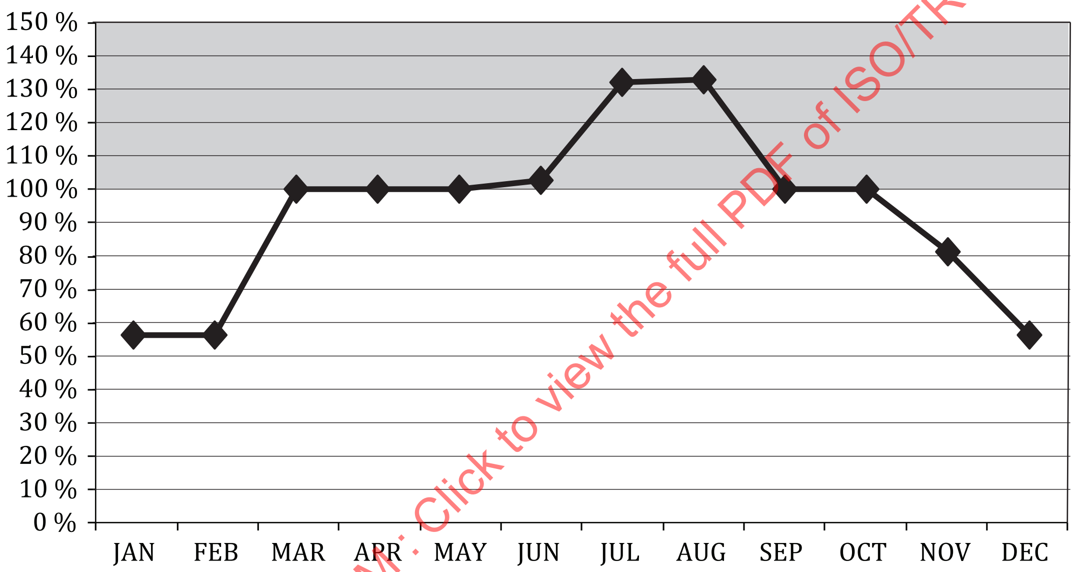
In the graph (Figure 4), when the threshold of 160 h/month/worker (defined month constant) is passed, the ratios enter the critical zone (100 % of the constant is exceeded: grey colour). The example shows an uneven distribution of working hours over the various months of the year, with some months where the hours are below the constant and others where they are above (these months often correspond to the harvest). Harvesting requires speed and also the addition of seasonal workers is often required.

Table 6 — Estimation of number of hours worked per month and per worker in homogeneous group 1

Total working hours per year/worker	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of hours worked per month (by the whole group or individual worker) including any seasonal or casual workers		900	1 600	1 920	1 920	2 300	3 800	3 400	2 080	1 600	1 300	900

Table 6 *(continued)*

Total working hours per year/worker	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
% reduction, considering the real shift duration and the net duration	0 %	86 %	86 %	86 %	86 %	86 %	86 %	86 %	86 %	86 %	86 %	86 %
No. of hours spent per month/worker performing repetitive tasks	0,0	77	137	137	137	140	181	182	137	137	111	77
No. of hours worked per month/worker		**90**	**160**	**160**	**160**	**164**	**211**	**213**	**160**	**160**	**130**	**90**
% based on a constant of 40 h/week, 160 h/month, 20 days/month		56 %	100 %	100 %	100 %	103 %	132 %	133 %	100 %	100 %	81 %	56 %
No. of workers versus total workers	10	10	10	12	12	14	18	16	13	10	10	10
No. of seasonal or casual workers				2	2	4	8	6	3			
Total working hours/worker	1 698											
Constant working hours/worker	1 760											



NOTE Grey area indicates when 100 % of the constant is exceeded.

Figure 4 — Number of hours worked per month and per worker as a percentage of 160 h/month constant, for homogeneous group 1, assigned to pruning and harvesting

6.4 Phase C – Assignment of tasks to a homogeneous group (or individual worker) and calculation of proportional tasks duration in each individual month

Before going on to complete the organizational analysis of the risk-exposed worker or homogeneous group of workers, Table 7 lists the exposure constants to which reference is made for calculating exposure time prevalence to various tasks and also for reconstructing “an artificial working day representative of the whole year” (see Annex B). In agriculture, it is quite common for work schedules to be irregular, depending on the season. It has been found useful to adopt several exposure constants representing the typical exposure level for the industry (see Annex B).

Table 7 lists all the constants used. Although expressed in different ways, (e.g. hours, days), they all reflect the aforementioned criteria.

Table 7 — Predefined exposure time constants

Constant hours/day	8	Constant hours/month	160

Table 7 *(continued)*

Constant minutes/day	440	Constant days/month	20
Constant days/week	5	Constant months/year	11
Constant minutes/week (440 min * 5 days)	2 200	Constant days/year	220
Constant weeks/month	4	Constant hours/year	1 760

To obtain a quantitative description of the active tasks it is necessary to insert the following in the specific simple tool previously mentioned.

a) The percentage duration per month of each task worked by the homogeneous group. The sum of the percentages per month in the column has always to add up to 100 % (Table 2 for homogeneous group 1). The proportional description of the tasks does not require extreme precision. The employer, or the members of the homogeneous group, can usually provide the information quite easily.

b) The number of hours worked each month of the year by each worker in homogeneous group 1 (Table 6).

Once percentage duration per month of each task has been provided, it is possible to estimate the number of hours worked on each task every month (Table 8) by matching the proportional task descriptions shown in Table 2 to the total number of hours worked per month/worker (Table 6). The free spreadsheet automatically estimates this distribution, as shown in the example in Table 8.

After obtaining the duration in hours of the various tasks performed each month, the next step is to obtain the critical figure enabling the final risk to be evaluated: the total number of hours worked per year on each task by each member of the homogeneous group, and the proportion of these hours versus both the total number of hours worked and the constant 1 760 h/year (Table 8).

Table 8 — Calculation of total hours worked, per task, in each month and per year, for homogeneous group 1 (full-time) and prevalence of worked annual hours in each task versus both the total hours worked in a year and constant 1 760 h/year

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	% of total hours worked per year	Hours worked per year/task	% on a year constant (1 760 h/ year)
Plowing (tractor)	0	0	0	0	0	0	0	0	0	0	0	0	0,0 %	0	0,0 %
Installing irrigation system	0	0	0	0	0	0	0	0	0	0	0	0	0,0 %	0	0,0 %
Planting (manual)	0	0	0	0	0	0	0	0	0	0	52	9	3,6 %	61	3,5 %
Planting (mechanical)	0	0	0	0	0	0	0	0	0	0	26	81	6,3 %	107	6,1 %
Pruning large branches with chainsaws	0	0	0	0	0	0	0	0	0	0	0	0	0,0 %	0	0,0 %
Pruning with manual shears	0	0	0	0	0	0	0	0	0	80	7	0	5,1 %	87	4,9 %
MMH of large branches	0	0	0	0	0	0	0	0	0	64	39	0	6,1 %	103	5,9 %
Pruning with manual shears	0	63	112	96	96	99	0	0	0	0	0	0	27,4 %	466	26,5 %
MMH of small branches	0	18	32	48	48	49	0	0	0	0	0	0	11,5 %	195	11,1 %
Manual harvesting on ground	0	0	0	0	0	0	95	96	72	0	0	0	15,5 %	263	14,9 %
Manual harvesting on ladder	0	0	0	0	0	0	74	74	56	0	0	0	12,0 %	204	11,6 %
MMH of ladder	0	0	0	0	0	0	21	21	16	0	0	0	3,4 %	58	3,3 %

Table 8 *(continued)*

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	% of total hours worked per year	Hours worked per year/task	% on a year constant (1 760 h/ year)
Preparing machine to apply fertilizer	0	0	0	0	0	0	0	0	0	0	0	0	0,0 %	0	0,0 %
Driving tractor	0	0	0	0	0	0	0	0	0	0	0	0	0,0 %	0	0,0 %
Composting (manual)	0	0	0	0	0	0	0	0	0	0	0	0	0,0 %	0	0,0 %
Disinfection (manual)	0	0	0	0	0	0	0	0	0	0	0	0	0,0 %	0	0,0 %
Disinfection (tractor)	0	0	0	0	0	0	0	0	0	0	0	0	0,0 %	0	0,0 %
Push/pull trolley with large branches	0	5	8	8	8	8	0	0	0	8	7	0	3,0 %	51	2,9 %
Push/pull trolley with small branches	0	5	8	8	8	8	0	0	0	8	0	0	2,6 %	45	2,5 %
Push/pull trolley with fruit boxes	0	0	0	0	0	0	21	21	16	0	0	0	3,4 %	58	3,3 %
														1 698	

7 Annual multi-task risk assessment of biomechanical overload for the upper limbs

7.1 General

To obtain the final risk index using the OCRA checklist method (see References [21] and [22] and ISO/TR 12295:2014, Annex B) for multi-task analysis, the following steps are necessary (the example refers to homogeneous group 1).

7.2 Phase A – Analysis of each individual task using the OCRA checklist to calculate the intrinsic risk score and prepare the tasks basic risk evaluation for each crop

To prepare the tasks basic risk evaluation for each crop, it is necessary to calculate the intrinsic risk score for all the tasks present in the crop, that means evaluating each task as if it were the only one performed by a worker all the time (i.e. for the whole shift and the whole year). To estimate the “intrinsic risk index” of each task, reference is made to a shift constant featuring:

— 430/460 net minutes of repetitive work (modal value = 440, duration multiplier = 1);

— one 30 min meal break and two 8 min to 10 min breaks (recovery multiplier = 1,33).

The “intrinsic risk index of each task” is calculated by applying the OCRA checklist to all the tasks performed in the specific crop, for both the right arm and the left arm. The final indexes are entered into the appropriate areas of the specific simple tool, along with all the scores for the various risk factors (e.g. frequency, force, awkward posture of upper limbs, additional) required by the OCRA checklist (Table 9).

Table 9 — Calculation of "intrinsic risk indexes" for all the tasks present in farming activities, regardless of who performs them

Tasks	Recovery multiplier,	Hours without recovery	Frequency	Force	Side	Shoulder	Elbow	Wrist	Hand	Stereotypy	Posture total	Additional	OCRA checklist intrinsic value (right side only)
Plowing (tractor)	**1,33**	**4**	3	0	Right	2	0	1	3	1,5	5		**9,98**
Installing irrigation system	**1,33**	**4**	6	0	Right	12	0	1	6	3	15		**27,93**
Planting (manual)	**1,33**	**4**	2	1	Right	1	2	3	6	3	9		**15,96**
Planting (mechanical)	**1,33**	**4**	4	1	Right	1	2	3	8	3	11		**21,28**
Pruning large branches with chainsaws	**1,33**	**4**	4	8	Right	8	2	2	2	1,5	10		**28,60**
Pruning with manual shears	**1,33**	**4**	5	0	Right	0	0	0	2	2	4		**11,97**
MMH of large branches	**1,33**	**4**	9	0	Right	12	0	0	8	0	12		**27,93**
Pruning with manual shears	**1,33**	**4**	5	0	Right	0	0	0	2	0	2		**9,31**
MMH of small branches	**1,33**	**4**	9	0	Right	12	0	0	8	0	12		**27,93**
Manual harvesting on ground	**1,33**	**4**	6	0	Right	8	0	0	8	0	8		**18,62**
Manual harvesting on ladder	**1,33**	**4**	3	0	Right	8	0	0	4	0	8		**14,63**
MMH of ladder	**1,33**	**4**	1	8	Right	6	0	0	0	0	6		**19,95**
Preparing machine to apply fertilizer	**1,33**	**4**	3	0	Right	0	0	0	2	0	2		**6,65**
Driving tractor	**1,33**	**4**	4	0	Right	0	0	0	3	0	3		**9,31**
Composting (manual)	**1,33**	**4**	4	0	Right	0	0	0	4	1,5	6		**12,64**
Disinfection (manual)	**1,33**	**4**	3	0	Right	0	0	0	5	0	5		**10,64**
Disinfection (tractor)	**1,33**	**4**	4	0	Right	0	0	0	3	0	3		**9,31**
Push/pull trolley with large branches	**1,33**	**4**	2,5	2	Right	0	0	0	0	1,5	2		**7,98**
Push/pull trolley with small branches	**1,33**	**4**	2,5	2	Right	0	0	0	0	1,5	2		**7,98**
Push/pull trolley with fruit boxes	**1,33**	**4**	2,5	2	Right	0	0	0	0	1,5	2		**7,98**

NOTE Considering the result of the intrinsic values of the OCRA checklist, the colours used in the table for the OCRA checklist results mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk

7.3 Phase B – Application of mathematical models and preliminary preparation of "artificial working day" representative of the whole year and of every month of the same year

Two models are proposed for calculating the final exposure risk index for the whole year and for each month of the same year:

a) One based on the "time-weighted average", calculation of the average value among the different tasks, weighted by their duration.

b) The other based on the "MultiGEI" based on the most overloading task (calculated with respect to its actual duration), as the minimum exposure score that can be increased versus the score of the other tasks, taking their relative durations into account. The new "MultiGEI" formula derived directly from "multitask complex" formula, used for daily turnover (see Annex B).

These two models have already been used for calculating the daily turnover, i.e. when the task rotation occurs within (time-weighted average) or outside (multitask complex) the 90-min timeframe. Both the mathematical models have been used and adjusted for calculating annual and monthly multi-task exposure risk.

In order to apply the models to annual and monthly exposure, it has been necessary to convert the data relative both to the individual months and to the year into an "artificial working day representative" of each month of the year first and then of the full year, respectively.

The steps necessary for performing this conversion, staring from data presented in Table 8 for homogeneous group 1 (detail in Annex B, also through calculation examples), are summarized as follows:

— active tasks assessment (tasks actually performed by the homogeneous group) in each month and over the entire year;

— task duration estimates in hours relative (net duration) to each month and over the entire year;

— estimate of proportional duration of each task versus the total net number of hours worked each month and over the entire year;

— evaluation of artificial day, or fictitious working day, representative of the year, by dividing the net hours worked/year ("net" means having excluded pauses, non-repetitive accessory works) for 220 (predefined constant number of working days per year) and multiplying the result by 60, thus obtaining the new duration in minutes, to proportionally represent the year. 1 790 h/year (default constant of working days per year) corresponds to an "artificial day" of 480 minutes, with a multiplier duration equal to 1. Reducing the duration of the "artificial day", the duration multiplier (Annex B) becomes proportionally less than 1. Applied then to the result of the final risk index, it will reduce it, always in proportion to the actual duration. In this way the risk can be reduced, reducing or increasing the number of hours worked in the year compared to the default constant.

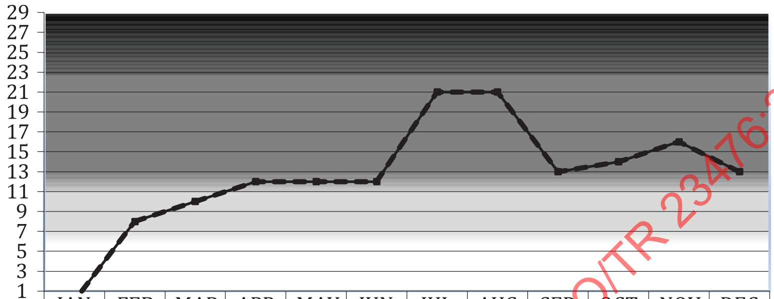
Figure 5 compares the month-by-month results (for the right limb) using the two formulas, i.e. "time-weighted average" and "MultiGEI", as obtained automatically using the specific simple tools. In order to better interpret the results, the two formulas have been used also to calculate the final risk index for each month of the year, thus displaying the final risk index trends for each month of the year.

With final risk index trends shown on a monthly basis, it is easier to comprehend the differences between the two final risk indexes formulas obtained with "time-weighted average" and "MultiGEI". Since the work is distributed differently over the various months of the year, the time-weighted average formula tends to flatten the peaks, determining lower risk scores than the "MultiTask Complex" formula, which is never lower than the highest peak, calculated for its actual duration.

If the workers on the farm are assigned to growing several crops (such as grapes and olives, or vegetables and fruit), the organizational data will need to evaluate the intrinsic risk score typical of all the tasks present in all the different crops cultivated over the year. It follows that a homogeneous group will also have to be identified, as described, even if the tasks involve different crops.

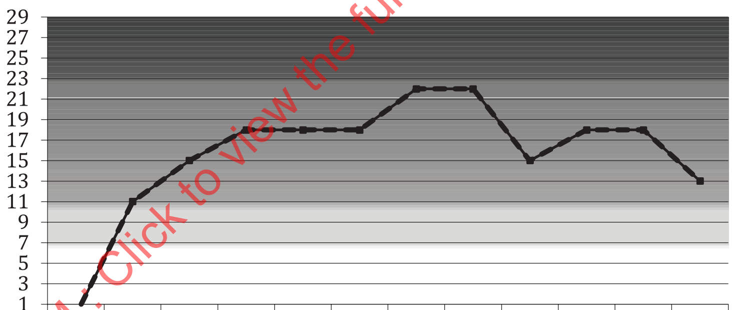
Figure 6 shows a scenario where a homogeneous group cultivates a crop for half the year but working very few hours and at very low risk for three out of the six months. The discrepancy between the scores obtained using the "time-weighted average" versus the "MultiGEI" is quite remarkable. The first formula flattens the peaks for the months with low or no exposure, while the second is based on the estimated highest risk task, considering its intrinsic duration.

Here, the interpretation of the results for the attribution of risk is problematic. In these cases, with workers exposed to risk for only half the year, it can be difficult to attribute a disease or disorder to occupational factors when the workers' activities in the other half of the year are unknown.



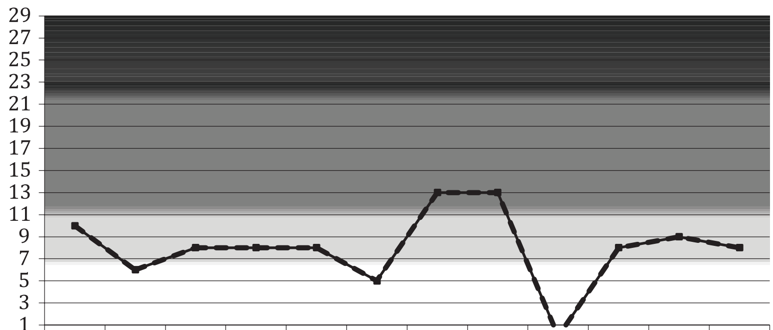
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RIGHT	0	8	10	12	12	12	21	21	13	14	16	13
LEFT	0	8	10	12	12	12	21	21	13	14	16	13

a) Time-weighted average evaluation: 13,8 right-left 13,8 in homogeneous group 1 (11 months, working full-time – 7 h/shift)



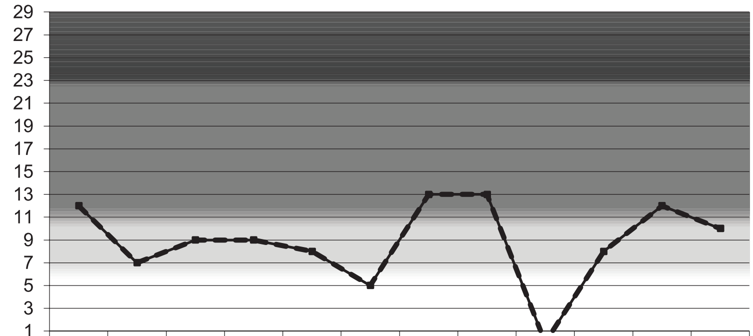
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RIGHT	0	11	15	18	18	18	22	22	15	18	18	13
LEFT	0	11	15	18	18	18	22	22	15	18	18	13

b) MultiGEI formula evaluation: Right 15,6 -left 15,6 in homogeneous group 1 (11 months, working full-time – 7 h/shift)



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RIGHT	10	6	8	8	8	5	13	13	0	8	9	8
LEFT	10	6	8	8	8	5	13	13	0	8	9	8

c) Time-weighted average evaluation: 8,8 right in homogeneous group 2 (11 months, working full-time – 7 h/shift)



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RIGHT	12	7	9	9	8	5	13	13	0	8	12	10
LEFT	12	7	9	9	8	5	13	13	0	8	12	10

d) MultiGEI formula evaluation: Right 12,4 in homogeneous group 2 (11 months, working full-time – 7 h/shift)

NOTE Considering the result of the intrinsic values of the OCRA checklist presented in the four figures, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk.

Figure 5 — Exposure index scores (for homogeneous group 1 in Table 2 and for homogeneous group 2 in Table 3, full-time) plotted by month over the whole year, using both the recommended formula

In agriculture, scenarios such as the one depicted in Figure 6 (homogeneous group 3) are anything but rare. Work may be organized in many different ways with respect to annual exposure; here are a few examples:

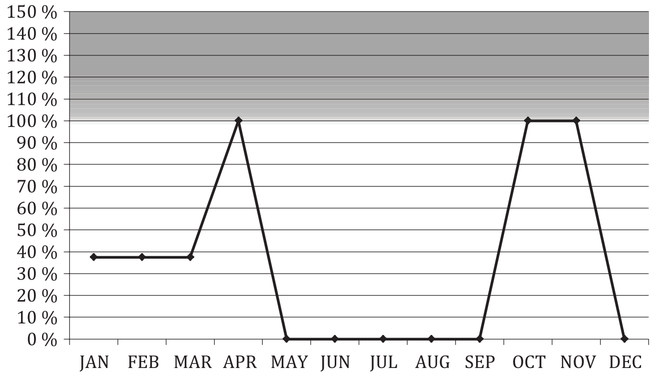
a) workers exposed to risk for only one or two months a year during harvesting of a specific crop (e.g. fruit in summer); worker employed by only one farm;

b) workers exposed to risk during the summer months during harvesting of several crops (e.g. different fruits) for one employer but on several farms;

c) workers exposed to risk practically all year round, working on more than one crop (e.g. grapes and fruit), for many small holdings (pruning work).

Distribution of hours/shift/worker performing different tasks each month of the year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plowing (tractor)	0	0	0	0	0	0	0	0	0	0	0	0
Installing irrigation system	0	0	0	0	0	0	0	0	0			0
Planting (manual)	0	0	0	0	0	0	0	0	0	0	64	
Planting (mechanical)	0	0	0	0	0	0	0	0	0	0	32	
Pruning large branches with chainsaws	42	42	36	96	0	0	0	0	0	32	16	0
Pruning with manual shears	18	18	24	64	0	0	0	0	0	128	48	0

% hours worked per month/worker based on a constant of 160 h/month



OCRA checklist: final exposure index for the whole year obtained using the two formulae:

— **Time-weighted average:** 6,4(right)

— **MultiGEI:** 13,1(right)

Figure 6 — Homogeneous group 3 (6 months, working full-time – 7 h/shift) does the same farming activities of homogeneous group 1, but working only 6 months with 3 months with very low exposure and 3 months with high exposure.

The aim of the approach described in this subclause is not to determine the causes and effects of many common musculoskeletal diseases and disorders, but rather to offer assessment options for tackling and discussing the problem at hand.

The use of the OCRA checklist for analysing the risk of biomechanical overload of the upper limbs in farm work may still seems very complex or at least time-consuming.

Arguably, many farming activities need monitoring all year round in order to analyse and evaluate each individual task, and often the number of tasks is extremely high. However, it has been observed that when the same techniques are used for the same crops, the tasks are always the same, and thus have the same intrinsic OCRA checklist scores. Hence, it is possible to speak of finite variable farm work, i.e. featuring uniform variables, which can be pre-set following an initial evaluation.

Going forward, efforts are being made to develop a basic software for a specific cultivation with all the specific intrinsic risk values of each task as pre-set data. To assess risk for a homogeneous group (many cultivations need the same tasks), the appraiser has only to enter the farm-specific organizational data.

8 Annual multi-task risk assessment for working postures

8.1 The meaning of postural tolerance

The earliest posture analysis methods ([28],[36],[42],[54]) were those suggesting a global approach towards analysing working postures. Most of the methods for working posture analysis do a satisfactory job of identifying and describing which postures to assess and how to work out the final scores, but rarely do they provide enough practical examples, especially in evaluating risk in complex multi-task activities, with complex rotation between tasks during the year.

None of the methods deliver a seamless transition from description to assessment[10]–[16],[24],[30],[36]–[41],[43],[48],[51]–[53],[55]–[58]. A meaningful contribution towards developing assessment methods will only be made when significant certainties are reported in the evaluation of postural tolerance. What criteria underpin posture evaluation and tolerance analysis? First, there needs to be a consensus that what is being assessed is not the posture itself but how it is tolerated within a specific time, space and operating environment. Hence, the question is: what postures can be defined as tolerable?

The assumption put forward here is that for postures to be tolerable, they must not:

— cause discomfort in the short term;

— cause MSDs or diseases in the long term.

Short-term discomfort describes a feeling of fatigue, pain or both in a joint or ligament that develops within the space of minutes, hours or days. However, with regards to this first requirement, preventing incapacitating injury is not sufficient: complete wellbeing and comfort must be ensured at all times.

There can be no doubt, theoretically or otherwise, regarding the second requirement: postures must not generate specific diseases or disorders.

8.2 Analysing the tolerability of working postures for the spine when performing manual lifting tasks, and for the upper limbs when performing repetitive movements and manual lifting: specific International Standards

The specific International Standards applied to the ergonomics of designing and redesigning workplaces at risk of biomechanical overload are ISO 11228-1, ISO 11228-2, ISO 11228-3 and ISO 11226.

The standards tell us that in order to study biomechanical overload, and consequently the tolerability of working postures (i.e. short- and long-term risk analysis), it is necessary to:

— analyse all the risk factors present, including organizational factors; a multifactorial analysis is strictly necessary;

— consider the results of epidemiological studies (i.e. analysis and distribution of damage caused to exposed versus non-exposed workers) to first validate and then interpret the resulting scores.

The OCRA method for studying repetitive movements (see Reference [49] and ISO 11228-3), and the NIOSH method for studying manual load lifting (see References [18], [20] and [49] and ISO 11228-1), both extensively validated in the literature and suggested by the specific International Standards, ultimately reach a final risk assessment through a multifactorial approach that includes investigating organizational aspects (frequency and duration), awkward postures, subjective force and other factors. Awkward postures are therefore included in both these evaluation techniques as one of several risk factors

8.3 Analysing spinal working postures without manual load lifting and lower limb postures (primarily static)

The OCRA and NIOSH methods cannot cover every aspect of biomechanical overload due to awkward postures; there are many jobs that do not entail lifting loads but still cause biomechanical overload of the spine and lower limbs, primarily due to awkward static postures. Examples include agricultural workers, kindergarten teachers, physiotherapists, building site workers and archaeologists.

It is emphasized that the reconstruction of the type and also the duration of exposure to postural risk factors is essential for being able to judge tolerability levels. In fact, before analysing posture it is necessary to analyse the tasks involved and how the work is organized.

Reconstructing the work of a homogeneous group of workers (or also of an individual worker) requires knowing (as already described for the study of the biomechanical overload of the upper limbs):

— what kind of task(s) are performed within the cycle (daily, weekly, monthly or yearly);

— the duration of each task;

— what postures are adopted during each task and the duration of each of the selected postures.

Although in the literature it is not difficult to single out which postures require evaluating, there are major shortcomings regarding:

— criteria for adjusting final scores based on task duration (job risk score);

— criteria for adjusting scores for the various postures characterizing each individual task (intrinsic task score), also according to the mutual different duration of each of the postures present in each task.

The aim of the method proposed here is not to decide which posture should be analysed; extensive use is in fact made of the ones currently featured in the literature and in current standards. The purpose is rather to suggest how to time them correctly even in very complex scenarios, where workers are exposed to multiple tasks and work cycles lasting longer than one day.

Since the data management activities and risk score calculations are so complex, a specific simple tool (in this case the same spreadsheets before presented for repetitive movements, in which a specific sheet is dedicated to the study of postures) have been developed to gather, condense and automatically process the data.

This "posture sheet", present in this simple tool, helps in implementing the strategy for calculating risk associated with exposure to awkward postures, i.e. the TACOS model[23],[24].

8.4 The TACOS method: contents and criteria for back and lower limb posture analysis

As for the other topics in this clause, the methodological details for this topic are collected in Annex C, dedicated to the analysis of working postures.

Figure 7 lists the main postures to study, broken down by main segment, and the specific scores assigned. The postures chosen for this analysis are those used in various methods reported in the literature and in International Standards; they have only been simplified or regrouped to ensure a clear understanding.

As to the criteria adopted for assigning scores, note that the exposure scores simply rank postures from the least to the most uncomfortable (generally from "neutral" to the most awkward). The risk scores are assigned starting from the most comfortable posture (e.g. seated upright, reclining against a back rest) as follows:

— score 0,5 when the worker spends 1/3 of the time (approximately 20 % to 40 %);

— score 1,5 when the worker spends half the time (approximately 40 % to 60 %);

— score 3 when the worker spends 3/3 of the time (approximately 60 % to 100 %).

As the discomfort caused by the posture increases, the scores increase accordingly, starting from a duration of 1/3 of the time. The other scores start from this figure, which is then doubled or tripled. The more tiring postures receive a score even if they are adopted for short periods (approximately 1/10 of the time). Scores range from 0,5 (lowest score for comfortable positions lasting up to 1/3 of the time) to 14 (most awkward positions lasting the whole time).

In other words, these descriptive exposure indexes (as in all the other methods found in the literature) are adjusted on the basis of the awkwardness and duration of the task: they cannot yet be regarded as risk indexes based on which future health issues can be predicted (no method of assessing risk from exposure to awkward posture, present in the literature, is in fact able to predict the likelihood of illness).

As an overall approach towards identifying and describing postures and posture duration, the following general rules were followed:

— postures are not identified and described for each area of the body to aggregate subsequently as proposed in other ergonomic methods (e.g. RULA, REBA, OWAS);

— overall postures for different body segments (e.g. standing, sitting, squatting postures) have been defined using sketches and simple descriptions;

— postures have to be identified by task, and each task will thus be defined by the posture(s) characterizing it;

— the duration of postures in each task can be readily measured with the help of pie charts depicting different risk scores in function of the different durations; stopwatches are seldom required.

The figures help to group postures into five main categories: standing postures, sitting postures, postures primarily involving the lower limbs, complex (mixed) postures involving many parts of the body, and postures involving the cervical spine.

Since the maximum score is 14, a series of five categories has been arbitrarily defined, each with a different colour (from green to violet), indicating the different degrees of awkwardness, also as a function of the duration of the posture (Table 10).

This approach is adopted intrinsically for each posture and for the final outcome of the total task analysis.

Table 10 — Definition of risk areas, with different degrees of awkwardness, as a function of the duration of the posture

Zone	TACOS values	Risk classification
Green	up to 1,5	Optimal
Green	1,6 to 2,2	Acceptable
Yellow	2,3 to 3,5	Borderline or very slight
Red-low	3,6 to 4,5	Slight
Red-medium	4,6 to 9,0	Medium
Red high	more than 9,0	High

8.5 Posture analysis of a multi-task job performed on a full-time or part-time basis with yearly job rotation

Returning to the example of homogeneous group 1, whose organizational data are shown in Table 2 and Table 8, the procedure entails the use of the specific sheet present as a simple tool (the same spreadsheet for studying all different risk factors that determine the biomechanical overload as postures, manual handling, pushing/pulling), "ERGOepmVINCIocraNIOSHpushTAeng (...)"[64].

In order to study biomechanical overload of the upper limbs as a whole, rather than examining only awkward postures, it is necessary to apply a method that investigates all related risk factors responsible for biomechanical overload. The OCRA method[21],[22],[49] for example, does just that.

The OCRA system analyses awkward postures as one of a range of risk factors. It looks at the main joint segments of both the left arm and the right arm, defining the awkward postures and assigning different scores, based on the region of the limb involved and the duration of the posture (Figure 8).

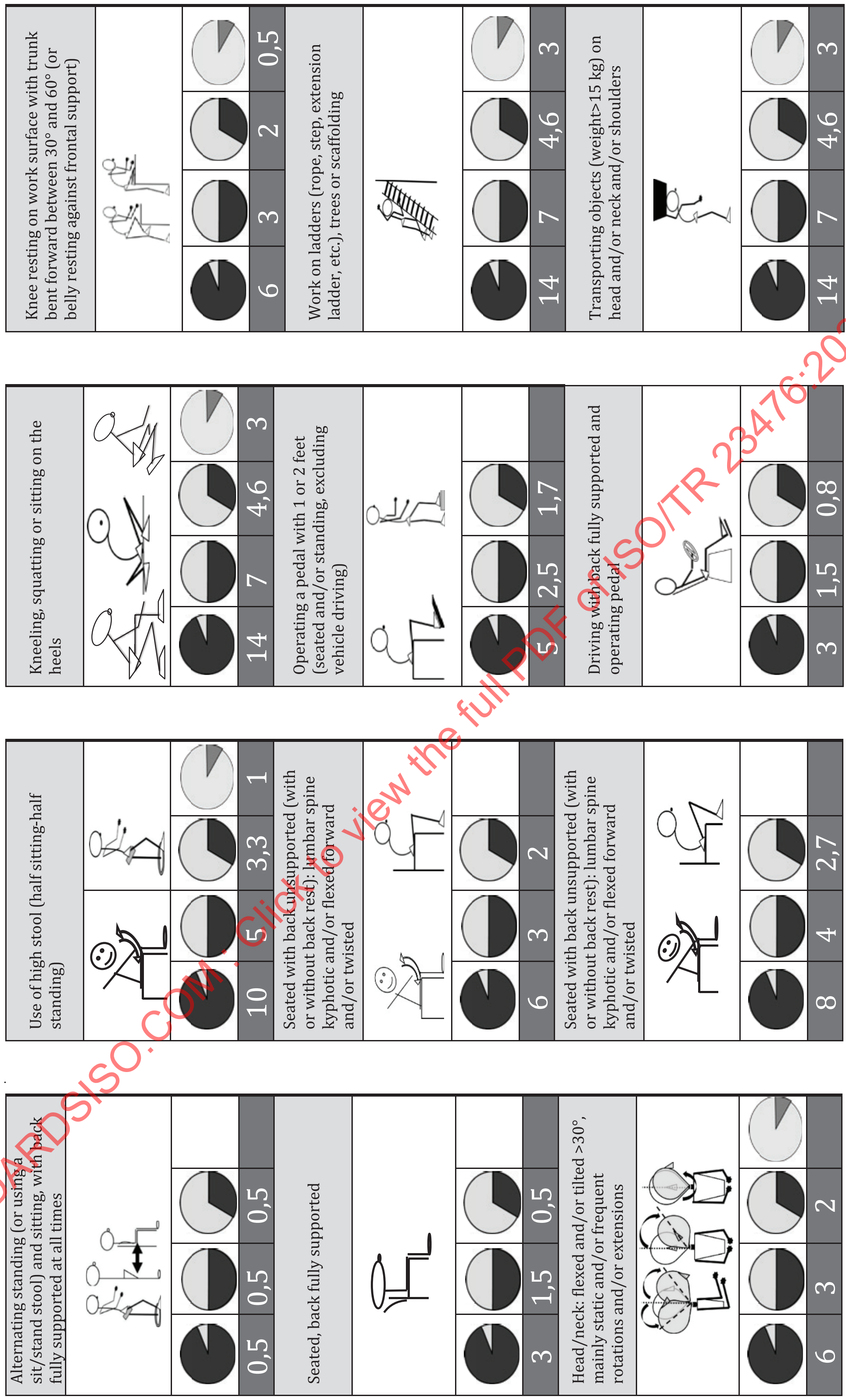


Figure 7 — Main postures analysed using the TACOS method, indicating pre-aggregated body postures and specific scores based on duration

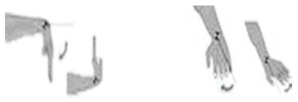
	Arm more or less at shoulder height and/or major extension	33 %	33 %
	Pinch or palmar or hook grip (not power grip)	66 %	66 %
	Extreme wrist deviations	10 %	10 %
	Complete object rotation (pronosupination) or wide arm-forearm (elbow) flexion-extension	10 %	10 %
		Right	Left

Figure 8 — Summary of awkward postures as intrinsic values for the upper limbs, obtained using the OCRA checklist method (homogeneous group 1 full-time)

Considering the risk scores for each individual risk factor, it is clear that the contribution of the posture factor to the final task score is about 50 %. As always, these studies featuring multi-task exposure start from an assessment of the intrinsic risk of each task (as if the duration of the task corresponds to the duration of a standard shift, defined as a constant).

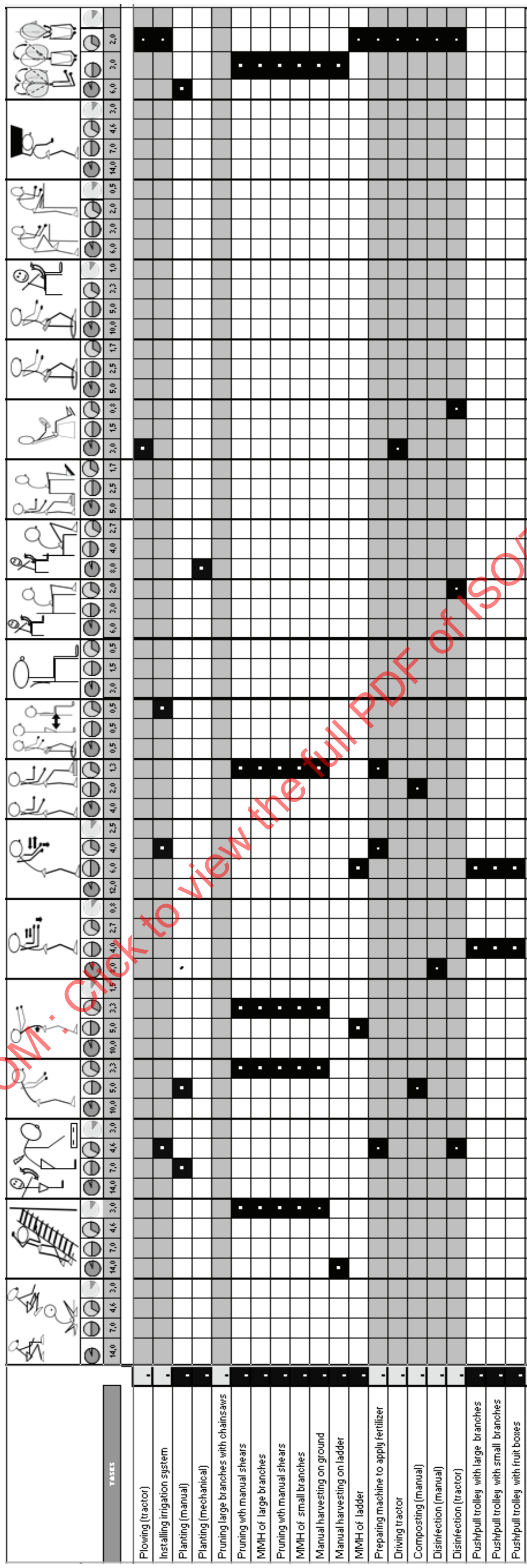
In Figure 9, the intrinsic values obtained for each task present in the cultivation and (sign in white line) carried out in the year by homogeneous group 1 are provided.

Since a task may be characterized by a single posture or multiple postures, it is important to check them considering also their specific duration in the task. In each single task, the single posture present (if there is only one) represents 100 % of duration. If there are many of them, the sum of the % duration of all the postures has to be always be equal to 100 % (except when there are uncomfortable postures of the head and pedals are used, because they are added to the other postures, without being alternatives to them).

The intrinsic postural score is generated for each task as the sum (horizontal line) of the corresponding scores for each postural risk score associated with that specific task. With the intrinsic risk scores and the duration of each task for each year, the same models as for the OCRA checklist multitask analysis can be used to estimate the risk indexes for the spine and lower limbs, i.e. both the "time-weighted average" and the "multi-task complex".

As final results, the risk scores related to the study of the spine and lower limbs are evaluated, both as a whole (applying the "time-weighted average" and the "multi-task complex" formulae) broken down by the four main body areas (Tables 11 to 13): spine standing, spine sitting, lower limbs, head-neck.

Figure 10 shows the proportional distribution of the different postures of the spine and lower limbs in their entirety and Figure 11, extracted in summary from Figure 10, shows the awkward postures, indicate as absolutely inadequate according to ISO 11226.



NOTE For estimation of exposure index, when a task is characterized by many postures, the sum, on horizontal lines, of the percentage duration has to always be equal to 100 %, except when there are awkward postures of the head and pedals are used.

Figure 9 — The estimation of intrinsic postural exposure indexes is obtained by signing with “X” the pre-timed scores (on horizontal lines) for each posture characterizing the task

Table 11 — Intrinsic awkward postures scores for each task performed by homogeneous group 1

Tasks	Net worked hours	Final scores	% worked hours based on a constant
Plowing (tractor)	0		
Installing irrigation system	0		
Planting (manual)	52	**18,0**	3,0 %
Planting (mechanical)	92	**8,0**	5,2 %
Pruning large branches with chainsaws	0		
Pruning with manual shears	74	**13,9**	4,2 %
MMH of large branches	88	**13,9**	5,0 %
Pruning with manual shears	399	**13,9**	22,7 %
MMH of small branches	167	**13,9**	9,5 %
Manual harvesting on ground	225	**13,9**	12,8 %
Manual harvesting on ladder	175	**17,0**	9,9 %
MMH of ladder	50	**13,0**	3 %
Preparing machine to apply fertilizer	0		
Driving tractor	0		
Composting (manual)	0		
Disinfection (manual)	0		
Disinfection (tractor)	0		
Push/pull trolley with large branches	44	**10,0**	2 %
Push/pull trolley with small branches	38	**10,0**	2 %
Push/pull trolley with fruit boxes	50	**10,0**	3 %

Table 12 — Awkward postures total final exposure scores

MultiGEI annual score	Time-weighted average annual score
15	11

Table 13 — Awkward postures final exposure scores subdivided by district

Head and neck	Spine in standing position	Spine in sitting posture	Legs
37 %	79 %	5 %	20 %
2,5	10,0	0,5	3,9

NOTE The sum of the percentages for scores subdivided by district can be higher than 100 %, as some postures can involve different body areas at the same time (such as the head-neck).

Posture	Hours	% duration
Kneeling, squatting or sitting on the heels	0	0 %
Work on ladders (rope, step, extension ladder, etc.), trees or scaffolding	253	15 %
Lumbar tract fully flexed (trunk flexed >60°) and/or trunk twisted	26	2 %
Lumbar tract semi-flexed with work area at approx. knee height with the trunk bent between 30° and 60°	312	18 %
Back in extension with upper limbs over the height of the head	311	18 %
Standing with back straight (<20° of trunk bent): pushing, pulling or transporting (using medium-high force)	113	7 %
Standing with back flexed (>20° to 30° of the trunk bent). Pushing, pulling or transporting (applying medium-high force)	91	5 %
Standing with back straight (<20 ° of the trunk bent), with or without support of foot stool and/or using pedal	286	17 %
Alternating standing (or using a sit/stand stool) and sitting, with back fully supported at all times	0	0 %
Seated, back fully supported	0	0 %
Seated, back not supported (with or without back rest): lumbar spine cifotized and/or flexed forward and/or twisted	0	0 %
Seated on low seat, back not supported (with or without back rest): lumbar spine cifotized and/or flexed forward and/or twisted	83	5 %
Use of pedal with one or two feet (seated and/or standing: excluding vehicles driving)	0	0 %
Driving with back fully supported and using a pedal	0	0 %
Use of high stool	0	0 %
Use of high stool with lumbar spine flexed forward and/or twisted	0	0 %
Knee supported on a work plan with trunk bending between 30° and 60° (or abdomen leaning against a front support)	0	0 %
Transporting objects (weight>15 kg) on head and/or neck and/or shoulders	0	0 %
Head/neck: flexions and/or inclinations > 30°, mainly static, and/or frequent rotations and/or extensions	627	37 %

NOTE When the lumbar tract is cifotized this means that its normal curve of lordosi straightens or reverses, causing an increase in overload.

Figure 10 — Proportional distribution of different postures of the spine and lower limbs in homogeneous group 1, full-time

Tables 14 to 16 summarize the results of the risk assessment for both upper and lower limbs. Given the shorter exposure (homogeneous group 1 working part-time, 3 h/day), the risk indexes are lower than those shown previously for homogeneous group 1 working full-time.

	Posture	Hours	% duration
	Kneeling, squatting or sitting on the heels	0	0 %
	Work on ladders (rope, step, extension ladder, etc.), trees or scaffolding	253	15 %
	Lumbar tract fully flexed (trunk flexed >60°) and/or trunk twisted	26	2 %
	Back in extension with upper limbs over the height of the head	311	18 %
	Transporting objects (weight>15 kg) on head and/or neck and/or shoulders	0	0 %
	Seated, back not supported (with or without back rest): lumbar spine cifotized and/or flexed forward and/or twisted	0	0 %
	Standing with back flexed (>20° to 30° of the trunk bent), pushing, pulling or transporting (applying medium-high force)	91	5 %
	Seated on low seat, back not supported (with or without back rest): lumbar spine cifotized and/or flexed forward and/or twisted	83	5 %

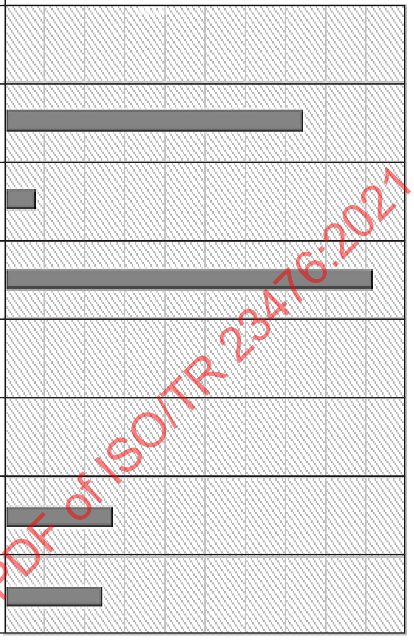


Figure 11 — Proportional distribution of different awkward postures of the spine and lower limbs that are "absolutely inadequate" according to ISO 11226, in homogeneous group 1, full-time

Table 14 — Results of the risk assessment for OCRA checklist in homogeneous group 1, part-time

Time-weighted average	MultiGEI
9,1 (upper limb right side)	11,9 (upper limb right side)

Table 15 — Results of the risk assessment for TACOS for body areas in homogeneous group 1, part-time

Head and neck	Spine in standing position	Spine in sitting posture	Legs
37,8 %	71,8 %	4,4 %	22,1 %
0,7	2,6	0,1	1,2

Table 16 — Results of the risk assessment for global TACOS in homogeneous group 1, part-time

MultiGEI annual score	Time-weighted average annual score
10,5	5,3

9 Annual multi-task risk assessment of manual material handling (MMH) and carrying

In order to study the annual exposure risk for manual lifting of loads, it is necessary, as for all the other biomechanical risk factors mentioned, to start from the quantitative organizational studies already set out in Clause 6.

For this topic, also, the methodological details are collected in Annex B, dedicated to the analysis of repetitive movements and manual lifting, through the use of many applicative examples.

Starting from the consideration that all the tasks that characterize a cultivation are “repetitive for the upper extremities” ("change of clothing", "travel to reach the place of work" and "occasional maintenance" are all considered to be non-repetitive work), the same repetitive tasks may also involve manual handling of loads (as the operators lift and carry using the upper limbs).

Therefore, a task is not only “repetitive for the upper limbs”, only “with load handling”, only “involving incongruous postures” or only with “pulling and pushing”. The evaluation criteria of the risk of biomechanical overload involves rather the criterion of “... and... and... and...” not “... or... or... or...”.

The definition of repetitive movements and manual lifting or carrying comes from the presence of positive answers to the specific “key-questions” according to ISO/TR 12295.

From Table 2 and Table 8 only the manual lifting tasks have extrapolated, by setting them alone in Table 17 and 18, keeping their durations first in per cent and then in minutes.

Tables 17 and 18 show only tasks featuring MMH, specifically their duration in % and in hours of work for each month of the year, the total duration of work over the whole year (357 hours only) and, in the same year, the % duration of the total hours dedicated to MMH versus the constant 1 760 h worked per year. The set of tasks with manual lifting accounts for only 20 % of all tasks performed during the year.

Applying the same criteria as for other hazards that can cause biomechanical overload, the intrinsic risk score for manual load lifting (the intrinsic LI) for each task is evaluated and presented in Table 19, using the calculation techniques defined in ISO 11228-1 and ISO/TR 12295[20],[59]–[63].

The manual load lifting work may be characterized as “mono task, composite task, variable task”. There are no task rotations (sequential tasks) typical of assembly lines or workbenches with up to four tasks rotated every few hours in the shift, since agricultural workers generally perform the same tasks for several days, with tasks alternating mainly with the change of season.

For this reason, to calculate the intrinsic risk indexes (due to manual lifting in agriculture) for each task present in a crop, it is important to stress again that the frequency/duration multiplier must be used for long periods, i.e. over 2 h (see ISO/TR 12295 and References [20] and [63]).

Table 17 — Example of quantitative description of pruning and harvesting tasks with manual load lifting per month for homogeneous group 1 (full-time)

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plowing (tractor)												
Installing irrigation system												
Planting (manual)												
Planting (mechanical)												
Pruning large branches with chainsaws												
Pruning with manual shears												
MMH of large branches										**40 %**	**30 %**	
Pruning with manual shears												
MMH of small branches		**20 %**	**20 %**	**30 %**	**30 %**	**30 %**						
Manual harvesting on ground												
Manual harvesting on ladder												
MMH of ladder							**10 %**	**10 %**	**10 %**			
Preparing machine to apply fertilizer												
Driving tractor												
Composting (manual)												
Disinfection (manual)												
Disinfection (tractor)												
Push/pull trolley with large branches												
Push/pull trolley with small branches												
Push/pull trolley with fruit boxes												

Table 18 — Net duration of tasks (hours) with MMH performed by homogeneous group 1 (full-time) over the year

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	% total hours/ year with MMH	Net hours/ year/task	% on a year constant
Plowing (tractor)															
Installing irrigation system															
Planting (manual)															
Planting (mechanical)															
Pruning large branches with chainsaws															
Pruning with manual shears															
MMH of large branches										**64**	**39**	**0**	28,9 %	88 (103)	5,9 %
Pruning with manual shears															
MMH of small branches	**0**	**18**	**32**	**48**	**48**	**49**							54,8 %	167 (195)	11,1 %

Table 18 *(continued)*

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	% total hours/ year with MMH	Net hours/ year/task	% on a year constant
Manual harvesting on ground															
Manual harvesting on ladder															
MMH of ladder							**21**	**21**	**16**	**0**	**0**	**0**	16,4 %	50 (58)	3,3 %
Preparing machine to fertilizer															
Driving tractor															
Composting (manual)															
Disinfection (manual)															
Disinfection (tractor)															
Push/pull trolley with large branches															
Push/pull trolley small branches															
Push/pull trolley fruit boxes															
	0	18	32	48	48	49	21	21	16	64	39	0	100 %	**306 (357)**	20 %

Table 19 — Intrinsic risk indexes of tasks with manual load lifting for homogeneous group 1 calculated considering different genders and ages

Tasks	Active tasks for MMH	Adult males	Adult females	Older and younger males	Older and younger females
Plowing (tractor)					
Installing irrigation system					
Planting (manual)					
Planting (mechanical)					
Pruning large branches with chainsaws					
Pruning with manual shears					
MMH of large branches	X	**1,5**	**1,9**	**1,9**	**2,5**
Pruning with manual shears					
MMH of small branches	X	**1,0**	**1,3**	**1,3**	**1,7**
Manual harvesting on ground					
Manual harvesting on ladder					
MMH of ladder	X	**3,0**	**3,8**	**3,8**	**5,0**
Preparing machine to apply fertilizer					
Driving tractor					
Composting (manual)					
Disinfection (manual)					
Disinfection (tractor)					
Push/pull trolley with large branches					
Push/pull trolley with small branches					
Push/pull trolley with fruit boxes					

NOTE Considering the result of the intrinsic values of the NIOSH method, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk.

Once the intrinsic risk scores, hours and percentage duration of each task have been calculated, both within each month of the year and over the whole year, it is possible, by calculating the artificial working days representative of each month and of the whole year, to calculate the final risk indexes. In the examples in Tables 17 and 18, the "artificial working day representative of the year" for manual load lifting is obtained from Formula (2).

$$M_{fwd}=H_{My/}\,C_{Dy} \times 60 \qquad (2)$$

where

M_{fwd} is the "artificial working day" in manual lifting in minutes;

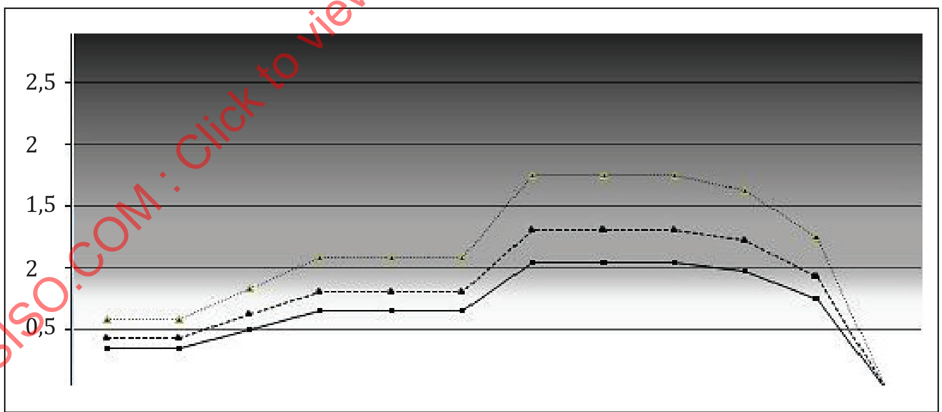
H_{My} is worked hours per year with manual lifting;

C_{Dy} is the number of worked days per year (constant).

Assuming H_{My} is equal to 360 hours per year, M_{fwd} is 84 min.

Considering "an artificial working day representative of the year" duration of 84 min, the corresponding duration multiplier is 0,5. The procedure and formulae [Formula (B.6)] are the same ones used for calculating exposure to repetitive movements and awkward postures of the spine (without load lifting) and lower limbs.

Figure 12 shows examples of manual load lifting risk assessment in homogeneous group 1, full-time, where manual handling is present but only in some tasks of the crop and not performed for the whole shift (Tables 17 and 18). The only model used to calculate monthly and annual risk indexes is the "MultiGEI". In fact, the NIOSH method never employs computational models that use the "time-weighted average".



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
male	0,0	0,4	0,5	0,7	0,7	0,7	1,1	1,1	1,1	1,0	0,8	0,0
female-older/younger male	0,0	0,4	0,6	0,8	0,8	0,8	1,3	1,3	1,3	1,2	0,9	0,0
older/younger female	0,0	0,6	0,8	1,1	1,1	1,1	1,8	1,8	1,8	1,6	1,3	0,0

a) NIOSH manual lifting index: distribution of exposure indexes in different months of the year obtained using the MultiGEI formula for homogeneous group 1, full-time

1,1	ADULT MALE (19-45 years old)
1,4	ADULT FEMALE (19-45 years old)
1,4	YOUNGER AND OLDER MALE (>45 years old)
1,9	YOUNGER AND OLDER FEMALE (<19years old)

b) NIOSH manual lifting indexes for the total year and for gender and age, in homogeneous group 1/full-time, using the multiGEI formula

NOTE Considering the result of the intrinsic values of NIOSH method, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk.

Figure 12 — MMC final exposure indexes for gender and age (relative to the homogeneous groups No. 1 full-time.

10 Annual multi-task risk assessment of pushing and pulling

In order to study the annual exposure risk for manual pushing and pulling it is necessary, as for other factors, to start again from the quantitative organizational studies already set out in Clause 6.

Taking Table 2 and Table 8 as a starting point for identifying the tasks performed during the year, only tasks, as for the tasks with MMH, involving pushing and/or pulling are activated (defined by the presence of positive "key-questions", according to ISO/TR 12295).

Tables 20 and 21 show examples of tasks featuring pushing and/or pulling, their net duration in hours for each month of the year, the total duration of the work over the whole year and, in the same year, the percentage duration of the total hours dedicated to pushing and/or pulling versus the constant 1 760 h worked per year.

Applying the same criteria as for other hazards, that may cause biomechanical overload, for each task intrinsic risk scores are calculated using the calculation techniques defined in ISO 11228-2 and ISO/TR 12295. Again, the intrinsic risk indexes have to be calculated for each task as if that task lasted for the entire shift (Table 22).

Once the intrinsic risk scores, hours and percentage duration of each task have been calculated, both within each month of the year and over the whole year, it is possible to calculate risk indexes by calculating "artificial working days representative of each month and of the year".

Table 20 — Percentage duration of pruning and harvesting tasks with pushing and/or pulling per month for homogeneous group 1 – full-time

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plowing (tractor)												
Installing irrigation system												
Planting (manual)												
Planting (mechanical)												
Pruning large branches with chainsaws												
Pruning with manual shears												
MMH of large branches												
Pruning with manual shears												
MMH of small branches												
Manual harvesting on ground												
Manual harvesting on ladder												
MMH of ladder												
Preparing machine to apply fertilizer												
Driving tractor												
Composting (manual)												
Disinfection (manual)												
Disinfection (tractor)												

Table 20 *(continued)*

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Push/pull trolley with large branches		**5 %**	**5 %**	**5 %**	**5 %**	**5 %**				**5 %**	**5 %**	
Push/pull trolley with small branches		**5 %**	**5 %**	**5 %**	**5 %**	**5 %**				**5 %**		
Push/pull trolley with fruit boxes							**10 %**	**10 %**	**10 %**			

Table 21 — Duration in hours of pruning and harvesting tasks with pushing and/or pulling per month for homogeneous group 1 – full-time

Tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	% of total hours per year at MMH	Hours per year per task	% on a year constant
Plowing (tractor)													0 %	0 %	0 %
Installing irrigation system													0 %	0 %	0 %
Planting (manual)													0 %	0 %	0 %
Planting (mechanical)													0 %	0 %	0 %
Pruning large branches with chainsaws													0 %	0 %	0 %
Pruning with manual shears													0 %	0 %	0 %
MMH of large branches													0 %	0 %	0 %
Pruning with manual shears													0 %	0 %	0 %
MMH of small branches													0 %	0 %	0 %
Manual harvesting on ground													0 %	0 %	0 %
Manual harvesting on ladder													0 %	0 %	0 %
MMH of ladder													0 %	0 %	0 %
Preparing machine to apply fertilizer													0 %	0 %	0 %
Driving tractor													0 %	0 %	0 %
Composting (manual)													0 %	0 %	0 %
Disinfection (manual)													0 %	0 %	0 %
Disinfection (tractor)													0 %	0 %	0 %
Push/pull trolley with large branches		**5**	**8**	**8**	**8**	**8**				**8**	**7**		33 %	51	3 %
Push/pull trolley with small branches		**5**	**8**	**8**	**8**	**8**				**8**			29 %	45	3 %
Push/pull trolley with fruit boxes							**21**	**21**	**16**				38 %	58	3 %
Total		9	16	16	16	16	21	21	16	16	7		100 %	154	9 %

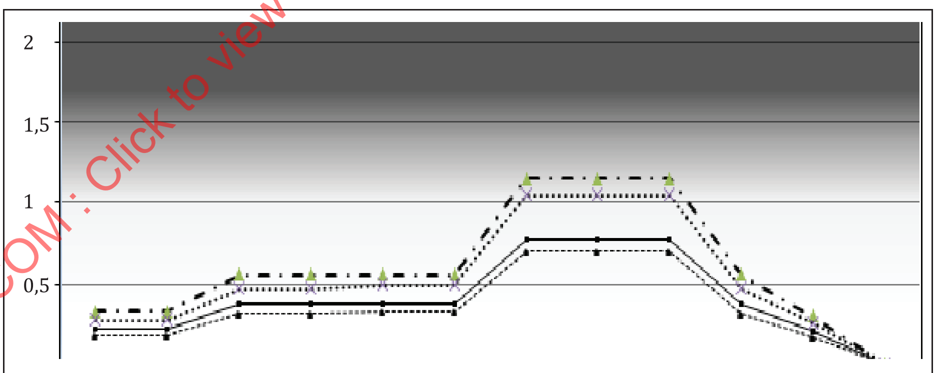
This procedure is the same one used for calculating exposure to repetitive movements, awkward postures of the spine (without load lifting) and lower limbs and MMH [Formula (B.6)].

Figure 19 shows the final risk assessment for pushing and/or pulling in homogeneous group 1 full-time. In the graph, for clarity problems, the following values are shown (separately for males and females): the worst peak value obtained between pulling and pushing (if both are present) and the worst maintenance value obtained between pulling and pushing (if both are present). To determine monthly and annual risk indexes only the “MultGEI” model is used, as for repetitive movements, awkward postures and MMH.

Table 22 — Intrinsic exposure indexes from pushing and/or pulling for homogeneous group 1 full-time risk

		Pushing		Pulling		The worst between pulling and pushing	
		m	m	m	m	m	m
Tasks	Active tasks for MMH	Peak values	Maintenance values	Peak values	Maintenance values	Peak values	Maintenance values
Disinfection (manual)							
Disinfection (tractor)							
Push/pull trolley with large branches	X	1,0	0,85			1,00	0,85
Push/pull trolley with small branches	X	1,2	1,1	1,4	1,0	1,4	1,1
Push/pull trolley with fruit boxes	X	2,1	1,7	2,2	2,0	2,2	2,0

NOTE Considering the result of the intrinsic values of the NIOSH method, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk.



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
pick male	0,0	0,2	0,4	0,4	0,4	0,4	0,8	0,8	0,8	0,4	0,2	0,0
maitenance male	0,0	0,2	0,3	0,3	0,3	0,3	0,7	0,7	0,7	0,3	0,2	0,0
pick female	0,0	0,3	0,6	0,6	0,6	0,6	1,2	1,2	1,2	0,6	0,3	0,0
maitenance female	0,0	0,3	0,5	0,5	0,5	0,5	1,1	1,1	1,1	0,5	0,3	0,0

a) Pushing/pulling exposure indices: distribution of exposure indexes in different months of the year obtained using the MultiGEI formula for homogeneous group 1, full-time

0,26	Peak-male
0,23	Maintenance-male
0,39	Peak-female
0,35	Maintenance-female

b) Pushing/pulling exposure indexes for the total year and for gender and age, in homogeneous group 1, full-time, using the MultiGEI formula

NOTE Considering the result of the intrinsic values of pushing/pulling exposure assessment method, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk.

Figure 19 — Pushing/pulling exposure indexes (relative to homogeneous group 1 full-time) calculated using the MultiGEImodel for each month of the year and the whole year

11 Manual material carrying (MMC) risk assessment

For this risk factor, as there are no computational models that can be applied to multi-tasking at cycles other than daily, it may be sufficient to identify a homogeneous group and then evaluate it for risk based on:

— the most representative modal day of the year and its frequency of occurrence, in per cent, during the year;

— the worst day of the year and its frequency of occurrence, in per cent, during the year;

— the easiest day of the year and its frequency of occurrence, in per cent, during the year.

To undertake this analysis, ISO 11228-1 is used.

In more complex cases, it can be sufficient to use the "quick assessment" for both carrying and pushing/pulling, as presented in Annex A and in ISO/TR 12295.

12 Conclusions

This document discusses the complex procedures for addressing biomechanical overload in agriculture, which include analysing the risk of:

a) repetitive upper limb movements, including awkward posture of upper limbs;

b) manual handling of loads and carrying (including awkward posture of spine during manual lifting);

c) pushing and pulling;

d) awkward postures in sitting and standing position for lower limbs and spine.

Criteria and measurement methods already included in International Standards for biomechanical studies (ISO 11228-1, ISO 11228-2 and ISO 11228-3) and static working postures (ISO 11226 and ISO/TR 12295) have been proposed and adapted to agricultural work with exposure to multiple tasks which may change qualitatively and quantitatively over the course of the year (annual cycle).

Considering the amount of data to be collected and written up and the amount of calculations to be done, with the use of complex formulas, to make reliably easy and therefore possible such risk assessments, two free downloadable simple tools (worksheets) were created, one for global pre-mapping of danger and discomfort and the second to enable the real risk evaluation of biomechanical overload (repetitive movements of the upper limbs, manual load lifting and carrying, awkward posture, pushing pulling)[64] to overcome the inherent difficulties mentioned above. The IEA (International Ergonomics Association) and WHO (Word Health Organization) have been recommending for years that those who do prevention are offered not only evaluation methods but also simple tools to make them easily applicable.

Given the complexity of risk assessments, the suggestion is to start with a simple qualitative analysis (using the approach that employs "key-questions and quick assessments") not only for biomechanical risk factors but for all risks, so as to undertake a sort of global risk pre-mapping exercise, and in this preliminary stage of the risk analysis highlight the presence of any discomfort and danger and suggest which priorities have to be addressed by more precise risk assessments.

The two simple tools for dealing with this initial stage of the analysis, free to download, are:

— EPMIES-agriERGOCHECKprecultivoENG;

— EPMIES-multiyearERGOCHECKpremapENG[64].

Figures and examples in this document derive from the two worksheets.

In all situations where it is not possible to complete the evaluation phase for real risk (e.g. no experience in ergonomics field, small businesses), pre-mapping at least generates one document itself sufficient to indicate the presence of potential risk factors and the priority with which they can be addressed. The evaluation can stop at this first step.

This document also suggests how to conduct the assessment of real risk, illustrating the relevant principles and criteria and offering in the annexes examples of applications. It also provides strategies for applying risk calculation methods (OCRA multitask for repetitive movements, NIOSH for manual variable load handling and TACOS for studying and timing awkward postures of the spine and lower limbs in multitask analysis and pushing/pulling).

The simple tool to conduct the assessment of real risk, free to download, is:

ERGOepmVINCIocraNIOSHpushTAeng (..)[64].

Annex A
(informative)

Initial identification and preliminary assessment (pre-mapping) of potential risks: criteria and presentation of a specific simple tool that allows its application

A.1 Aim

The fact that farm workers often carry out numerous activities on different days or in different months of the year makes risk assessments extremely complex (see References [8], [9], [17], [19], [26] and [27] and ISO/TR 12295). This is why it is crucial to conduct an in-depth preliminary analysis on how agricultural work is organized.

The purpose is to report exposure which, in agricultural settings, tends to vary in duration at different times of the year and therefore to be associated with different risk factors. Without this information, risk levels can clearly be regarded as identical regardless of whether workers are exposed to full-time, part-time or seasonal work.

Given the complexity of organizational studies in agriculture, a simple yet specialized digital tool has been developed to help operators pre-map the discomfort and dangers involved in farm work. This tool is illustrated in this annex.

Two simple spreadsheets models, free to download, are available[64]:

— EPMIES-agriERGOCHECKprecultivoENG: this model (no.1) is a universal cultivation model, already broken down into macro-phases and tasks, that can be adapted to many crops and is the easier of the two to use; this is the model used in all the examples in this clause;

— EPMIES-multiyearERGOCHECKpremapENG: this model (no.2) uses the same calculation structure of model no.1 but the macro-phases and tasks are blank. It may be used not only in agriculture but also other working sectors in which many different tasks are performed at different times throughout the year (e.g. building construction).

The main focus is on the first model.

A.2 General pre-mapping model for agriculture – A facilitated organizational analysis

A.2.1 General

The general organizational process underlying a pre-mapping analysis, or an actual exposure risk assessment, requires a step-by-step approach. First of all, the various tasks involved in the crop growing or cultivation process have to be identified from the qualitative and quantitative standpoint. Next, the distribution of tasks throughout the year is analysed. Lastly, the tasks are matched to the workers and the workers are divided into homogeneous groups. This complex study, including the pre-mapping part, is illustrated in the following subclauses.

A.2.2 Phase 1 – Identification of tasks involved in cultivation

As it is so inherently difficult to identify macro-phases, phases and tasks in the crop growing or cultivation process,[21]–[24],[26],[27] a kind of universal cultivation system has been developed that enables even beginners to conduct a preliminary organizational analysis in an agricultural setting.

It consists of macro-phases (soil preparation, treatment, disinfection and fertilization, planting, intermediate processes, harvesting) that include a certain number of typical tasks broken down by type, technique and tool(s) used or load(s) lifted (Table A.1).

Table A.1 — Principal tasks characterizing a generic cultivation activity

Preparation and treatment of soil, mechanical weeding	with tractor
	with animals
	with manual tools
	manual carrying (weight up to max. 3 kg)
	manual carrying (weight 3 kg)
	with manual tool and pulling or pushing
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)
Disinfection, disinfestation, fertilizing, chemical weeding	with tractor
	manual with machinery
	manual with tools
	with manual tools and pulling or pushing
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)
Planting	automatic with tractor
	semi-automatic with tools and/or machinery
	manual with manual tools (product weight up to max. 3 kg)
	manual without tools (product weight up to max. 3 kg)
	manual with manual tools (product weight over 3 kg)
	manual without tools (product weight over 3 kg)
	manual carrying (product weight up to max. 3 kg)
	manual carrying (product weight over 3 kg)
	with manual tools and pulling or pushing
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)
Intermediate farm work (e.g. pruning, binding, thinning)	pruning with manual tools
	pruning with pneumatic/electric tools
	pruning with chainsaws
	manual pruning without tools
	manual carrying (weight up to max. 3 kg)
	manual carrying (weight 3 kg)
	with manual tool and pulling/ pushing
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)

Table A.1 *(continued)*

Harvesting of crops	automatic with tractor
	semi-automatic with tools and/or machinery
	manual with manual tools
	manual with pneumatic/electric tools
	manual without tools
	manual carrying (weight up to max. 3 kg)
	manual carrying (weight 3 kg)
	with manual tools and pulling or pushing
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)

A.2.3 Phase 2 – Identification of a homogeneous group

The first spreadsheet model mentioned in A.1 (no.1) requires the completion of an organizational analysis that is presented on spreadsheet page 1 (1-organization) and begins with the identification of homogeneous groups.

The next step is to assign tasks to individual workers or groups of workers exposed to the same risk: the homogeneous group. When tasks of the same type and duration are assigned to the same group of workers, a homogeneous group can be spoken of in terms of risk exposure. A homogeneous group may sometimes comprise one person, if no other workers perform the same task (from the qualitative and quantitative standpoint).

For instance, typically, a single group of workers may be assigned the job of actually growing a certain crop (tasks can include pruning, harvesting), while other workers prepare and disinfect the soil, apply fertilizers and so on.

When using “EPMIES-agriERGOCHECKprecultivoENG(..)”a new file has to be createde for each homogeneous group assigned to cultivating one or more crops during the year.

Having opened the predefined universal cultivation document page, first of all it is necessary to write, for each worked month, the number of hours worked per person in that month (including all the tasks performed that month).

Subsequently an “X” has to be placed in the appropriate box to activate the tasks (in columns) performed by the homogeneous group, in each month of the year, for subsequent analytical quantification. The various tasks performed during different months of the year are thus recorded qualitatively and quantitatively (in percentages). The sum of the percentages indicated for each month (at the end of each column) must always equal 100 %. The percentages need not be perfectly accurate; they only describe the proportion of time spent each month performing a certain task.

Table A.2 shows an example of a form filled out for the homogeneous group 1 of full-time workers at a large farm that grows top-quality wine grapes. This homogeneous group of about 10 male workers performs many tasks that are variously distributed throughout the year.

To report the quantitative data required to define exposure durations, it is necessary to enter the number of hours worked by each worker each month. As the group is homogeneous, all the members of the group work the same number of hours.

Table A.2 shows also how the total number of hours worked per month can vary considerably.

A.2.4 Phase 3 – Definition of duration multipliers for adjusting the different risk scores based on their specific duration

The software (no.1) then converts the total number of hours worked per month, using the specific tasks duration percentages, into tasks duration hours, with respect to the default constants of 160 h/month, which corresponds to 8 working hours per day (430 min to 480 min), 5 days a week, 4 weeks a month[21]–[24],[26],[27].

Therefore, if the percentage is 100 % that means that the number of hours worked that month is the same as the constant. If the percentage is higher or lower, it means that exposure to work-related risk is proportionally greater or lesser; deviations from the exposure constants become the basic criteria for calculating variations in risk levels (or priorities) as a function of changes in exposure duration.

Table A.2 — Identification in the predefined universal cultivation form of tasks performed by homogeneous group 1, in the example (tasks activated by entering an "X" in column "active tasks")

Main predefined tasks		Active tasks	Hours worked per month per worker											
				160	160	160	160	160	160	200	200	200	100	50
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Preparation and treatment of soil, mechanical weeding	with tractor	x				5 %	5 %							30 %
	with animals	x							5 %					10 %
	with manual tools	x								10 %				
	manual carrying (weight up to max. 3 kg)													
	manual carrying (weight 3 kg)	x		10 %		30 %								10 %
	with manual tool and pulling or pushing	x			20 %		5 %			10 %			5 %	
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)													
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)													
Disinfection, disinfestation, fertilizing, chemical weeding	with tractor	x				5 %	5 %							
	manual with machinery													
	manual with tools	x								10 %				
	with manual tools and pulling or pushing	x		10 %										
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)													
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)													
Planting	automatic with tractor	x					5 %							
	semi-automatic with tools and/or machinery	x		30 %			5 %							
	manual with manual tools (product weight up to max. 3 kg)	x								10 %				
	manual without tools (product weight up to max. 3 kg)													
	manual with manual tools (product weight over 3 kg)													
	manual without tools (product weight over 3 kg)	x			10 %	10 %	10 %							
	manual carrying (product weight up to max. 3 kg)													
	manual carrying (product weight over 3 kg)	x			10 %	10 %	10 %							
	with manual tools and pulling or pushing	x		10 %										10 %
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)													

Table A.2 *(continued)*

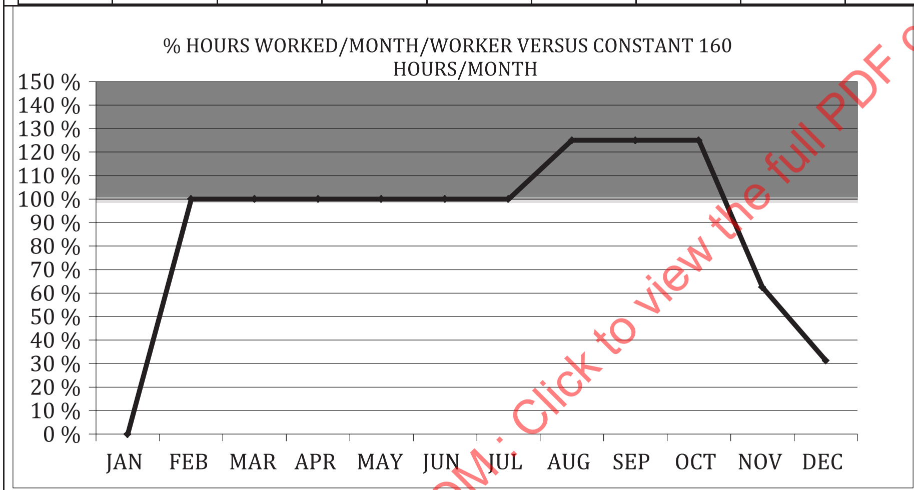
Main predefined tasks		Active tasks	Hours worked per month per worker											
				160	160	160	160	160	160	200	200	200	100	50
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Intermediate farm work (e.g. pruning, binding, thinning)	pruning with manual tools	x						90 %	90 %	40 %	10 %	10 %		
	pruning with pneumatic/electric tools	x				5 %	5 %							
	pruning with chainsaws	x											5 %	
	manual pruning without tools													
	manual carrying (weight up to max. 3 kg)	x												
	manual carrying (weight 3 kg)	x					5 %							10 %
	with manual tools and pulling/pushing	x				30 %				10 %	10 %			10 %
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)													
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)													
Harvesting	automatic with tractor	x					45 %						5 %	
	semi-automatic with tools and/or machinery	x											5 %	
	manual with manual tools	x								10 %	10 %		70 %	
	manual with pneumatic/electric tools	x			30 %			5 %			70 %	80 %		
	manual without tools													
	manual carrying (weight up to max. 3 kg)													
	manual carrying (weight 3 kg)	x			30 %							10 %	10 %	10 %
	with manual tools and pulling or pushing	x		10 %		5 %								10 %

The graph in Figure A.1 shows the percentage of hours worked per month (by homogeneous group 1 in the example depicted in Table A.2), obtained by dividing the number of hours/month/workers by 160 h/month constant. The curves in the red area (here in grey) indicate levels above the constant; the number of hours worked per month is also not evenly distributed – it rises during the harvest season.

It is now possible to assign these duration percentages, on a month-by-month basis, to certain risk factors where the total number of hours worked coincides with the duration of exposure to that particular risk factor. Repetitive movements, awkward postures, lighting, micro-climate, UV radiation from outdoor work and biological pollutants are almost always present and inherently linked to farm work.

In Figure A.1, the graph indicates the duration in hours worked in the "artificial working day". This calculation converts the total duration of hours worked/year into a single day by comparing the constants. In the calculation, 100 % means that the year is equivalent to an artificial 430 min to 80 min per day (duration multiplier = 1, for the duration factor, as per the OCRA checklist method). The number of hours worked per year in the example amounts to 1 710 (which is very close to the constant 1 760 h/year).

0	160	160	160	160	160	160	200	200	200	100	50
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	125 %	125 %	63 %	31 %



1710	466	1 000	100 %
No. of hours worked/year	Fictitious (artificial) day in minutes		

NOTE The grey area in the graph indicates that the constant has been exceeded.

Figure A.1 — Graph plotting the monthly distribution of tasks with durations indicated in per cent versus a constant 160 h/month for homogeneous group 1

Dividing this figure of 1 710 min by 220 working days/year and multiplying the result by 60, the number of minutes in the "artificial working day representing the time worked" in the year can be calculated: 466 min in this example.

Based on the data shown in Table A.3 (illustrating the duration multipliers used to adjust the risk indexes as a function of task duration, as per the OCRA checklist), it can be seen that the multiplier corresponding to 466 min is equal to 1, therefore the risk calculated for this situation is unchanged: the "artificial working day" has a duration of 421 min to 480 min.

Table A.3 — Duration multipliers for adjusting exposure indexes as a function of task duration

Duration multipliers used for the OCRA checklist			
Net time min	**Duration multiplier**	**Net time** min	**Duration multiplier**
0–1,86	0,007	241–300	0,85
1,87–3,74	0,018	301–360	0,925
3,75–7,4	0,05	361–421	0,95
7,5–14,99	0,1	421–480	1
15–29,99	0,2	481–539	1,2
30–59,99	0,35	540–599	1,5
60–120	0,5	600–659	2
121–180	0,65	660–719	2,8
181–240	0,75	720	4

When considering tasks that involve lifting loads weighing 3 kg or more, it is essential to examine the actual duration of such tasks throughout the year, which is undoubtedly lower than the duration attributed to the aforementioned potential risk factors (because not all the tasks listed involve manual load lifting).

These critical data are easy to obtain (in order to avoid overestimating exposure) by placing an “X” in the form against tasks featuring the characteristics indicated here: the hours of exposure automatically appear for each individual task along with the total for each month.

The estimated percentages are then calculated with respect to the constant 160 hours per month (Table A.4).

If the software “EPMIES-agriERGOCHECKprecultivoENG” with predefined tasks for universal cultivation is used, the tasks entailing manual lifting are already activated, but can be modified if necessary.

Tables A.5, A.6 and A.7 show the results of the search for exposure duration data, for each month of the year, for the remaining risk factors.

Table A.5 shows exposure duration data for each month of the year for manually carrying and pushing/pulling (the names of the pre-entered tasks emphasize the existence of these jobs). Here, too, when such tasks are present, they appear already activated in the software with an “X” in the appropriate place (as described for Table A.4).

Table A.6 shows exposure duration data for each month of the year for noise and vibrations from vibrating tools. The attribution of possible risk due to noise is applied to all tasks involving the use of vibrating tools, as well as for tasks that involve driving farm vehicles.

Table A.7 shows exposure duration data for each month of the year for risk factors associated with the use of inadequate equipment and machinery and exposure to whole body vibrations, again with a view to calculating the actual duration of exposure.

Table A.4 — Calculation of sum of hours worked/month/year only for tasks that involve the manual lifting of loads weighing equal to or more than 3 kg and calculation of % versus the constant 160 h/month

Main predefined tasks		Sign with "x" the active tasks	Hours worked per month per worker											
				160	160	160	160	160	160	200	200	200	100	50
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Preparation	manual carrying (weight 3 kg)	X		16		48								5
	with manual tools and pulling or pushing													
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)													
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)	X												
Planting	automatic with tractor													
	semi-automatic with tools and/or machinery													
	manual with manual tools (product weight up to max. 3 kg)													
	manual without tools (product weight up to max. 3 kg)													
	manual with manual tools (product weight over 3 kg)	X												
	manual without tools (product weight over 3 kg)	X			16	16	16							
	manual carrying (product weight up to max. 3 kg)													
	manual carrying (product weight over 3 kg)	X			16	16	16							
	with manual tools and pulling or pushing													
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)													
Intermediate farm work (e.g. pruning, binding, thinning)	pruning with manual tools													
	pruning with pneumatic/electric tools													
	pruning with chainsaws	X											5	
	manual pruning without tools													
	manual carrying (weight up to max. 3 kg)													
	manual carrying (weight 3 kg)	X					8							5
	with manual tools and pulling/pushing													
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)													
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)	X												

Table A.4 *(continued)*

Main predefined tasks		Sign with "x" the active tasks	Hours worked per month per worker											
				160	160	160	160	160	160	200	200	200	100	50
			Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Harvesting of crops	automatic with tractor													
	semi-automatic with tools and/or machinery													
	manual with manual tools													
	manual with pneumatic/electric tools													
	manual without tools													
	manual carrying (weight up to max. 3 kg)													
	manual carrying (weight 3 kg)	X		48	48			8				20	10	5
	with manual tools and pulling or pushing													
	other activities, without tools, with repetitive movements of the upper limbs (without lifting up to max. 3 kg)													
	other activities, without tools, with repetitive movements of the upper limbs (with lifting up to max. 3 kg)	X												
		Duration of tasks that involve load handling												
			0	64	80	80	40	8	0	0	0	20	15	15

Table A.5 — Calculation of sum of hours worked/month/year (with durations indicated in % versus a constant 160 h/month) only for tasks that involve (a) the manual carrying of loads equal to or more than 3 kg and (b) pushing/pulling

a) Duration of tasks that involve carrying											
0	16	64	64	24	0	0	0	0	20	10	15
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 %	10 %	40 %	40 %	15 %	0 %	0 %	0 %	0 %	13 %	6 %	9 %
b) Duration of tasks that involve pushing/pulling											
0	48	32	56	8	0	8	40	20	0	5	20
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 %	30 %	20 %	35 %	5 %	0 %	5 %	25 %	13 %	0 %	3 %	13 %

Table A.6 — Calculation of sum of hours worked/month/year (with durations indicated in % versus a constant 160 h/month) only for tasks that involve (a) noise and (b) upper limb vibrations

a) Duration of tasks in noisy environment											
0	96	48	24	112	16	0	0	140	160	15	15
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 %	60 %	30 %	15 %	70 %	10 %	0 %	0 %	88 %	100 %	9 %	9 %
b) Duration of tasks performed with vibrations affecting the upper arms											
0	96	48	8	16	16	0	0	140	160	10	0
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 %	60 %	30 %	5 %	10 %	10 %	0 %	0 %	88 %	100 %	6 %	0 %

Table A.7 — Calculation of sum of hours worked/month/year (with durations indicated in % versus a constant 160 h/month) only for tasks that involve (a) the use of tools, machinery and (b) whole-body vibrations

a) Duration of tasks performed with tools and equipment or parts of machines											
0	144	96	96	136	160	160	200	200	180	90	35
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 %	90 %	60 %	60 %	85 %	100 %	100 %	125 %	125 %	113 %	56 %	22 %
b) Duration of tasks performed with equipment – tractors, farm machinery (whole body vibrations)											
0	96	48	8	16	16	0	0	140	160	10	0
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 %	30 %	0 %	10 %	65 %	0 %	0 %	0 %	0 %	0 %	6 %	9 %

As described in Figure A.1, the graphs in Figures A.2 and A.3 depict the distribution of working hours in percentages for the various risk factors. It is easy to see how the potential duration of exposure differs considerably in relation to the various risk factors and months of the year.

For each risk factor there is now an estimated duration in the “artificial working day representative of the year exposure”, and with its relative duration multiplier.

This value is of the utmost importance because it is used to modify the weight of each individual risk factor versus its actual duration, procedure necessary for determining priorities between them.

“EPMIES-agriERGOCHECKprecultivoEN” automatically calculates the duration multiplier and applies it to the various risk factors, depending on its duration in the year.

This is only possible if the data entered for organizational analysis in model no.1 (page 1 of the spreadsheat: 1-organization) indicates the number of hours worked/month and the duration in percentages of the various tasks performed by the homogeneous group each month.

A.3 Similarities and differences between "EPMIESagriERGOCHECKprecultivoEN" and the classic "ERGOCHECK" model

A.3.1 Results of the first part regarding key-enters for biomechanical overload and key-questions regarding other risk factors

Having entered all the necessary organizational data (i.e. tasks and task durations for each month of the year) into the first worksheet of the "EPMIES-agriERGOCHECKprecultivoEN" programme, and automatically generated the specific duration multipliers for each risk factor, it is now possible to fill in the various parts as per the classic "ERGOCHECK model" (see ISO/TR 12295 and references [26] and [27]).

Each risk factor present appears automatically in percentage terms per month, and the duration multipliers automatically adjust the risk scores for the various factors based on their actual duration.

For the example analysed earlier and depicted in Table A.2 (homogeneous group 1), Figure A.4 indicates the "key-enters" for biomechanical overload, due to repetitive movements, manual load lifting, manual load transporting pushing/pulling.

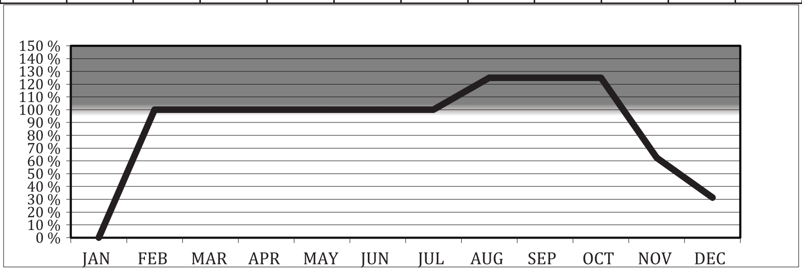
The data regarding the estimated duration, in this subclause, appear automatically due to the "key-enters" that were marked, as presence in percentage, each month of the year.

The data derives from the first worksheet indicating the relevant organizational data. It can be observed that the various risk factors are present at very different levels throughout the year.

Figure A.5 shows all the preliminary key-enters required to record the presence of awkward postures; all that needs to be done is to place an "X" indicating which awkward postures are observed. A more specific worksheet is used to describe the type and duration of the main awkward postures reported by the homogeneous group.

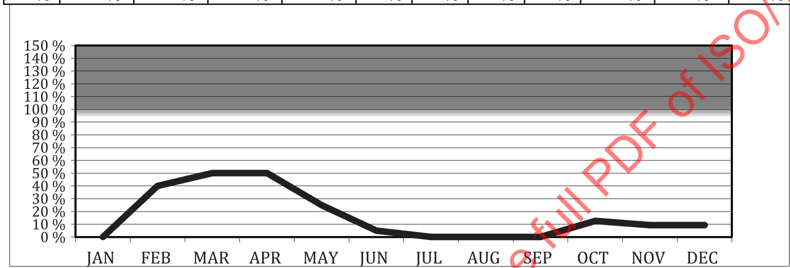
At this point the various parts of the worksheet are completed for each individual risk factor, in the usual way. Figures A.6 and A.7 sum up the overall results. Although the duration multiplier cannot be seen, it nonetheless automatically modifies the risk score, depending on the relevant "danger level".

0	160	160	160	160	160	160	200	200	200	100	50
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	100 %	100 %	100 %	100 %	100 %	100 %	125 %	125 %	125 %	63 %	31 %



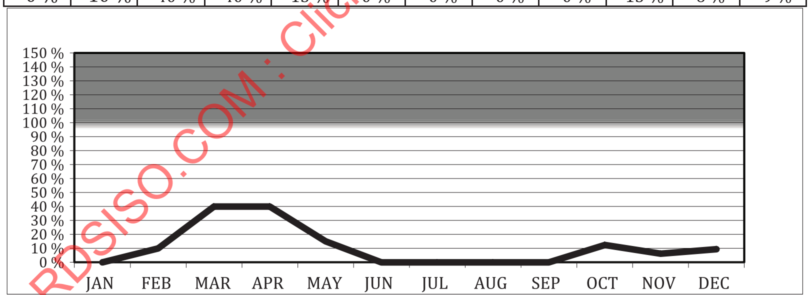
a) Risk factors for which exposure equates to the total hours worked/year: worked hours/year = 1 710 (100 %)

0	64	80	80	40	8	0	0	0	20	15	15
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	40 %	50 %	50 %	25 %	5 %	0 %	0 %	0 %	13 %	9 %	9 %



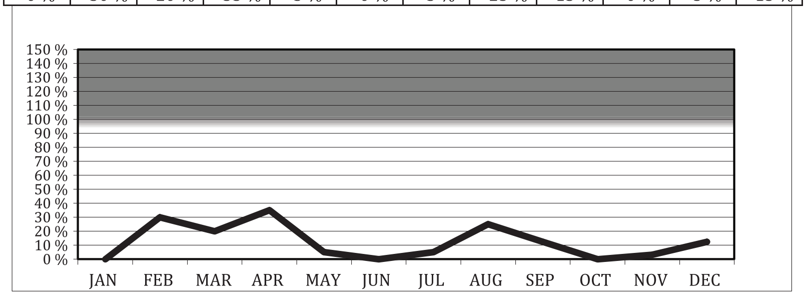
b) Duration of tasks that involve manual lifting of load: worked hours/year = 322 (50 %)

0	16	64	64	24	0	0	0	0	20	10	15
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	10 %	40 %	40 %	15 %	0 %	0 %	0 %	0 %	13 %	6 %	9 %



c) Duration of tasks that involve carrying: worked hours/year = 213 (35 %)

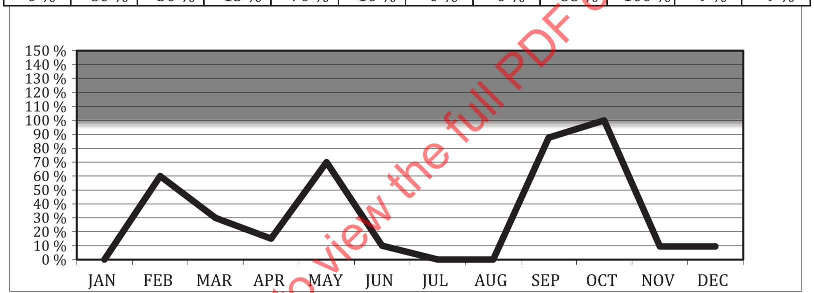
0	48	32	56	8	0	8	40	20	0	5	20
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	30 %	20 %	35 %	5 %	0 %	5 %	25 %	13 %	0 %	3 %	13 %



d) Duration of tasks that involve pushing/pulling: worked hours/year = 237 (50 %)

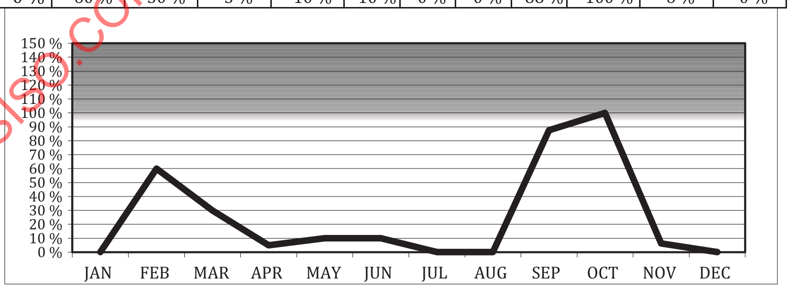
Figure A.2 — Percentage of hours worked/month versus the constant

0	96	48	24	112	16	0	0	140	160	15	15
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	60 %	30 %	15 %	70 %	10 %	0 %	0 %	88 %	100 %	9 %	9 %



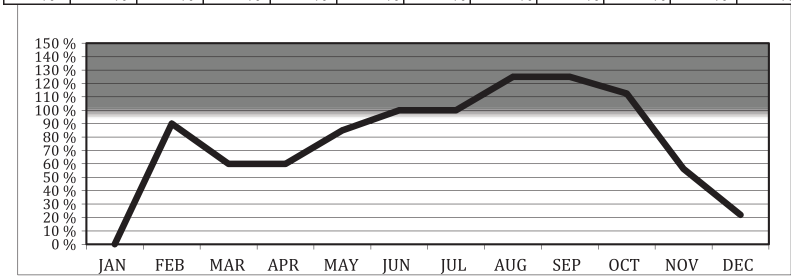
a) Duration of tasks in noisy environment: worked hours/year = 626 (65 %)

0	96	48	8	16	16	0	0	140	160	10	0
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	60 %	30 %	5 %	10 %	10 %	0 %	0 %	88 %	100 %	6 %	0 %



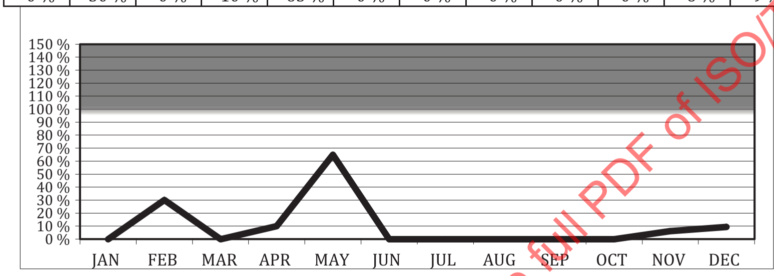
b) Duration of tasks performed with vibrations affecting the upper arms: worked hours/year = 494 (65 %)

90	144	96	96	136	160	160	200	200	180	90	35
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	90 %	60 %	60 %	85 %	100 %	100 %	125 %	125 %	113 %	56 %	22 %



c) Duration of tasks performed with tools and equipment or parts of machines – worked hours/year = 494 (65 % %)

0	96	48	8	16	16	0	0	140	160	10	0
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	30 %	0 %	10 %	65 %	0 %	0 %	0 %	0 %	0 %	6 %	9 %

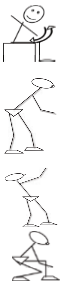


d) Duration of tasks performed with equipment – tractors, farm machinery (whole body vibrations): worked hours/year = 1 497 (95 %)

Figure A.3 — Percentage of hours worked/month versus the constant

Biomechanical overload - key enters												
a) Biomechanical overload of upper limbs in repetitive tasks												
	Are there repetitive tasks? The task is organized in cycles, regardless of their duration, or the task is performed with the same actions for over 50 % of time. The term “repetitive” does not mean presence of risk.								YES	X		
									NO			
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	0 %	100 %	100 %	100 %	100 %	100 %	100 %	125 %	125 %	125 %	63 %	31 %
b) Biomechanical overload from manual handling – lifting												
	Does the task involve lifting objects weighing 3 kg or more? (If the objects weigh less, there is no need to continue the investigation)								YES	X		
									NO			
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	0 %	40 %	50 %	50 %	25 %	5 %	0 %	0 %	0 %	13 %	9 %	9 %
c) Biomechanical overload from manual handling – carrying												
	Does the task involve carrying objects weighing more than 3 kg? (If the objects weigh less, there is no need to continue the investigation).								YES	X		
									NO			
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	0 %	10 %	40 %	40 %	15 %	0 %	0 %	0 %	0 %	13 %	6 %	9 %
d). Biomechanical overload from manual pushing and pulling												
	Does the task involve whole-body pushing or pulling of loads?								YES	X		
									NO			
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	0 %	30 %	20 %	35 %	5 %	0 %	5 %	25 %	13 %	0 %	3 %	13 %

Figure A.4 — “Key-enters” for biomechanical overload: presence (in %) for each month of the year

Biomechanical overload from awkward postures - trunk and lower limbs			
Are there static or awkward working postures of the HEAD/NECK, TRUNK and/or UPPER AND LOWER LIMBS that are held for more than 4 seconds consecutively and repeated for a significant proportion of the working time? In practice, postures are generally in awkward (mark "NO") when the work is performed: - sitting with the back well supported, when there is sufficient leg room, and the subject can stand up (change position) at least every hour;	YES	X	
	NO		
EXAMPLES	NO	YES	
 Head/neck (neck bent back/forward/sideways, twisted)		X	
 Trunk (trunk bent forward/sideways/, back bent with no support, twisted)		X	Go straight to work sheet postures for trunk and lower limbs or to work sheet repetitive-mov for upper limbs
Upper limbs (hand(s) at or above head level, elbow(s) at or above shoulder level, elbow/hand(s) behind the body, hand(s) turned with palms completely facing up or down, extreme elbow flexion-extension, wrist bent forward/back/sideways)		X	
Lower limbs (squatting or kneeling) position held for more than 4 seconds consecutively and repeated for a significant proportion of the working time		X	

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	100 %	100 %	100 %	100 %	100 %	100 %	125 %	125 %	125 %	63 %	31 %

Figure A.5 — “Key-enters” for a preliminary definition of awkward postures

General lighting: assessment of visual effort required at work		
Sufficient		
Poor :	For a few hours a day	X
	All day	
Excessive:	For a few hours a day	X
	All day	
Artificial lighting: needed but unavailable		
Localized lighting. assessment of visual effort required at work		
Sufficient		X
Poor :	For a few hours a day	
	All day	
Excessive:	For a few hours a day	
	All day	
Needed but unavailable		
Work surfaces: assessment of visual effort required at work		
Work surfaces	Matte	
	Bright and shiny	
Surface of object being processed	Matte	X
	Bright and shiny	

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0 %	100 %	100 %	100 %	100 %	100 %	100 %	125 %	125 %	125 %	63 %	31 %

a) Key-questions for identifying indoor (or outdoor) lighting problems

perceived noise level

the task calls for verbal communications with co-workers	
noise level is not bothersome	
noise level bothers a little, but it is possible to talk to co-workers	
noise level is maddening, making it difficult to talk to co-workers	
noise level is very high, making it impossible to talk to co-workers	

the task does not call for verbal communications with co-workers	
noise level is not bothersome	
noise level bothers a little, but it is possible to talk to co-workers	
noise level is maddening, making it difficult to talk to co-workers	X
noise level is very high, making it impossible to talk to co-workers	

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
0 %	60 %	30 %	15 %	70 %	10 %	0 %	0 %	88 %	100 %	9 %	9 %

b) Key-questions for identifying hazards due to the presence of noise

Indoor or outdoor work

Acceptable all year	

Indoor work

Very warm:	Only in summer	
	All year	
Very cold:	Only in winter	
	All year	

Outdoor work with exposure to the elements

Only in summer	
Only in winter	
All year	X

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
0 %	100 %	100 %	100 %	100 %	100 %	100 %	125 %	125 %	125 %	63 %	31 %

c) Key-questions for identifying microclimate problems

adequate and kept in good condition or not used	
heavy	X
noisy	X
requires strength	X
not operating properly	X
cumbersome and/or hard to grasp	
not fit for specific use and/or technologically backward	
frequent overheating	
requires excessive attention	
may produce lesions (cuts, scrapes, blisters, burns......)	X
requires use of body parts as equipment with consequent lesions (calluses, scrapes, cuts, etc.)	X

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
0 %	90 %	60 %	60 %	85 %	100 %	100 %	125 %	125 %	113 %	56 %	22 %

d) Key-questions for identifying problems arising from the use of equipment, machinery and/or parts of machinery

Figure A.6 — “Key-questions” for the study of risk factors

No exposure to vibrations	
Task calls for the use of vibrating tools	
Occasionally	
Power screwdrivers at least 1/3 of the time	
Grinders/cutters/polishers at least 1/3 of the time	X
Jackhammers for at least 1/3 of the time	

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
0 %	60 %	30 %	5 %	10 %	10 %	0 %	0 %	88 %	100 %	6 %	0 %

a) Key-questions for identifying upper limb problems related to vibrations (use of vibrating tools)

No exposure to whole body vibrations	

Task involves driving:	
Occasionally	
Most of the time driving cars, motorcycles, vans	
Most of the time driving trucks, buses	
Most of the time driving tractors, farm vehicles, scrapers, diggers	X

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
0 %	30 %	0 %	10 %	65 %	0 %	0 %	0 %	0 %	0 %	6 %	9 %

b) Key-questions for identifying whole body problems related to vibrations (driving trucks or other vehicles)

No biological or other pollutants present			
dust: specify type		present	
		significant presence	
fumes: specify type		present	
		significant presence	
unpleasant odours: specify type		present	
		significant presence	
chemicals: specify type		present	X
		significant presence		go to work sheet pollutants
biological pollutants		present	X
		significant presence		go to work sheet biological

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
0 %	100 %	100 %	100 %	100 %	100 %	100 %	125 %	125 %	125 %	63 %	31 %

c) Key-enters for identifying problems associated with biological or other pollutants

Exposure to UV radiation and/or weather	
indoor work	
occasional outdoor work	
outdoor work for a significant proportion of the year (1/3) or welding work with low risk exposure to UV radiation	
outdoor work for more than half the year (2/3) or welding work with medium risk exposure to UV radiation	
outdoor work nearly all year (3/3) or welding work with high risk exposure to UV radiation	X

jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
0 %	100 %	100 %	100 %	100 %	100 %	100 %	125 %	125 %	125 %	63 %	31 %

d) Key-questions for identifying outdoor work-related problems – UV radiation

Figure A.7 — Key-questions for the study of risk factors

A.3.2 Results concerning the "quick assessment" for biomechanical overload of the upper limbs

Although the "quick assessment" part of the worksheets is completed in the same way as the classic "ERGOCHECK" model,[27] all of the completed worksheets are presented here for use as exercises and for learning to use the tool later on.

Figures A.8, A.9, A.10 and A.11 show the results of this initial assessment in the upper limb analysis. As the working conditions feature neither a total absence of risk (code green) nor a critical environment, the part calling for a more accurate description of the activities performed by the upper limbs is activated (Figure A.10).

Biomechanical overload due to repetitive movements			
Repetitive task present. The task is organized in cycles, regardless of duration or the task is characterized by similar gestures performed over 50% of the time. The term does not indicate the presence of risk.			Yes
Summary of repetitive work net duration on a representative average day			
Total shift average duration (in minutes)	480	Total repetitive working time (in minutes)	440
Description of non-repetitive tasks, their duration, and timing of breaks - total duration			
supply	10		1,0
cleaning			
other	10		
Total duration of non-repetitive work per shift (in minutes)		20	
Breaks (average): total duration per shift (in minutes): including meal break only if included in the shift		20	
Number of breaks (including meal break) lasting at least 8 minutes		3	

Figure A.8 — "Quick assessment" for biomechanical overload of the upper limbs: estimation of the net duration of repetitive work and pauses

Acceptable conditions If all conditions are described and replies are all "Yes", the risk level is acceptable for repetitive work and it is not necessary to continue the risk evaluation. NB. Please answer all questions by placing an "X" only in the blank spaces				
Are one or both upper limbs used less than 50 % of the total duration of the repetitive task(s)?	No	X	Yes	
Are both elbows held below shoulder level almost 90 % of the total duration of the repetitive task(s)?	No	X	Yes	
Is moderate or no force required (perceived effort = max 3 or 4 on CR-10 Borg scale) by the operator for no more than 1 hour during the repetitive task(s) and are there are no force peaks (perceived effort = 5 or more on CR-10 Borg scale)?	No	X	Yes	
Are there breaks (including meal break) lasting at least 8 minutes every 2 hours and is the repetitive task performed less than 8 hours a day?	No		Yes	X
Critical conditions If at least one of the following conditions is present (YES), risk must be considered as CRITICAL and task re-design is URGENTLY REQUIRED. NB. Please answer all the questions by placing an "X" only in the blank spaces				
Are technical actions performed with a single limb so fast that they cannot be counted by simple direct observation?	No	X	Yes	
Are one or both arms used to perform the task with elbow(s) at shoulder level for half or more than the total repetitive working time?	No	X	Yes	
Is a “pinch” grip (or any type of grasp using the finger tips) held for more than 80 % of the repetitive working time?	No	X	Yes	
Is peak force applied (perceived effort = 5 or more on the CR-10 Borg scale) for 10 % or more of the total repetitive working time?	No	X	Yes	
Is there only one break (including meal break) in a shift of 6-8 hours, or does the total repetitive working time exceed 8 hours in the shift?	No	X	Yes	

Figure A.9 — “Quick assessment” for biomechanical overload of the upper limbs: check for the presence of acceptable or critical conditions

Are there other risk factors to be considered when neither critical conditions nor acceptable conditions are present?						
Frequency						
High frequency technical actions performed with the dominant hand						
Slow (no more than 1 action every 2 seconds)			No	X	Yes	
Medium (no more than 1 action per second) or holding an object in the hands most of the time			No		Yes	X
High (more than 1 action per second): difficult to count actions			No	X	Yes	
Shoulder		Are the arms used with the elbow at shoulder level from one third to half of the total repetitive working time?	No	x	Yes	
Hand	 	Is a “pinch” grip (or any kind of grasp using the finger tips) used from half to 80 % of the repetitive working time?	No		Yes	X
Use of force						
Is peak force (perceived effort = 5 or more on the CR-10 Borg scale) applied from 1 % to 9 % of the time?			No	X	Yes	
Is moderate force (perceived effort = max 3 or 4 on the CR-10 Borg scale) required by the operator?			No		Yes	X
Indicate the fraction of time (1/3, 2/3, 3/3 of the shift) during which moderate force is used: Duration of moderate force					2/3 of time	

Figure A.10 — “Quick assessment” for biomechanical overload of the upper limbs: risk analysis in the absence of acceptable or critical conditions

	Biomechanical overload of upper limbs in repetitive tasks	
	Summary of pre-assessment and intervention priorities	It is necessary to conduct a risk assessment. To consider within brief period.

Figure A.11 — “Quick assessment” for biomechanical overload of the upper limbs: final evaluation with corrective actions in order of priority

A.3.3 Results concerning the “quick assessment” for manual load lifting

Figures A.12, A.13 and A.14 show the results of this second assessment of biomechanical overload due to manual load lifting. No critical conditions emerge (but risk is not absent); the lifting is extensively reported, with loads occasionally weighing as much as 10 kg (but not exceeding critical weights).

A.3.4 Results concerning the “quick assessment” for manual carrying and pushing/pulling loads

Figure A.15 shows the results for manual load carrying; no critical conditions appear.

A.16, A.17, and A.18 show the data for manual pushing and pulling and the final outcome of the overall manual load handling analysis. Again, no critical conditions emerge, although there are some issues.

Additional organisational and environmental risk factors to be considered				
Is the working environment unsuitable for manual lifting and carrying?				
There are extreme (low or high) temperatures	No	X	Yes	
Floors are slippery, uneven or unstable	No		Yes	X
There is insufficient space for lifting and carrying	No	X	Yes	
Are the objects unsuitable for manual lifting and carrying?				
The size of the object reduces the operator’s view and hinders movement	No		Yes	X
The centre of gravity of the load is not stable (e.g.: liquids, loose items inside a container)	No		Yes	X
The object has sharp edges, rough surfaces or protrusions	No	X	Yes	
Contact surfaces are too cold or too hot	No	X	Yes	
Does the work involve manual lifting or carrying for more than 8 hours a day?	No	X	Yes	

Figure A.12 — “Quick assessment” for manual load lifting: preliminary factor analysis for the object to be lifted and the working environment

Critical conditions If only one of the following conditions is present (YES), the risk must be considered high and the task must be immediately re-designed.					
Task lay-out and frequency					
Vertical location	The hand location at the beginning/end of the lift is higher than 175 cm or lower than 0cm	No	X	Yes	
Vertical displacement	The vertical distance between the origin and the destination of the lifted object is more than 175cm	No	X	Yes	
Horizontal distance	The horizontal distance between the body and load is greater than full arm reach	No	X	Yes	
Asymmetry	Extreme body twisting without moving the feet	No	X	Yes	
Frequency	equal to or higher than 15 times/min with short duration (max 60 min)	No	X	Yes	
	equal to or higher than 12 times/min with medium duration (max 120 min)	No	X	Yes	
	equal to or higher than 8 times/min with long duration (over 120 min)	No	X	Yes	
Loads exceed the following limits					
men (18-45 years)	25 KG	No	X	Yes	
women (18-45 years)	20 KG	No	X	Yes	
men (<18 or >45 years)	20 KG	No	X	Yes	
women (<18 or >45 years)	15 KG	No	X	Yes	

Acceptable conditions If NO LOADS >10 KG and all the following conditions are present, and if all replies are "YES" (lifting with both hands) in every weight category (<10KG), the risk level is acceptable for manual load lifting. However, additional factors must also be checked (see above). NB. Please place an "X" only in white boxes.					
Loads weigh between 3 and 5 kg		No		Yes	X
3 to 5 kg	No asymmetry (e.g. body rotation, trunk twisting)	No	X	Yes	
	Load is held close to the body	No		Yes	X
	Load vertical displacement is between hips and shoulders	No		Yes	X
	Maximum frequency: less than 5 lifts per minute	No	X	Yes	
Loads weigh between 5 and 10 kg		No		Yes	X
5 to 10 kg	No asymmetry (e.g. body rotation, trunk twisting)	No	X	Yes	
	Load is held close to the body	No		Yes	X
	Load vertical displacement is between hips and shoulders	No		Yes	X
	Maximum frequency: less than 5 lifts per minute	No	X	Yes	
Loads weigh more than 10 kg		No		Yes	X

Figure A.13 — “Quick assessment” for manual load lifting: check for the presence of acceptable or critical conditions

Characteristics and frequency of certain loads (over 10kg)					
Loads weigh between 10 and 15 kg		No		Yes	X
10,5 to 15 kg	No asymmetry (e.g. body rotation, trunk twisting)	No		Yes	X
	Load is held close to the body	No	X	Yes	
	Loadvertical displacement is between hips and shoulders	No	X	Yes	
	Maximum frequency: less than 1 lift every 5 minutes	No	X	Yes	
Loads weigh between 15 and 25 kg		No		Yes	X
15,51 to 25 kg	No asymmetry (e.g. body rotation, trunk twisting)	No		Yes	X
	Load is held close to the body	No	X	Yes	
	Load vertical displacement is between hips and shoulders	No	X	Yes	
	Maximum frequency: less than 1 lift every 5 minutes	No	X	Yes	

Figure A.14 — "Quick assessment" for manual load lifting: exposure analysis for loads weighing more than 10 kg

Conditions of manual carrying							
Representative period of carrying in a shift (min)	200	min					
No. of objects exceeding 3kg carried in a shift	Weight of objects carried	Cumulative mass (kg)		Max. distance (m):	4 m - 10 m		
100	10	1000					
30	25	750					
		0					
		0					
Cumulative Mass (total load carried in a shift)) =		1750	Does not exceed the limit				
Estimated cumulative mass for each hour =		525	Does not exceed the limit				
Estimated cumulative mass for each minute =		8,8	Does not exceed the limit				
Carrying is performed under unfavourable environmental conditions or loads are lifted from/to low levels, e.g. below knee level, or with arms raised above shoulder level				No		Yes	X

Figure A.15 — "Quick assessment" for carrying manual load: comparison between transported cumulative mass and recommended cumulative mass

Biomechanical overload due to manual pushing and pulling				
Perceived effort (obtained via worker interviews using the CR-10 Borg scale):	3 -moderato			
Additional organizational and enviromental risk factors to be considered				
Is the working environment unsuitable for pushing or pulling?				
Floors slippery, unstable, uneven, sloping upward or downward or cracked/broken	No		Yes	X
Poor layout makes moving loads awkward	No	X	Yes	
High temperatures in the working area	No		Yes	X
Do the characteristics of the object make it unsuitable for pushing or pulling?				
Object (or trolley, transpallet, etc.) limits the view of the operator or hinders movement	No	X	Yes	
Object is unstable	No		Yes	X
Object (or trolley, transpallet, etc.) has hazardous features, e.g. sharp surfaces, protrusions etc. that may cause injury	No	X	Yes	
Wheels or casters worn, broken or not properly maintained	No		Yes	X
Wheels or casters unsuitable for working conditions	No		Yes	X

Figure A.16 — "Quick assessment" for manual pushing/pulling: preliminary factor analysis for the object to be handled and the working environment

Acceptable conditions If all the following conditions are present, and if all replies are "Yes", the risk level is acceptable for pushing-pulling tasks. However, additional factors must also be checked (see above). NB. Please place an "X" only in the white boxes.					
Perceived effort (obtained via worker interviews using the CR-10 Borg scale) during pushing-pulling task(s) indicates up to SLIGHT force exertion (perceived effort) (score 2 or less on the Borg CR-10 scale).	No	X		Yes	
Task(s) that include manual pushing and pulling last up to 8 hours a day.	No	X		Yes	
Pushing or pulling force applied to the object between hip and mid-chest level.	No	X		Yes	
Pushing-or-pulling action performed with an upright trunk (not twisted or bent).	No	X		Yes	
Hands held within shoulder width and in front of the body.	No			Yes	X
Critical conditions If just one of conditions indicated below is present (YES), the risk must be considered high and the task must be immediately re-designed.					
Perceived effort (obtained via worker interviews using the CR-10 Borg scale) indicates the use of high peak force (perceived effort) (i.e. a score of 8 or more).	No	X		Yes	
Pushing-or-pulling action performed with the trunk significantly bent or twisted.	No	X		Yes	
Pushing-or-pulling action performed in a jerky or uncontrolled manner.	No	X		Yes	
Hands held either beyond shoulder width or not in front of the body.	No	X		Yes	
Hands are held higher than 150 cm or lower than 60 cm.	No	X		Yes	
Pushing-or-pulling action combined with vertical force components ("partial lifting").	No	X		Yes	
Task(s) that include manual pushing and pulling last more than 8 hours a day.	No	X		Yes	

Figure A.17 — "Quick assessment" for manual pushing/pulling: check for the presence of acceptable or critical conditions

Summary of manual load handling quick assessment

Biomechanical overload due to load manual lifting

Summary of pre-assessment and intervention priorities	It is necessary to conduct a risk assessment.	
	Intervention is urgent.	

Mechanical overload due to manual carrying

Summary of pre-assessment and intervention priorities	It is necessary to conduct a risk assessment.	
	To consider but long term.	
Summary of additional environmental factors that are important for MMH	Check the presence of few environmental problems	

Biomechanical overload due to manual pulling and pushing

Summary of pre-assessment and intervention priorities	It is necessary to conduct a risk assessment.	
	To consider but long term.	
Summary of additional environmental factors that are important for pushing and pulling	Presence of significant environmental problems	

Figure A.18 — "Quick assessment" for biomechanical overload due to manual load handling: final evaluation with corrective actions in order of priority

A.3.5 Results concerning the "quick assessment" for awkward postures

The worksheet on awkward postures must summarize – albeit roughly – all the postures adopted throughout the whole year (Figure A.19).

Trunk posture	
Standing or squatting (not seated)	
Nearly always upright	20 %
Frequent moderate bending	20 %
Frequent twisting	10 %
Frequent deep bending	20 %
Seated posture	
Works leaning on the back rest	20 %
Works in upright position but there is no backrest	
Works mostly bending forward	
Frequent twisting of trunk	10 %
described duration of trunk posture:	100 %
Lower limb postures	
Standing or squatting (not seated)	
Standing and able to walk around	50 %
Standing in a fixed posture	
Kneeling or crouching	50 %
Sitting	
Legs room sufficient	30 %
Legs room insufficient or very limited	
Legs room non-existent	
described duration of lower limb posture:	100 %
Use of pedal with lower limbs	
No use of pedals	70 %
Lower limbs used to press pedals	30 %
described duration of lower limb use:	100 %

Figure A.19 — "Quick assessment" for the study of awkward working postures

A.3.6 Results concerning the "quick assessment" for chemical and biological pollutants

The completed worksheets are attached (Figures A.20 and A.21).

A.3.7 Results concerning the "quick assessment" and "preliminary analysis" for work-related stress

The workers did not report any major organizational issues or problems with coworkers ("exposure" factor acceptable); certain "sentinel" events or early warning signals are present, such as an increase in time off due to sickness or accident (Figures A.22 and A.23).

	Qualitative/quantitative identification of chemicals or other agents generated by the manufacturing process																			Work process					
	Health risks due to acute exposure						Health risks due to chronical exposure					Safety risks								Brief description of process to characterize worker's exposure					
	Extremely high	High		Medium	Low	Sensitization risk	Extremely high	High	Medium	Low	Sensitization risk	Extremely high		High			Medium	Low		Type of exposure			Frequency of exposure		
	Very toxic	Toxic	Corrosive	Harmful	Irritating	Sensitizing	Carcinogenic; mutagenic; reproductive cycle risk; teratogenic	Carcinogenic; mutagenic; reproductive cycle risk; teratogenic; toxic	Toxic	Irritating	Sensitizing	Explosive	Extremely flammable	Combustive	Easily flammable	Explosive	Flammable	High flash point (i.e >70°)		Closed cycle	Controlled cycle	Open cycle	Occasional (not every day)	Low but every day	High every day
	H300 H310 H330	H301 H311 H331	H314 H318	H302 H312 H332	H315 H319 H335	H317 H334	H340 H350 H360	H341 H351 H361 H370 H372	H371 H373	H315 H319 H335 O SENZA ETICHETTA "H"	H317 H334	H200 H201 H202 H203 H240 H241	H220 H222 H224 H241 H242 H251 H252	H250	H225 H228	H204	H223 H226 (UNDER CERTAIN CONDITIONS) H225: if flash point < 23 °C and boiling point >35 H223 H224 H225 H226 (SECONDO CONDIZIONI)	NO LABEL		Complete	Inhalation separation	Direct contact and handling			
Acids																			Acids						
Bases																			Bases						
Fuels																			Fuels						
Organic compounds						X													Organic compounds			X	X		
Dusts						X													Dusts			X	X		
Gas fumes																			Gas fumes						
Plastic materials																			Plastic materials						
Metalloids and metals																			Metalloids and metals						
Oxidants																			Oxidants						
Pesticides						X													Pesticides			X	X		
Solvents																			Solvents						

Figure A.20 — "Quick assessment" for the study of chemical and particulate pollution

Biological pollutants used in the manufacturing process (bacteria and similar organisms, parasites, fungi)	Sporadic (1-2 times a month or less)	**Rare** (no more than 1-2 times a week)	**Frequent** (exposure weekly, but not daily)	**Very frequent** (exposure daily)
Group 1 biological pollutants generally unlikely to cause human disease as per annex xlvi of Italian leg. decree nr. 81/08: (saccharomyces cerevisiae, streptococcus thermophilus, lactobacillus casei, staphylococcus xylosus, etc.)				
Group 2 biological pollutants. may cause human disease and constitute a risk for workers; unlikely to spread to the community; effective prophylaxis or treatment generally available; as per annex xlvi of Italian leg. decree nr. 81/08 (campylobacter spp, clostridium spp, corynebacterium spp, enterobacter spp, klebsiella spp, legionella spp, salmonella paratyphi, staphylococcus aureus, streptococcus spp, treponema spp, cytomegalovirus, measles virus, mumps virus, duodenal ancyclostoma, toxoplasma gondii, candida albicans, etc.)				
Group 3 biological pollutants. may cause severe human disease and constitute a serious risk for workers; may spread to the community, but effective prophylaxis or treatment generally available; as per annex xlvi of Italian leg. decree nr. 81/08 (bacillus anthracis, brucella melitensis, mycobacterium tuberculosis, rickettsia ricketti, salmonella typhi, yersinia pestis, dengue virus, nile virus, yellow fever virus, aids virus, plasmodium falciparum, taenia solium, etc.)				
Group 4 biological pollutants. may cause severe human disease and constitute a serious risk for workers; at high risk of spreading to the community; no effective prophylaxis or treatment generally available; as per annex. xlvi of Italian leg. decree nr. 81/08 (ebola virus, lassa virus, marburg virus, etc.)				
Biological pollutants potentially present - criticalities (this area must be completed whether or not biological pollutants are used in the manufacturing process)				
Presence of centralized air conditioning system with air conditioning unit (AIR TREATMENT UNIT)				
Activities involving water nebulization (spas and wellness centres, showers, etc.)	X			
Activities involving contact with animals, feces and bio-aerosols deriving from same (farms, veterinary and grooming services, pest control, park rangers, etc.)	X			
Activities involving contact with products/substances derived from animals (farms. food industries, slaughterhouses, tanneries, dairies, kitchens, etc.)		X		
Activities involving contact with products/substances derived from plants (agriculture, food industries, paper mills, cosmetics, feed mills, wine cellars, oil presses, carpentry shops, kitchens etc.)				X
Outdoor activities with potential danger of bites by insects, snakes, etc. (example in agriculture)				
Activities involving potential exposure to blood or other biological fluids (health and care professions, child care, research and analytical laboratories, beauticians, tattoo parlours)				
Activities involving the collection, management, treatment, recycling and/or disposal of solid or liquid urban/industrial waste and production of organic fertilizers				
Cleaning and disinfection activities (premises, equipment, materials, etc.) and/or laundering				
Activities involving the use of mineral oils (engineering, etc.)				
Construction activities, animal-free agriculture, involving contact with soil and/or plant- and animal-derived substances			X	
Plant maintenance activities (HVAC, etc.)			X	
Personal care services (kindergartens, nursing homes, barbershops and hairdressers, etc.)				
Activities involving the use of animal and plant metabolites (proteins, enzymes, etc.)	X			
Wholesale/ retail trade excluding contact with plant and animal derived products				
Activities in crowded environments such as schools, gyms etc. (lice, mite allergies ...)				
Transport and storage activities (excluding products of plant and animal origin)				
Manufacturing activities: textile, chemical, pharmaceutical, rubber and plastic industries, hydrocarbon refining or other on signalling.				
PRESENCE IN THE HOMOGENEOUS GROUP OF DISEASES/DISORDERS CAUSED BY EXPOSURE TO BIOLOGICAL AGENTS: describe which and how many pathologies and tick the box indicated below with an "X"				
BIOLOGICAL POLLUTANTS POTENTIALLY PRESENT - CRITICALITIES (THIS AREA MUST BE COMPLETED WHETHER OR NOT BIOLOGICAL POLLUTANTS ARE USED IN THE MANUFACTURING PROCESS)				

Figure A.21 — "Quick assessment" for the study of exposure to biological agents

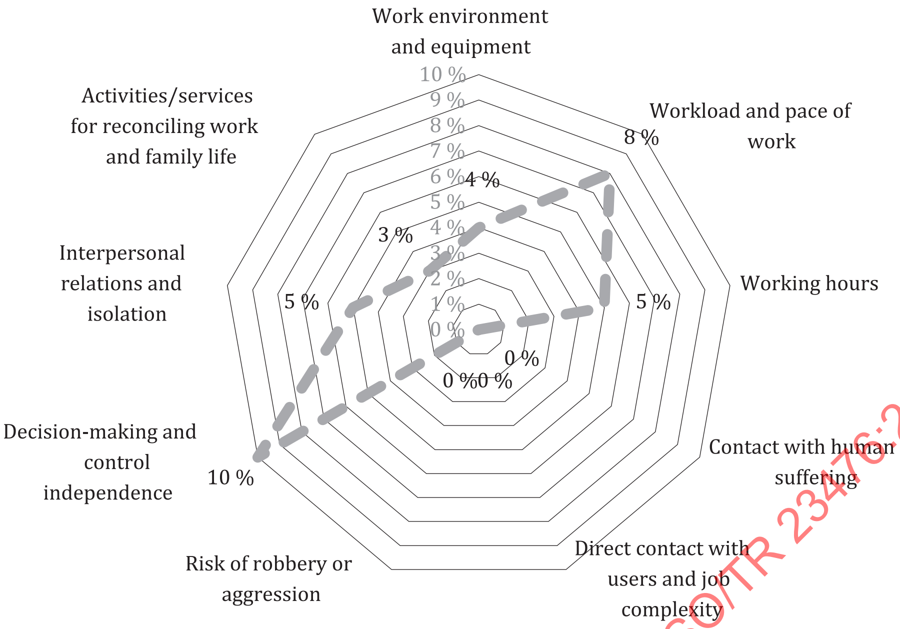
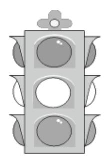


Figure A.22 — "Quick assessment" of work-related stress: workplace/organizational settings reported by the homogeneous group and graphic depiction (in %) of results for individual risk factors

(mark with an "x" if present)	**Presence of events**	**Increase of events** reported over the past 3 years	**Events higher than the company average**	**Descriptive numerical data** (enter here some quantitative numeric data specifying the meaning, e.g. number of events, rate etc., and the year of reference)
Work-related diseases/disorders caused by occupational stress certified by the physician (LEAVE THE BOX BLANK IF NONE)			0	0
Turnover (voluntary resignations)			0	0
Disciplinary actions		0		
Medical examination requested by the worker	**X**	**X**	2	0
Sick leave	**X**	**X**	2	0
Occupational injuries (not ongoing)	**X**	**X**	2	0

a) Sentinel events (hazards) description

	HAZARDS						
	HIGH						
X	MEDIUM		X				
	LOW						
	ABSENT						
		ACCEPTABLE	LOW	MEDIUM	HIGH	CRITICAL	EXPOSURE
			X				



b) Preliminary assessment stress result crossing hazard scores and exposure factors scores

NOTE Considering the result of the table: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk).

Figure A.23 — "Quick assessment" of work-related stress: workplace/organizational settings reported by the homogeneous group (exposure factors)

A.3.8 Summary of final results

Figure A.24 shows a summary of the final results, with priorities ranked for each risk factor (from 0 % to 100 %), in relation to homogeneous group 1 examined here.

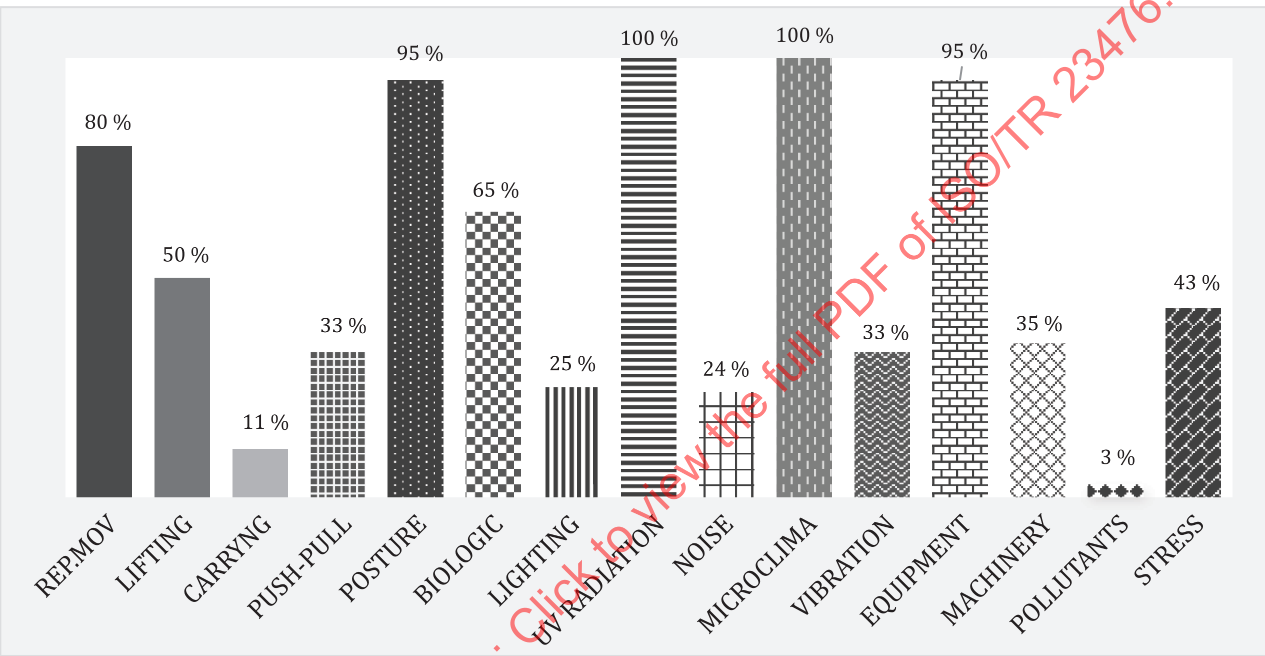


Figure A.24 — Summary of results with a ranking of priorities for each risk factor (from 0 % to 100 %), for homogeneous group 1

A.4 A comparison between the summary of final results for the various homogeneous groups – conclusions

The main purpose of the "simple tool" (EPMIES-agriERGOCHECKprecultivoENG) is to avoid complex calculations and automatically prioritize the highly variable dangers and discomfort that farm workers are exposed to. The results of the analysis vary proportionally with the type, level and duration of exposure.

Two simple examples are provided (i.e. homogeneous groups 2 and 3), for comparison with the example of homogeneous group 1 included in the previous subclauses. The characteristics of the three homogeneous groups can be summarized as follows:

— homogeneous group 1: works 11 months/year and performs a variety of tasks, including driving tractors, pruning and harvesting;

— homogeneous group 2: works 3 months/year and only carries out harvesting activities (for over 8 hours a day);

— homogeneous group 3: works 3 months/year and only carries out harvesting activities (but for 4 hours a day).

Figure A.25 summarizes and compares the results in terms of the percentage of hours worked/month (versus a constant 160 hours worked/month) for the three different homogeneous groups. The workers in groups 2 and 3 perform only harvesting activities; group 2 works over 8 hours a day; group 3 works only 4 hours a day.

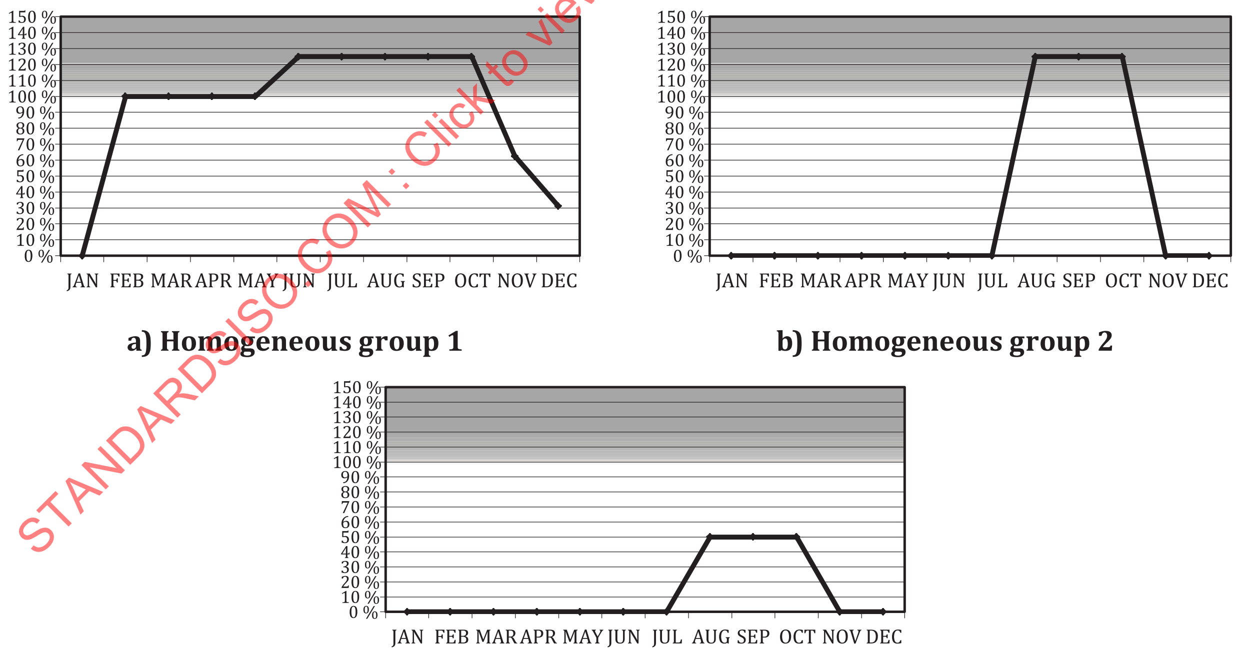
Figure A.26 compares the results obtained using “EPMIES-agriERGOCHECKprecultivoENG”. The differences are clear-cut and obvious.

This last example allows us to argue that, while complex, an organizational analysis is not only important but essential, even for a preliminary exposure risk analysis. The three examples included in this clause prove that without a qualitative and quantitative analysis of the tasks performed by the workers, the same risks and the same priorities for three different homogeneous groups would appear.

An effort has been made to simplify the organizational analysis through the use of a kind of “universal cultivation” model that includes predefined macro-phases and tasks, and various risks are already pre-assigned to tasks.

Having made available this list of macro-phases and tasks, all that remains to be done to complete the organizational study is to assign tasks to each homogeneous group and indicate their duration in percentages.

Another programme is also available for defining and determining tasks and risks from scratch (EPM IES-multiyearERGOCHECKpremapENG) and can be applied to more specific agricultural cultivations (e.g. greenhouse crops) and even other industries (e.g. building construction). Its use requires first of all the definition of the list of tasks that characterize a given work, attributing to them which risks can determine.



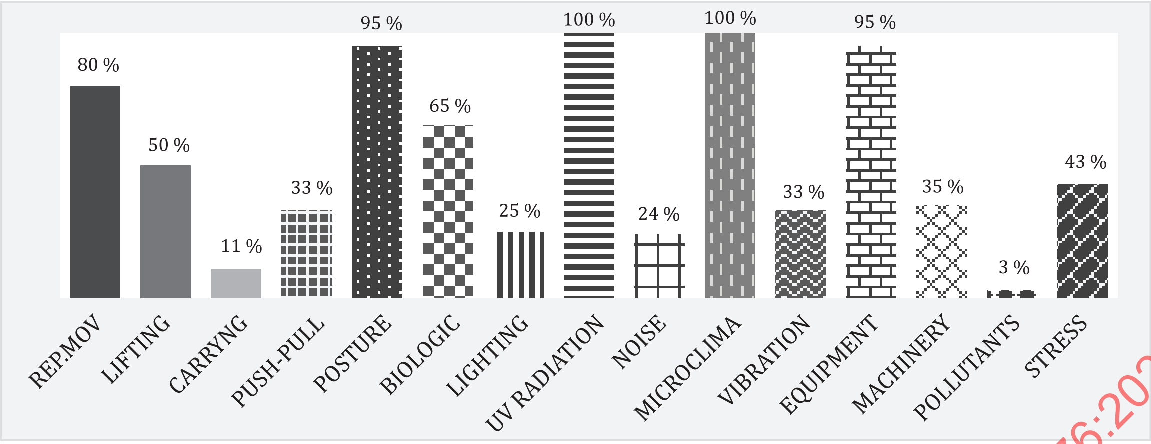
a) Homogeneous group 1

b) Homogeneous group 2

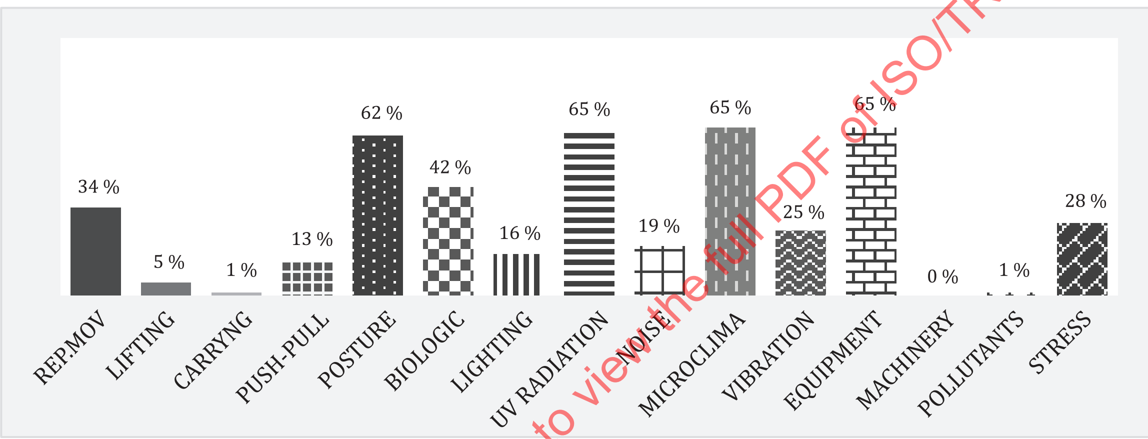
c) Homogeneous group 3

NOTE When 100 % of the constant duration is exceeded the line enters the grey area.

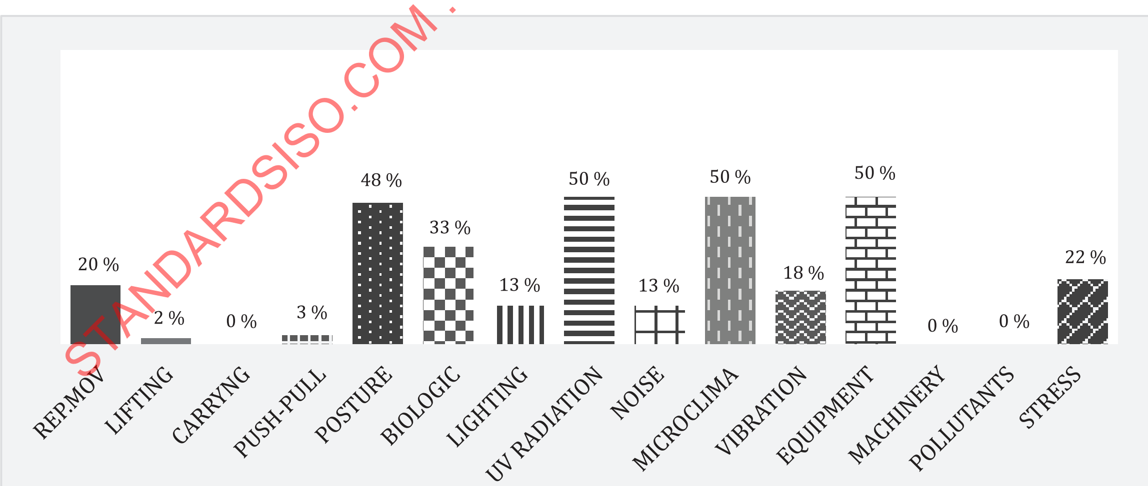
Figure A.25 — Summary of results in terms of percentage of hours worked/month (versus constant 160 hours worked/month) for the three homogeneous groups (a, b, c) compared here



a) Homogeneous group 1: works 11 months/year and performs a variety of tasks, including driving tractors, pruning and harvesting



b) Homogeneous group 2: works 3 months/year and only carries out harvesting activities (for over 8 hours a day)



c) Homogeneous group 3: works 3 months/year and only carries out harvesting activities (but for 4 hours a day)

Figure A.26 — Summary of results with a ranking of priorities for each of the three different homogeneous groups (a, b, c) and for the various risk factors (from 0 % to 100 %)

Annex B
(informative)

Criteria and mathematical models for analysing exposure to biomechanical overload in multitask jobs featuring complex macro-cycles (e.g. weekly, monthly, annual turnover)

B.1 Introduction

In industrial manufacturing sectors, workers generally rotate between manual tasks the same way every day and therefore the multitask analysis may be applied to just one representative working shift.

Conversely, in other production sectors such as construction, agriculture, cleaning and retail, manual tasks may not be rotated only on a daily basis but over longer macro-cycles (where the most common are weekly, monthly, annual macro-cycles), and there may be dozens or even hundreds of rotated manual tasks, each with a different level of exposure and distribution pattern. This naturally makes the multitask analysis more complex insofar as it must factor in multiple problems over extended periods of time[20],[22],[44],[46],[47],[59]–[63].

Recommendations for analysing multiple manual tasks with daily rotation can be found in the literature and in International Standards, in particular for:

— lifting tasks, as an extension of the revised NIOSH lifting equation;[20],[31],[32],[62],[63]

— tasks characterized by repetitive movements of the upper limbs, using the OCRA method and in particular the OCRA checklist.[22],[32],[33],[50]

However, there are still very few recommendations for the analysis of manual tasks when rotations take place over longer periods (macro-cycles) (e.g. weeks, months or years).

Considering this background, the aim of this annex is to start from the existing recommendations for multitask analyses on a daily basis, and to define procedures, criteria and a reference framework for conducting a multitask analysis of manual tasks featuring complex macro-cycles (more specifically, the annual turnover, more typical in agriculture) presenting potential conditions of biomechanical overload. An example of studying a multitask risk assessment in viticulture is presented, using the specific simple tool[64]. The study regards both the biomechanical overload of the upper limbs (OCRA checklist) and the lumbar spine for manual load lifting (revised NIOSH lifting equation). To save space, not all results regarding awkward postures (TACOS) and pushing/pulling are presented; however, these are obtainable using the same simple tool.

B.2 Daily job rotation

B.2.1 Daily rotation of jobs featuring repetitive tasks

Reference is made here to the OCRA method, in particular the OCRA checklist[22].

The OCRA method for assessing risk associated with repetitive movements of the upper limbs consists of two tools, the OCRA checklist and the OCRA index. The tools feature different analytical details and purposes, although both are inspired by the same conceptual model. The OCRA checklist is the simpler of the two tools and is used for the initial screening of workstations (ISO/TR 12295); the OCRA index is more complex and was chosen as the reference risk assessment method by International Standards relating to high-frequency repetitive manual work (ISO 11228-3).

The OCRA checklist consists of five parts that focus on the four main risk factors (lack of recovery periods, frequency, force, awkward posture/stereotype) and a number of additional risk factors (e.g. vibration, low temperatures, precision work, repeated impacts), and also factoring the net duration of repetitive jobs on the final estimate of risk. The classic analysis proposed by the OCRA checklist entails using pre-assigned scores (the higher the score, the higher the risk) to define the risk associated with each of the aforementioned factors. The sum and product of the partial values generate a final score which estimates the exposure level, featuring four different levels (green, yellow, red and purple). The calculation procedure for reaching the final result (Figure B.1) shows how all the risk factors are included: the lack of recovery period factor is a multiplier to be applied (recovery multiplier), along with the duration factor (and its duration multiplier), to the sum of the scores for the other risk factors.

One OCRA checklist is used to describe a workstation and estimate the exposure level embedded in the task, as if this task was the only performed by a single worker for the entire duration of the shift. When two or more repetitive tasks are rotated, the OCRA checklist can be used to estimate the level of exposure associated with combination of rotating tasks, and the duration in which the individual rotated tasks is performed has to be known.

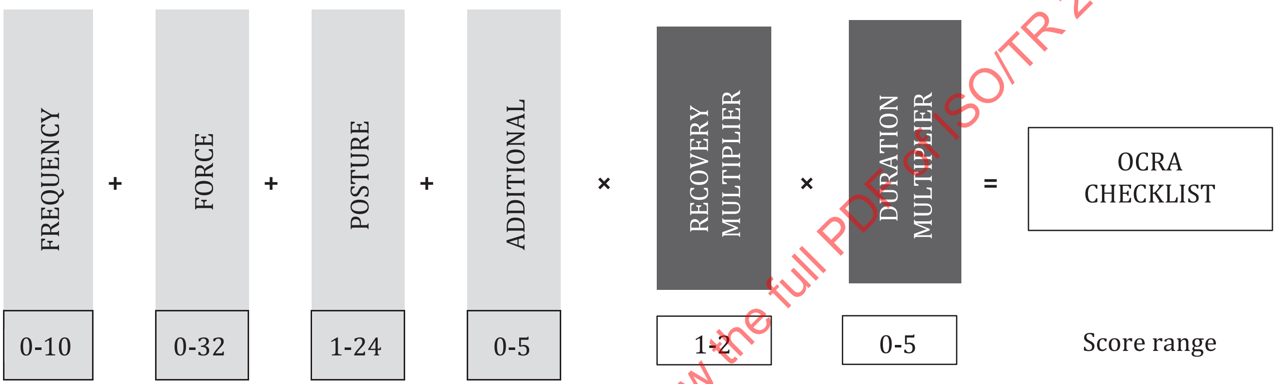


Figure B.1 — OCRA checklist: final score calculation procedure

Considering a daily shift, two main ways of rotating repetitive tasks can be considered:

— task rotation is frequent, i.e. within a period of less than 90 consecutive minutes for each task performed: "time-weighted average" mathematical model is used;

— task rotation takes place within a period of more than 90 consecutive minutes for each task performed: "multitask complex" mathematical model is used.

The "time-weighted average" model involves weighting the final individual checklist scores for the different tasks under examination, based on the total duration of repetitive tasks in the shift and their corresponding specific duration in the shift (expressed in time fractions). Formula B.1 is applied:

$$C_{\text{K.TWA}=} [(C_{\text{K}\cdot 1} \times F_{\text{T.1}}) + (C_{\text{K}\cdot 2} \times F_{\text{T.2}}) + \ldots. (C_{\text{K}\cdot 2} \times F_{\text{T.2}}) + \ldots. (C_{\text{K}\cdot \text{n}} \times F_{\text{T.n}})] \times D_{\text{m.tot}} \quad \text{(B.1)}$$

where

$C_{K.TWA}$ is the final exposure index of the multitask analysis with OCRA checklist (C_K) evaluated with time-weighted average model;

$C_{K\cdot 1,2,..,n}$ are the scores obtained from the OCRA checklists of the various tasks that the worker performs, calculated using the recovery multiplier corresponding to the actual distribution and duration of recovery periods in the shift while the duration multiplier is a constant = 1;

$F_{T.1,2,..,}$ $F_{T.n}$ represent the time fractions of duration of the various repetitive tasks versus the total duration of repetitive work;

$D_{m.tot}$ is the total duration multiplier, relative to the net duration of all the repetitive tasks present in the shift.

This approach and calculation model are intended to be used when the task rotation rate is fairly high, for instance once every 90 min or less. The approach is particularly intended to be used when different products (or models of the same product) are processed at the same workstation during the shift. In such cases, it can be assumed that higher risk exposure is somewhat offset by lower risk exposure, with the worker alternating between the two, within a relatively short time frame. Accordingly, rotating tasks serves to reduce risk proportionally with respect to the risk level and duration of each task identified in the turnover.

The “multitask complex” model is based on the concept of the task generating the highest overload (peak task), according to its effective continuous duration, taken as the minimum, to which is added the contribution of the other tasks in relation to their intensity and duration. With this approach, the final result is at the least not less than the highest OCRA checklist score, calculated using its effective duration. In this case the procedure is based on Formulae B.2 and B.3:

$$C_{K.MC=}\ C_{K.1\ eff} + (\Delta\ C_{K.1} \times K) \tag{B.2}$$

$$K = ((C_{K.2\ max} \times F_{T.2}) + (C_{K.3\ max} \times F_{T.3}) + \ldots + (C_{K\ n\ max} \times F_{T.n}))/\ C_{K\ 1\ max} \tag{B.3}$$

where

$C_{K.MC}$ is the final risk index of the multitask analysis OCRA checklist evaluated with multitask complex model;

$C_{K.1,2,3,..j..,n}$ is the repetitive tasks listed according to the score of the OCRA checklist (task$_1$ = the task with the highest C_K score; task$_n$ = the task with the lowest C_K score);

$C_{K.j\ eff}$ is the score of task j, calculated considering $D_{m.j}$ (duration multiplier according to the actual duration of each relevant task$_j$ in the shift) and with the lack of recovery time multiplier actually present in the shift; $C_{K\ 1\ eff}$ represents the task with the highest $C_{K.j\ eff}$;

$C_{K.j\ max}$ is the score of task j, calculated considering $D_{m.tot}$ (duration multiplier for the total duration of all relevant tasks in the shift) and with the lack of recovery time multiplier actually present in the shift; $C_{K\ 1max}$ represents the task with the highest $C_{K.j\ max}$;

$\Delta\ C_{K.1}$ is $C_{K.1\ max} - C_{K.1\ eff}$

F_{Tj} is the time fraction (between 0 and 1) of each task j, except task$_1$, with respect to the residual repetitive working time (total repetitive working time minus working time devoted to task$_1$) in the shift.

Note that in the general model for computing $C_{K.MC}$, the formula for calculating K (Formula B.3) was slightly changed with respect to previous proposals in literature.[22] The updated procedure is now aimed at avoiding an undue contribution of task 1 in determining the value of K.

This model has to be used when the repetitive task rotation occurs more than once every 90 min, for instance a repetitive task for the whole morning and another for the whole afternoon.

For these scenarios, the "time-weighted average" approach can in fact underestimate the actual exposure level. This problem is particularly acute in the study of certain jobs where tasks featuring high intrinsic risk indexes alternate with lighter tasks.

Table B.1 shows the duration multipliers to be used as a function of both the overall duration (in minutes) of all the repetitive tasks (sum of the duration of each of the repetitive tasks present in the shift and included in the rotation) and of the effective continuous durations of each individual task.

The multipliers shown in Table B.1 are reliable enough for durations of between 30 minutes and 480 minutes (the most common); durations of below 30 minutes or over 480 minutes are "extrapolated" by using Formula (B.4):

$$D_m = (M_d \times 0{,}008) + (-2{,}547 \times 10^{-5} \times M_d^{\ 2}) + (2{,}875 \times 10^{-8} \times M_d^{\ 3}) \qquad \text{(B.4)}$$

where:

D_m is duration multiplier;

M_d is task duration in minutes (evaluated for values below 30 minutes or over 480 minutes).

Table B.1 — OCRA checklist duration multipliers as a function of the duration of repetitive tasks in the shift[22]

Net duration of repetitive task min	Central value min	Duration multiplier
< 1,9	1,5	0,007
1,9–3,6	2,8	0,018
3,7–7,4	5,5	0,05
7,5–14	10,7	0,1
15–29	22,5	0,2
30–59	40	0,35
60–120	90	0,5
121–180	150	0,65
181–240	210	0,75
241–300	270	0,85
301–360	330	0,925
361–420	390	0,95
421–480	450	1
481–540	510	1,2
541–600	570	1,5
601–660	630	2
661–720	690	2,8

Note that when proposing the revised strain index[32]–[34] it is recommended that the D_m is computed using a formula that gives similar results, almost for the more common daily task durations (60 minutes to 480 minutes), with some assumptions regarding very short durations (less than 3 minutes) and durations over 480 minutes.

The two proposals for duration multiplier evaluation are synthetized, referring to the central values (in minutes) reported in Table B.1, in Figure B.2. The values are similar for most common durations and are slightly different for very short durations or durations over 480 minutes. In Figure B.2, the relation between the duration multiplier and the duration of the task in the shift is graphically reported for the two methods.

Duration repetitive task (minutes)	1,5	2,8	5,5	10,7	22	40	90	150	210	270	330	390	450	510	570	630	690
OCRA CK Duration Multiplier (Dm)	0,007	0,018	0,05	0,1	0,2	0,35	0,5	0,65	0,75	0,85	0,925	,95	1	1,2	1,5	2	2,8
RSI Duration Multiplier (Dm)	0,2	0,2	0,266	0,329	0,404	0,483	0,576	0,664	0,737	0,801	0,861	0,918	0,973	1,027	1,079	1,130	1,180

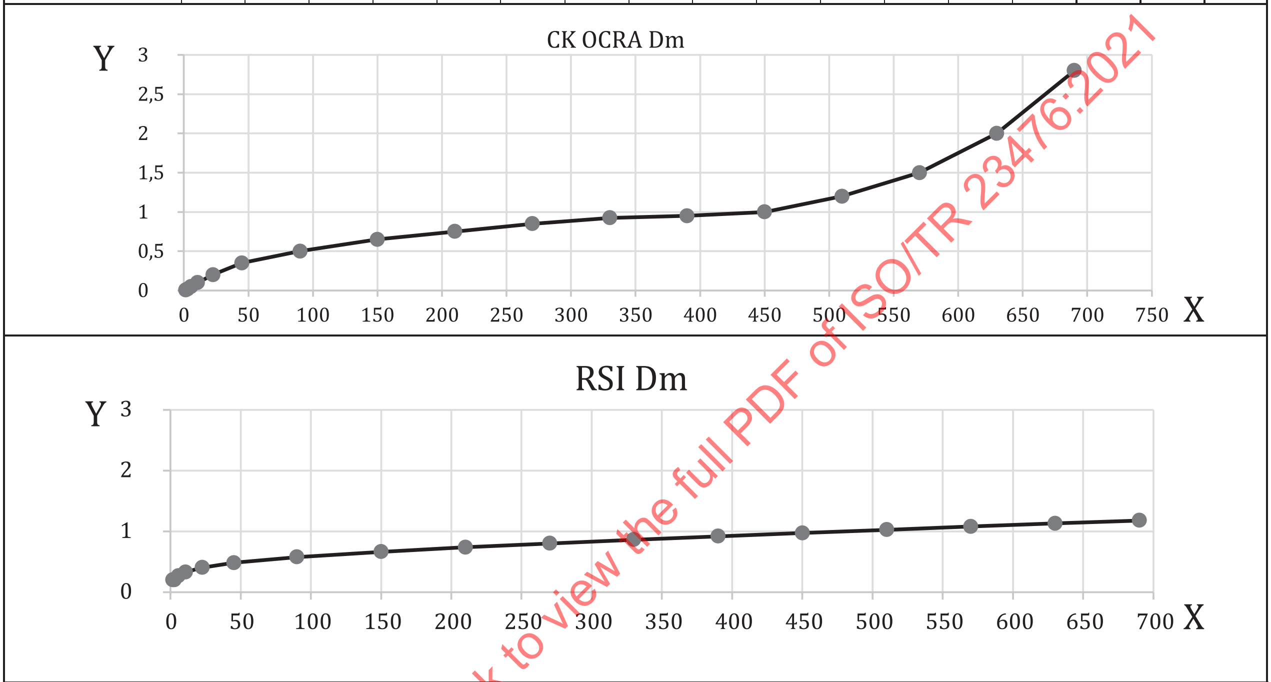


Figure B.2 — Duration multipliers as a function of the duration of repetitive tasks in the shift in the OCRA checklist method and the revised strain index (RSI) method

B.2.2 Daily manual lifting task rotations

Here reference is referred to the revised NIOSH lifting equation (RNLE) method and its extensions as published in the literature and embedded in ISO 11228-1 and ISO TR 12295[20],[32],[59]–[63].

The RNLE[59] envisages a formula that integrates organisational, weight and geometry (layout and body position) factors; its aim is to define the recommended weight limit (R_{WL}) for a lifting activity. This R_{WL} is then compared with the weight actually lifted (L) to compute the lifting index (L_I), according to Formula B.5:

$$L_I = L / R_{WL} \qquad \text{(B.5)}$$

where:

L_I is lifting index;

L is the load weight in kg;

R_{WL} is the recommended weight limit.

The R_{WL} is estimated to start from the maximum weight nearly all healthy workers ought to be able to lift under optimal conditions (load constant or reference mass = 23 kg in the original proposal) reduced by the intervention of other relevant risks factors (multipliers or reduction factors) as reported schematically in Table B.2.

Table B.2 — Multipliers used in the RNLE method for computing the recommended weight limit (R_{WL})

LC	Load constant or reference mass	Maximum recommended weight under ideal lifting conditions
VM	Vertical multiplier	Vertical distance of the hands from the floor at the start/end of lifting
DM	Distance multiplier	Vertical distance of the load between the beginning and the end of lifting
HM	Horizontal multiplier	Horizontal distance between the load and the body at the start/end of lifting
AM	Asymmetry multiplier	Angular measure of displacement of the load from the sagittal plane at the start/end of lifting
CM	Coupling multiplier	Assessment of the quality of grip of the object (from tables)
FM	Frequency multiplier	Frequency of lifts per minute and duration scenario (from tables)

In the study of manual lifting activities, four types of lifting tasks and relevant turnover can be operationally identified, with the following definitions and features:

— Mono task

This task involves lifting objects generally of the same type and with the same weight, with no changes in the parameters (same position of the lay-out and body “geometry”) from one lift to the other both at the origin of the lifting and at the destination. In this case, the classic lifting index mono task (MLI)[59] calculation method can be used.

— Composite task

Lifting objects that are generally of the same type (and weight) but over different “geometries” (e.g. grasping and moving objects from or to shelves at different heights and/or different horizontal distances) within the same time period. Each individual geometry (i.e. each combination of vertical height and horizontal distance at origin or destination) is called a “subtask”. In this case, the “composite lifting index (CLI)” can be computed following the specific procedure. However, it has been postulated that no more than 10 to 12 subtasks can be computed in this procedure, hence the need to introduce standardized simplifications[20],[59],[63].

— Variable task

This refers to lifting or lowering objects of different weights and/or over different “geometries” (vertical heights, horizontal distances) within the same time period of the shift. Different weight categories can be identified in this case. The handling of each separate weight category over each individual geometry is called a subtask. In this case the “variable lifting index (VLI)” is the calculation methodology to use[20],[63].

— Sequential task

When a daily shift includes several different lifting tasks (single, composite or variable), each performed continuously for at least 30 min. Workers rotate between a series of single or composite or variable lifting rotation (in general for no more than four or five different tasks, each job-rotation lasting no less than 30 consecutive minutes) during a work shift. In this case, that represents the real rotation between different lifting tasks, the “sequential lifting index (SLI)”[20] is the approach to be used.

As regards the analysis of single, composite and variable lifting tasks, reference is made to the literature and the relevant manuals[20],[62].

B.3 Rotations over periods longer than a day: the macro cycle (e.g. weekly, monthly, yearly)

B.3.1 Main elements of this procedure

Having explained how to deal with daily task rotations, the next step is to define a set of procedures and criteria for estimating exposure in more complex situations, where workers rotate along several manual tasks with different levels of exposure and variously distributed, in qualitative and quantitative terms, over periods longer than a day (macro-cycles of different time). In this case organizational analysis becomes more and more relevant.

The key elements of this procedure are listed below:

— Identification of the period over which the tasks are rotated: week, month, year or some other representative period.

— Identification of the homogeneous group of workers (homogeneous for professional risks exposure) who perform the same rotating tasks, in the same workplace, for the same duration and in the same sequence. A group can be composed also by only a worker if any other does the same job.

— Analysis of the duration and sequence of all the various manual tasks performed by each homogeneous group over the macro-cycle analysed.

— Use of the methods suggested in the literature and in the standards to assess the corresponded exposure index in each manual task, as if it lasted a whole daily shift of a predefined constant duration: the “intrinsic risk value” of each task. Each task can take more aspects of biomechanical overload, for example, both from repetitive movements and from manual lifting or pushing/pulling. In this case for each aspect the specific intrinsic exposure value for that task has to be calculated. Reference is made here to the OCRA checklist for repetitive tasks and to the RNLE for manual lifting tasks.

— Reconstruction of an “artificial working day (in min)” with respect to reference “time constants” where this artificial day is used for representing of entire macro-cycle, regarding any duration presented. This study includes all the rotated tasks, with the proportional time over which the tasks are distributed in the period considered. For accordingly calculating the “artificial working day representative of the macro-cycle”, the proportional duration of each task in the macro-cycle is transformed in representative minutes. Practically any macro-cycle is transformed (using predefined constants) in a representative working day in minutes and so on the task durations in this new representative working day.

— Recalculation of the intrinsic risk value of each task (evaluated using a constant duration) considering now the estimated real duration of each task, using specific duration multipliers.

— Application of the formulas employed to analyse the daily rotations considering the individual tasks present in the macro-cycle in study.

Methodological details about each of these steps are provided in the following subclause. Examples of the procedure illustrated here are provided in B.5.

B.3.2 Identification of the rotation period (macro-cycle) and the predefined macro cycle periods as week, month, year

The first step is to define the period – the macro-cycle during which all the significant tasks in the analysis are rotated.

The types of macrocycles durations certainly are infinite, but if there are no simplification criteria that allow us to estimate the risk, every risk assessment remains unfinished and nobody does anything (the excuse that the mission is impossible). For applicative purposes, one option is to use the predefined macro cycle periods as week, month, year as a modal representation of the different real macro-cycle durations.

The modal annual macro-cycle, in the agriculture and construction sectors, results in the best representative macro-cycle. In agriculture, task rotations are typically annual but the annual cycles can be used even when more cycles of few months in each year are repeated identically (e.g. more harvesting per year of the same product).

In civil constructions generally a year cycle for large construction sites is present but a month cycle (modal) is more frequently adopted for small civil renovations. In other sectors (logistics for retail chains, cleaning services, food preparation facilities), the most common rotation scenario is monthly, while in other situations (e.g. supermarkets) tasks may be rotated on a weekly or, occasionally, monthly basis.

In summary, some practical options are provided for using the predefined macrocycle (week, month, year), certainly able to simplify even the subsequent evaluations:

— Check if more identical sub-macro-cycles are repeated during the year; if so, use the annual macrocycle.

— Check if more identical sub-macro-cycles (e.g. one week, 15 days) are repeated within a month. If the following months are repeated identically, use the month macro-cycle.

Whichever macro-cycle duration is chosen, the criteria and procedures for dealing with the biomechanical overload risk analysis are the same. Given the extreme variability, the recommendation is however to identify and evaluate representative modal scenarios.

B.3.3 Identification of all the manual tasks typical of certain production present in a macro-cycle (job analysis) and identification of the homogeneous groups of workers

The preliminary step is to identify all the significant manual tasks performed in the macro-cycle, organized with rotations, characterizing a certain production. Note that it is better to have a complete list of all the manual tasks performed before attributing these tasks to one or more homogeneous groups of workers.

Since the focus of the analysis is the exposure of workers to a set of conditions determined by the tasks assigned to perform, it is first necessary to identify which homogeneous group of workers are present that need to be examined.

The homogeneous group of workers for risk exposure (as defining groups of workers homogeneous for working conditions and not groups of people homogeneous for other factors such as weight, age, culture, gender) is the group of workers that performs the same tasks, in the same workplace and with similar durations (or time patterns) during the selected period (macro-cycle). Note that a homogeneous group may sometimes be made up of just one person, if no other workers perform the same tasks qualitatively and quantitatively.

Moreover, if two groups of workers perform the same tasks in the same workplaces but with different durations or time patterns (e.g. one group works full-time and the other works part-time) the two groups must be analysed separately.

B.3.4 Analysis of the duration and sequence of all the various manual tasks performed by each homogeneous group over the macro-cycle

This step involves assigning the tasks performed by the homogeneous group (or individual exposed worker) qualitatively and, most of all, quantitatively. This part of the analysis is the most difficult one since it is needed to know how much time is spent, during the macro-cycle (week, month, year) in performing the different tasks.

The level of detail in the analysis depends on the period examined. It regards presence and duration of different tasks in single days for analysis of a week or months, and single months for analysing a year. Extreme accuracy is not required when starting to define the first time-assessment, the proportional assignment of tasks (the employer, or even the members of the homogeneous group, are able to provide this information).

These data allow the total number of hours worked by the homogeneous group on each task in the macro-cycle and all the duration multipliers to be computed.

It is also necessary to define the general characteristics of the "typical working shift" (the modal shift, see B.3.6) to obtain important information:

— the proportional reduction between the total shift duration and the net duration (without breaks and other short accessory tasks (e.g. cleaning), useful to obtain all the real tasks duration in the macro-cycle;

— the modal recovery multiplier.

B.3.5 Analysis of biomechanical overload typical of each individual task – the intrinsic risk value of each task to prepare the "basic tasks list with all the intrinsic risk evaluation"

All the manual tasks performed by the workers have to be analysed using the appropriate method (in the present paper, OCRA checklist and L_I-RNLE) to calculate the intrinsic risk value for each task.

Calculating the intrinsic risk value for a certain task means evaluating the task as if it is (only theoretically) the only one performed by the worker all the time (i.e. for the whole shift and the whole period).

When computing the intrinsic OCRA checklist score ($C_{K.i}$), reference is made to a shift scenario featuring:

— 430/460 net minutes of repetitive work (modal value = 440, duration multiplier = 1);

— one 30 min meal break and two 10 min breaks (recovery multiplier = 1,33).

When computing the intrinsic L_I (MLI or CLI or VLI) for lifting tasks, reference is made to a "long duration scenario" (more than 2 hours of consecutive manual lifting in the shift) with the corresponding classical frequency multiplier (by L_I-RNLE).

Note that in any case it is better to have a complete analysis with the intrinsic risk scores of all the manual tasks performed in the macro-cycle (the basic tasks list with all the intrinsic risk evaluation), before studying who performs them. It is then possible to attribute the tasks specifically to each homogeneous group of workers (the active tasks performed by each different homogeneous group).

B.3.6 Reconstruction of the artificial working day (or fictitious day) representative of macro-cycle (in term of total net duration of work and duration of each task) performed by each homogeneous group

Based on the analysis carried out in B.3.3, it is then possible to estimate the proportion of time that the homogeneous group spends on each manual task. This proportion may be calculated with reference to the total working time of the group in the period (macro-cycle).

However, since the total working time of the group may vary from group to group (e.g. one group may work full-time and another part-time), to reconstruct the "artificial working day representative of the macro-cycle", it is necessary to estimate the proportion with respect to standard work duration scenarios such as those typical of industry. These scenarios are called "prefixed exposure time constants" and are detailed in Table B.3.

Table B.3 — Exposure time constants

Hours/day constant	8	Hours/month constant	160
Minutes/day constant	440	Days/month constant	20
Days/week constant	5	Months/year constant	11
Minutes/week (440 min * 5 days) constant	2 200	Days/year constant	220
Weeks/month constant	4	Hours/year constant	1 760

Some examples of “artificial working day” calculations, in annual macro-cycles are presented in Table B.4.

Table B.4 — Some examples of different “artificial working day” calculations, in annual macro-cycles

	Representative day in annual macro-cycles
1	— if the overall hours worked in the year are 1 760 (in this case the worked hours/year corresponds to the constant), they correspond to a representative day of 480 minutes: **1 760 h really worked per year * 60/220 worked days per year constant = 480 min.**
2	— if the overall hours worked in the year are 880 (part-time job of 4 hours per day), they correspond to a representative day of 240 minutes: **880 h really worked per year * 60/220 worked days per year constant = 240 min...**
	Representative day in monthly macro-cycles
1	— if the overall hours worked in the month are 160 (in this case the worked hours/month corresponds to the constant), they correspond to a representative day of 480 minutes (160 hours really worked per year/20 worked day per month constant *60): **160 h really worked per month * 60/20 worked days per month constant = 480 min.**
2	— if the overall hours worked in the month are 80 (part-time job of 4 hours per day), they correspond to a representative day of 240 minutes: **80 h really worked per month * 60/20 worked days per year constant = 240 min**
	Representative day in a not predefined macro-cycle duration
1	— if the macro-cycle duration is 66 days, the constant days for that period is 44 days obtained through the following formula: **X:66 = 20:30 or 66 * 20/30 or 66 * 0,667** (from Table 5).
2	— now if the overall hours worked in this macro-cycle are 352 (44 days * 8 worked hours a day, that represents the worked hours in 66 days of macro cycle) it corresponds to the obtained constant and the representative day corresponds to 480 minutes: **352 h really worked * 60/44 worked days constant = 480 min**

The proportion of time that the homogeneous group spends on each manual task in the macro-cycle is the basis for estimating the time (in minutes) spent on each task in the artificial working day. Having in fact reconstruct the artificial working day and having the proportion of time that the homogeneous group spends on each manual task in the macro-cycle, it is easy to calculate the tasks duration in artificial minutes with which the final evaluations is made, using the suitably adapted calculation methods indicated previously for exposures with a daily rotation schedule.

B.3.7 Recalculation of intrinsic risk indicators according to the real task duration

To start with, it is necessary to define the general characteristics of the “typical working shift”:

— For the analysis of risk exposure to repetitive tasks it is necessary to estimate the overall shift duration, the number and duration of pauses, and the duration of non-repetitive tasks in order to obtain the "net duration of repetitive work" (necessary for obtaining the duration multiplier) and score for the distribution of recovery times (necessary for obtaining the recovery multiplier).

— In a multitask analysis, with a complex macro cycle, while all the tasks present (with the exception of a few auxiliary activities, to be excluded from the net-working time), have to be considered "repetitive" and therefore upper limbs activities to be analysed, not all such tasks also have manual lifting of loads. To study the risk of manual lifting, these tasks have to be extrapolated, in order to obtain the specific net duration of manual lifting and so the specific duration multiplier DM. The same for pushing-pulling activity.

— The analysis can be more or less detailed, depending on whether the period of time considered is a week/month or a year. In the first case data is required day by day, in the last one "typical or modal" shift can be considered representative of each month of the year.

Now all the intrinsic risk values obtained for each task (calculated on a constant of 8 hours and pre-established recoveries) can be corrected, considering the true duration of each task in the macro-cycle. Their correction occurs through the use of recovery and duration multipliers, obtained respectively from the organizational analysis of "typical working shift" and from the "artificial working day".

B.3.8 Application of the final formulas, used for daily rotations, to calculate the final risk index both for checklist OCRA and for NIOSH lifting index LI (MLI, CLI; VLI) and other risk assessment methods

B.3.8.1 General

Starting from the consideration that almost all the manual tasks that characterize a productive process are "repetitive for the upper extremities" (other occasional tasks are in fact considered as non-repetitive and excluded from consideration), it is not to be excluded that the same repetitive tasks may also involve manual handling of loads (where in fact the operators lift objects using the upper limbs) or awkward postures of the whole body (trunk and lower limbs). This implies that, in these latter cases, there is the need to apply both the analysis for the upper limbs and the analysis for different aspects of manual handling (or eventually awkward postures). The analysis follows the same general approach but also has slight differences when considering upper limbs repetitive movement or manual handling of loads, especially in the reconstruction of the corresponding artificial working day. These two aspects consequently are presented in the following subclauses.

B.3.8.2 Application of the final formulas, used for daily rotations, to calculate the final risk index both for checklist OCRA

To calculate the final risk exposure using the models and formula presented for daily rotations it is necessary to convert in "artificial minutes" both the total duration of manual tasks in the observed macro-cycle (artificial working day for repetitive movements representative of macro-cycle) and the duration of each task too, with a procedure that involves recalculating the intrinsic OCRA checklist scores, reflecting the actual organizational conditions in the homogeneous group, through both the real duration and recovery multiplier (Table B.1).

These data allow now, to compute the final synthetic risk exposure index. In analysing repetitive tasks with the OCRA checklist, the final synthetic exposure value can be calculated using two calculation models: "time-weighted average" and the new "MultiGEI" derived by the "multitask complex" model presented for used in daily rotation.

The following parameters are used for this purpose:

— Recovery multiplier: this value is derived from the organizational data describing the presence and distribution of breaks tasks in a typical or modal working shift.

— Total duration multiplier ($D_{m.tot}$): this value is derived from the overall duration of all the repetitive tasks considered in the "artificial working day representative of the macro-cycle"; it is calculated using the criteria reported in Table B.1. Different overall duration of all the manual lifting tasks and its specific total duration multiplier have to be calculated for tasks with manual lifting and for tasks with pushing-pulling.

Moreover, to complete the two formulae, the following parameters can also be considered:

— Partial duration multiplier (D_{mJ}): this value is derived from the individual duration of each single repetitive task (and separately from tasks with manual lifting and pushing/pulling) considered in the artificial working day; it is calculated using the criteria again in Table B.1.

— Fraction of time of each task (F_{TJ}): this value is the proportional (in %) duration of each single task in the artificial day for repetitive movements.

B.3.8.3 Application of the final formulas, used for daily rotations, to calculate the final risk index for NIOSH lifting index LI (MLI, CLI; VLI)

In essence, the same formula used, in a daily rotation, Formula (B.2), after appropriate adaptations that make it applicable to multitask evaluations with non-daily cycles, is used. In order to adapt the formula to multiday lifting tasks on a rotating schedule, it is necessary to:

— calculate $L_{I\ 1,2,3,....n\ eff}$ based on intrinsic lifting index L_I of each task (MLI or CLI or VLI, see B.3.4) considering the respective specific duration in minutes, derived from the specific "artificial day for manual lifting" (representative of the total duration of the only tasks with manual lifting present in the macro-cycle) and apply the respective duration multipliers according to the criteria in Table B.1;

— calculate $L_{I\ max1,2,3....n}$ based on intrinsic lifting index considering the total duration of all lifting tasks in the specific "artificial day for manual lifting" and apply the duration multipliers (for the total duration of all lifting tasks) according to the criteria in Table B.1;

— extrapolate from these data $L_{I.1\ eff}$ and $L_{I.1\ max}$, the worse lifting tasks, calculated respectively on the actual duration and on the total duration;

— the $F_{T\ 2,3,....n\ eff}$ used to calculate K consider the duration in % of each task (starting from the second worse manual lifting task) with respect to the total duration of all lifting tasks, less the duration of the first worse lifting task.

B.3.8.4 MultiGEI: multitask general exposure index

A new general formula: "multitask general exposure index" (MultiGEI), derived by "multitask complex" model was created. It allows to analyse all the different aspects of biomechanical overload and calculate the final exposure indexes in multitask analysis, in macro-cycles, for all the different risk factors

This new approach can be summarized as a more general formula, called the "MultiGEI" that can be used, starting from any exposure index suggested in the literature or from International Standards, for analysing various aspects of biomechanical overload (awkward postures, manual load handling including pushing and pulling, repetitive movements and strain of the upper limbs) in multitask analysis in macro-cycle.

The above approach can be applied also to the revised strain index[33],[34] the TACOS method,[23],[24] methods for assessing pushing and pulling actions as summarized in ISO 11228-2, and to many other methods that are of technical and application-related importance.

Formulae (B.6) and (B.7) are suggested:

$$\text{MultiGEI} = E_{I.1eff} + (\Delta E_{I.1} \times K) \tag{B.6}$$

$$K = ((E_{I.2\ max} \times F_{T.2}) + (E_{I.3\ max} \times F_{T.3}) + \ldots + (E_{I.j\ max} \times F_{Tj})) / E_{I1\ max} \tag{B.7}$$

where:

MultiGEI is the final risk value of the exposure index of the multiple rotating manual tasks, using the multitask complex approach.

$E_{I\cdot 1,2,3,\,j\ eff}$ is the score of all the active tasks, calculated considering D_{mj} (duration multiplier according to the effective duration of each relevant task$_s$ in the artificial working day.

$E_{I\cdot 1,2,3,\,j\ max}$ is the score of all the active tasks, calculated considering D_{mtot} (duration multiplier for the total duration of all relevant tasks in the artificial working day.

$E_{I.1\ eff}$ is the score of task1, the task with the highest risk score, calculated considering D_{m1} (duration multiplier according to the actual duration of task$_1$ in the artificial working day.

$E_{I1\ max}$ is the score of task1, the task with the highest risk score, calculated considering Dm_{tot} (duration multiplier for the total duration of all relevant tasks in the artificial working day.

$\Delta\ E_{I.1}$ $E_{I1\ max}$ - $E_{I1\ eff}$

F_{Tj} is the time fraction (between 0 and 1) of each task j – except task $_{1,}$ the worst task – with respect to total working time minus working time devoted to task1) in the artificial working day for that specific risk.

The calculation structure thus for OCRA method and RNLI for multiday rotations, can also be extended to other valuation methods however using the same duration multipliers reported in Table B.1.

It is also worth noting that in many cases, especially when repetitive task rotations take place in monthly and annual scenarios, analyses are generated for dozens of tasks that the homogeneous group performs in the period, each of which has an “artificial duration” of only few minutes. In such cases, and whenever there are more than 10 rotated tasks summarized in the artificial working day, it is recommended that tasks are grouped together with a similar final risk index score.

Given that the formula used is strongly supported by the task with a worse value, calculated with respect to its actual duration, having created six risk classes in which to group the analysed tasks, six representative tasks are displayed, each obtained from the sum of the times of the tasks present in each class and their representative risk. It thus become more significant also in relation to the application of the duration multipliers in Table B.1.

Although tasks can be grouped in various ways, grouping the results of the various tasks included in the artificial working day into six categories is recommended. Those six categories are determined according to the distribution of the individual exposure scores ($E_{I.j\ max}$) using preferentially the sextile distributions as key points for grouping (or in other terms the scores corresponding to the 16,6th, 33,3rd, 50th, 66,6th, and 83,3rd percentile of the score distribution). In any case, the original durations (in the artificial working day) of individual tasks are consequently grouped and accumulated in the six categories. Within each resulting category a representative score value is chosen; this value corresponds to the resulting time-weighted average score of all the tasks considered in that category.

This produces the representative score and cumulative duration of each category. With these two elements it is possible to apply the general Formula (B.6) to six exposure index categories, taking into account the duration multipliers indicated in Table B.1.

B.4 Conclusions

Starting from well-established methods for measuring biomechanical overload in repetitive and/or lifting tasks on a daily rotation schedule, the next step was to define and illustrate criteria and procedures for examining the risk of biomechanical overload due to exposure to multiple tasks with macro-cycle rotations of more than a day (e.g. weekly, monthly, yearly).

The “multitask complex” model is the preferred approach for calculating the overall exposure level. It is based on the duration of the most overloading task in the macro-cycle, increased by the contribution of the other tasks considered. This is a particularly useful model when there is variable exposure to different tasks and the tasks are not distributed evenly within the relevant macro-cycle.

The "time-weighted average" model remains suitable for daily rotation scenarios only when rotated repetitive tasks are frequently or even constantly alternated, while in multi-day rotation scenarios it will possibly still be suitable only where the rotated tasks are distributed evenly over the period under examination in terms of their level, duration and sequence.

A great deal of experience has already been acquired applying the OCRA checklist to assess exposure of the upper limbs to repetitive tasks, with regards not only to agriculture, but also to services such as supermarkets, cleaning jobs and canteens.

There is less experience in assessing multi-day exposure to manual lifting work.

Admittedly, it is still difficult to gather health care surveillance data for epidemiological purposes in the relevant sectors in order to validate the proposed models for analysing multi-day exposure.

Based on preliminary findings (involving about 300 people in the agri-food sector) nevertheless the "MultiGEI" method appears to be more predictive for annual exposure schedules covering at least 6 to 7 months.

In light of these considerations, it can be stressed that the proposed models can be considered useful for estimating exposure levels to various biomechanical overload conditions, when task rotations are scheduled over multi-day macro-cycles.

For the time being the present evaluation approahes cannot be considered as precise models for estimating the risk of adverse health effects, insofar as further epidemiological studies are required to verify the exact association between estimated exposure levels and consequent health effects.

It must be pointed out, however, that based on current understandings, considering that usually the risk value obtained with the "MultiGEI" formula is higher than that obtained with the "time-weighted average" formula, the presence of exposure risk (for health effects) can be confirmed when already the score obtained with the "time-weighted average" indicates the presence of risk.

Lastly, it appears obvious that the analyses proposed here are somewhat complex, especially as regards the collection of organizational data. However, exposure cannot be assessed without having some idea of which tasks, where, for how long and in what sequence a worker performs certain tasks. Consequently, if these aspects are complex, the analysis is necessarily complex too, but not impossible.

The procedures used to calculate the summary risks indicators presented here are undeniably difficult and, especially where the work entails numerous tasks, virtually impossible to manage manually. This is why a number of free downloadable spreadsheets have been made available and can help the user to collect the necessary organizational data and measure the "intrinsic" exposure level, while the final exposure values are generated automatically[64].

The calculations and images shown in the examples were in fact produced using these same spreadsheets.

B.5 Examples of evaluating the final risk in exposure to biomechanical overload

B.5.1 Introduction

The strictly methodological part is best illustrated with a real application that discloses the outcome of the exposure assessment under biomechanical overload conditions that change during the course of an entire year (the most complex scenario typical of many cultivation).

Winegrowing was studied in various parts of the year and of the world, which is why data are available for virtually all of the tasks involved in producing wine grapes. Table B.5 provides a short list, for reasons of space, only of the relevant macro-phases and phases. All highly specialized tasks were considered, also in relation to the type of vines: very low-growing, small, medium-to-tall and pergola/trellis systems. Over 60 tasks were found.

Before starting any evaluation, it is first necessary to calculate the "intrinsic risk score" for each task and for each different biomechanical risk factor typical of the task present in this kind of cultivation, e.g. repetitive tasks, lifting and carrying loads, pushing and pulling, and awkward postures of back and lower limbs. To calculate the intrinsic risk score of each task, exposure to all of the aforesaid factors, it has to be measured as if the task lasted a whole 480-min shift with two 10-min breaks and one meal break, i.e. the score for a pre-set constant duration. The intrinsic risk scores of each task therefore are calculated for examining repetitive movements with the OCRA checklist[22] and for lifting loads with the techniques derived from extensions of the RNLE[20] awkward postures with TACOS,[24] and other biomechanical risk factors like pushing-pulling.

Table B.5 — Jobs required to produce wine grapes, broken down by macro-phases, phases and number of tasks

Macro phases	Phases	Number of tasks
Vineyard maintenance	Soil preparation	1
	Maintenance supporting structure vineyard	3
	Fertilizing	2
	Vineyard tilling	2
	Treatments using tractor	3
	Planting and uprooting vines	5
	Manual irrigation, weeding and fertilization	5
	Lifting and carrying materials and tools	4
	Manual pushing and pulling	3
Vine maintenance	Dry pruning	6
	Mechanical pruning	1
	Tying and training in dry pruning	4
	Green pruning	4
	Green tying	2
	Thinning	4
	Manual lifting and carrying branches	2
Harvest	Manual grape picking	4
	Mechanical grape picking	1
	Transporting baskets	6

B.5.2 Risk assessment of repetitive movements using the OCRA checklist in annual multitask exposure

Table B.6 shows some examples of the intrinsic risk scores obtained using the OCRA checklist for several specific wine-growing tasks, calculated for both the right and left arm.

Once these organizational data have been acquired (e.g. a list of all possible tasks which characterizes a given cultivation) along with the relevant risk scores (i.e. intrinsic risk scores for repetitive movements using the OCRA checklist and RNLE for manual load lifting), it is possible to actually measure complex multi-task exposure in an annual cycle for the different biomechanical risks.

The first step is to divide the workers into "homogeneous exposure groups" in which exposure is classified as homogeneous when all the members perform the same tasks for the same length of time and in the same workplace.

Table B.7 shows the tasks performed by the first homogeneous group of 10 male workers, who work 12 months of the year preparing the vineyard, treating and pruning the vines, and harvesting the grapes.

The tasks are quantified on a monthly basis in percentages, where within each month, the sum of the percentages must always add up to 100 %.

However, simply quantifying each task in terms of its duration within the year is not sufficient because in the agricultural sector, the number of hours worked each month is not always the same. Much depends on the inherent characteristics of each crop, and on the presence of “quiet” times versus extremely busy times.

With regards to the first homogeneous group considered here, Figure B.6 shows the hours worked by the whole group each month, along with a calculation of the hours worked each month/worker performing repetitive work (excluding breaks and any other non-repetitive and ancillary tasks present in the shift).

The graphs in Figure B.3 depicts the levels of the work commitment with respect to a constant 160 h/month, indicated as 100 %.

With the final organizational information (Table B.8) it is possible to obtain the data relative to the organization of the most representative shift on a monthly basis (generally the one included in the work contract).

Based on this data a more or less accurate distribution of breaks can be worked out, which is useful for calculating the recovery multipliers for calculating the OCRA checklist, month by month, and over the whole year, and the ratio in percentages between the gross to net duration of repetitive work, for calculating the duration multipliers (for repetitive work).

It is now possible to obtain the hours actually spent performing each task per month and over the whole year (Table B.9). The data for the whole year is important because it summarizes how many hours were actually spent on each task, the corresponding percentage versus the total number of hours worked, as well as the percentage versus the predetermined constant of 1 760 h/year.

Table B.6 — Examples of intrinsic risk scores calculated with the OCRA checklist for some of the specific tasks in the vineyard (not exhaustive list)

Recovery multiplier	**Hours without recovery**	**Frequency**	**Force**	Side	Shoulder	Elbow	Wrist	Hand	Stereotype	**Posture total**	Additional	**Ocra checklist intrinsic value** (8 hours with canteen and two breaks of 10 min)		**Recovery multiplier**	**Hours without recovery**	**Frequency**	**Force**	Side	Shoulder	Elbow	Wrist	Hand	Stereotypy	**Posture total**	Additional	**Ocra checklist intrinsic value** (8 hours with canteen and two breaks of 10 min)
1,33	**4**	2,5	2	Right	0	0	0	0	1,5	1,5	1	**9,31**		**1,33**	**4**	1	2	Left	0	0	0	0	1,5	1,5	1	**7,32**
1,33	**4**	8	11	Right	2	3	6	7	3	10	2	**41,23**		**1,33**	**4**	2	11	Left	2	3	6	7	3	10	2	**33,25**
1,33	**4**	5	2	Right	4	2	2	4	3	7	2	**21,28**		**1,33**	**4**	2	2	Left	4	2	2	4	3	7	2	**17,29**
1,33	**4**	0	24	Right	8	2	0	6	1,5	9,5	2	**47,22**		**1,33**	**4**	2	24	Left	8	2	0	6	1,5	9,5	2	**49,88**
1,33	**4**	2,5	2	Right	0	0	0	0	1,5	1,5	1	**9,31**		**1,33**	**4**	1	2	Left	0	0	0	0	1,5	1,5	1	**7,32**
1,33	**4**	1	24	Right	6	3	0	0	1,5	7,5	2	**45,89**		**1,33**	**4**	2	24	Left	6	3	0	0	1,5	7,5	2	**47,22**
1,33	**4**	2,5	2	Right	0	0	0	0	1,5	1,5	1	**9,31**		**1,33**	**4**	1	2	Left	0	0	0	0	1,5	1,5	1	**7,32**
1,33	**4**	2,5	2	Right	0	0	0	0	1,5	1,5	1	**9,31**		**1,33**	**4**	1	2	Left	0	0	0	0	1,5	1,5	1	**7,32**
1,33	**4**	2,5	2	Right	0	0	0	0	1,5	1,5	1	**9,31**		**1,33**	**4**	1	2	Left	0	0	0	0	1,5	1,5	1	**7,32**
1,33	**4**	2,5	2	Right	0	0	0	0	1,5	1,5	1	**9,31**		**1,33**	**4**	1	2	Left	0	0	0	0	1,5	1,5	1	**7,32**
1,33	**4**	6	4	Right	2	2	4	2	1,5	5,5	1	**21,95**		**1,33**	**4**	1	4	Left	2	2	4	2	1,5	5,5	1	**15,30**
1,33	**4**	2,5	2	Right	0	0	0	0	1,5	1,5	1	**9,31**		**1,33**	**4**	1	2	Left	0	0	0	0	1,5	1,5	1	**7,32**
1,33	**4**	2,5	2	Right	0	0	0	0	1,5	1,5	1	**9,31**		**1,33**	**4**	1	2	Left	0	0	0	0	1,5	1,5	1	**7,32**
1,33	**4**	2,5	2	Right	0	0	0	0	1,5	1,5	1	**9,31**		**1,33**	**4**	1	0	Left	1	2	3	6	3	9	0	**13,30**
1,33	**4**	7	0	Right	0	0	0	0	3	3	0	**13,30**		**1,33**	**4**	0	0	Left	0	0	0	3,5	0	3,5	0	**4,66**
1,33	**4**	4,5	6	Right	1	0	2	0	3	5	0	**20,62**		**1,33**	**4**	0	6	Left	1	0	2	0	3	5	0	**14,63**
1,33	**4**	4,5	32	Right	1	0	2	0	3	5	0	**55,20**		**1,33**	**4**	0	32	Left	1	0	2	0	3	5	0	**49,21**
1,33	**4**	4,5	2	Right	2	3	2	0	3	6	0	**16,63**		**1,33**	**4**	0	0	Left	2	0	0	2	0	2	0	**2,66**
1,33	**4**	5	4	Right	8	2	2	0	3	11	0	**26,60**		**1,33**	**4**	0	0	Left	0	0	0	0	3	3	0	**3,99**
1,33	**4**	4,5	4	Right	0	0	3	0	3	6	2	**21,95**		**1,33**	**4**	2	4	Left	0	0	3	0	3	6	2	**18,62**
1,33	**4**	2,5	1	Right	1	0	0	0	1,5	2,5		**7,98**		**1,33**	**4**		1	Left	1	0	0	0	1,5	2,5		**4,66**
1,33	**4**	2,5	8	Right	1	0	0	0	1,5	2,5		**17,29**		**1,33**	**4**		8	Left	1	0	0	0	1,5	2,5		**13,97**
1,33	**4**	2,5	24	Right	1	0	0	0	1,5	2,5		**38,57**		**1,33**	**4**		24	Left	1	0	0	0	1,5	2,5		**35,25**

Table B.7 — Distribution of tasks in percentages for each month of the year, for the first homogeneous group

Tasks	Breakdown of the task duration for each month of the year											
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Preparation of trellises, posts, stakes and wires		11 %	10 %	10 %	1 %							
Maintenance (replacement) of trellis and wire stretching: with tools	20 %	11 %	1 %	16 %	1 %		1 %	1 %		1 %	3 %	1 %
Manual hoeing	4 %	8 %	2 %	1 %	3 %					1 %		
Tractor-mounted tilling driving tractor								1 %		4 %	4 %	
Mechanical irrigation: driving tractor	3 %	10 %	29 %	12 %	14 %	20 %	19 %	14 %		6 %	29 %	6 %
Treatment of vines with pesticides: driving tractor	2 %		2 %	8 %	4 %					2 %		4 %
Cutting and bundling mother-vines					17 %	15 %	20 %	19 %				
Mechanical planting: driving tractor	5 %	1 %								4 %		5 %
Mechanical planting (of seedlings into the ground)			5 %	12 %	15 %	5 %						1 %
Collection and manual transport of material or tools (weight 3 kg to 5kg)			2 %	4 %	6 %	2 %						
Collection and manual transport of material or tools (weight 6 kg to 10kg)					2 %	2 %	4 %	2 %				
Collection and manual transport of material or tools (weight more than 20 kg)	1 %									1 %		1 %
Manual pushing-pulling moderate force		1 %	1 %	2 %	1 %							
Dry pruning and removal of vine shoots (with manual, pneumatic and electric shears): low vines	63 %	51 %	23 %	1 %	8 %					15 %	64 %	83 %
Tying and dry training, cutting back: low vines		4 %	22 %	18 %								
Green pruning (suckering, disbudding, stripping, leaf thinning), tying, training and staking: low vines				13 %	26 %	54 %	56 %	41 %				
Collection and manual transport of material cut from vines (weight 3 kg to 5kg)	2 %	2 %	3 %	3 %	2 %	2 %						
Manual grape picking (cutting clusters): low vines								14 %	41 %	50 %		
Manually carrying full baskets at a time (5 kg to 8 kg)								7 %	59 %	15 %		
	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

Table B.8 — First homogeneous group: data relative to the organization of the most representative shift for each month, with a description of breaks and the calculation of recovery multipliers per month and for the whole year

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Shift net duration	**480**	**480**	**480**	**480**	**480**	**480**	**480**	**480**	**480**	**480**	**480**	**480**
No. pauses official and real (excluding lunch break)	2	2	2	2	2	2	2	2	2	2	2	2
Actual duration of pauses (excluding lunch break)	20	20	20	20	20	20	20	20	20	20	20	20
Duration lunch break if this inside the shift (paid	30	30	30	30	30	30	30	30	30	30	30	30
Non-repetitive tasks												
Putting on/taking off uniforms (protective gear)	30	30	30	30	30	30	30	30	30	30	30	30
Total minutes of non-repetitive tasks in shift	30	30	30	30	30	30	30	30	30	30	30	30
Net repetitive working time (in minutes)	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**	**400**
% reduction (net duration), considering the total duration of shift and of repetitive tasks	83	83	83	83	83	83	83	83	83	83	83	83
	"Recovery" scores											
Recovery multiplier per month	1,33	1,33	1,33	1,33	1,33	1,33	1,33	1,33	1,33	1,33	1,33	1,33
							1,33	**Average of recovery multiplier**				

Table B.9 — First homogeneous group: calculation of hours actually worked, broken down by task and month and over the whole year

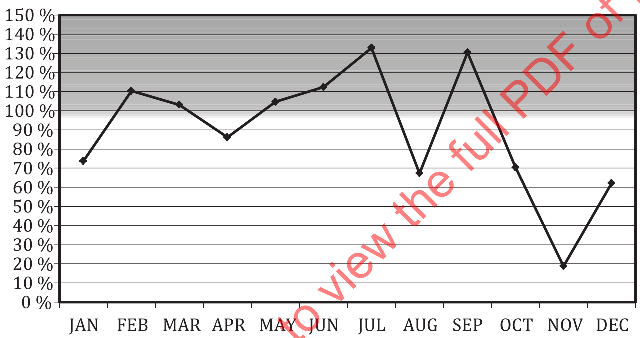
Tasks	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	% of total hours per year	Hours per year per task	% on a year constant
Preparation of trellises, posts, stakes and wires	0,0	19,4	16,5	13,8	1,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	**3,0 %**	**51**	**2,9 %**
Maintenance (replacement) of trellis and wire stretching: with tools	23,7	18,7	1,6	21,5	1,6	0,0	1,8	1,0	0,0	1,6	1,0	1,4	**4,3 %**	**74**	**4,2 %**
Manual hoeing	5,1	14,8	4,0	0,7	5,3	0,0	0,0	0,0	0,0	1,6	0,0	0,0	**1,8 %**	**32**	**1,8 %**
Tractor-mounted tilling driving tractor	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,7	0,0	4,6	1,1	0,0	**0,4 %**	**6**	**0,4 %**
Mechanical irrigation: driving tractor	3,5	18,5	48,0	16,8	23,3	35,8	41,3	15,4	0,0	6,8	8,6	5,6	**13,0 %**	**224**	**12,7 %**
Treatment of vines with pesticides: driving tractor	1,9	0,0	3,2	11,4	6,6	0,0	0,0	0,0	0,0	2,4	0,0	3,8	**1,7 %**	**29**	**1,7 %**
Cutting and bundling mother-vines	0,0	0,0	0,0	0,0	28,5	27,0	42,5	20,5	0,0	0,0	0,0	0,0	**6,9 %**	**118**	**6,7 %**
Mechanical planting: driving tractor	5,9	2,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	4,5	0,0	5,0	**1,0 %**	**18**	**1,0 %**
Mechanical planting (of seedlings into the ground)	0,0	0,0	8,2	16,5	25,1	9,0	0,0	0,0	0,0	0,0	0,0	0,8	**3,5 %**	**60**	**3,4 %**
Collection and manual transport of material or tools (weight 3 kg to 5kg)	0,0	0,0	3,3	5,5	10,0	3,6	0,0	0,0	0,0	0,0	0,0	0,0	**1,3 %**	**22**	**1,3 %**
Collection and manual transport of material or tools (weight 6 kg to 10 kg)	0,0	0,0	0,0	0,0	3,3	3,6	8,5	2,2	0,0	0,0	0,0	0,0	**1,0 %**	**18**	**1,0 %**
Collection and manual transport of material or tools (weight more than 20 kg)	1,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,1	0,0	1,0	**0,2 %**	**3**	**0,2 %**
Manual pushing-pulling moderate force	0,0	1,8	1,6	2,8	1,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	**0,5 %**	**8**	**0,4 %**
Dry pruning and removal of vine shoots (with manual, pneumatic and electric shears): low vines	74,3	90,0	37,9	1,6	12,8	0,0	0,0	0,0	0,0	16,4	19,4	82,2	**19,5 %**	**335**	**19,0 %**
Tying and dry training, cutting back: low vines	0,0	6,9	36,3	24,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	**4,0 %**	**68**	**3,9 %**
Green pruning (suckering, disbudding, stripping, leaf thinning), tying, training and staking: low vines	0,0	0,0	0,0	17,9	43,5	97,1	118,0	44,2	0,0	0,0	0,0	0,0	**18,7 %**	**321**	**18,2 %**

Table B.9 *(continued)*

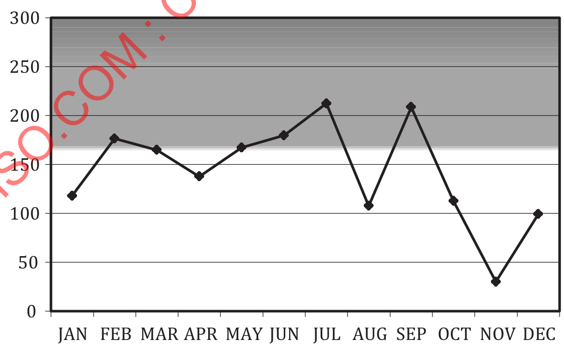
Tasks	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	% of total hours per year	Hours per year per task	% on a year constant
Collection and manual transport of material cut from vines (weight 3 kg to 5 kg)	2,4	3,5	4,9	4,1	3,3	3,6	0,0	0,0	0,0	0,0	0,0	0,0	**1,3 %**	**22**	**1,2 %**
Manual grape picking (cutting clusters): low vines	0,0	0,0	0,0	0,0	0,0	0,0	0,0	15,6	85,0	56,3	0,0	0,0	**9,2 %**	**157**	**8,9 %**
Manually carrying full baskets at a time (5 kg to 8 kg)	0,0	0,0	0,0	0,0	0,0	0,0	0,0	7,9	123,7	16,9	0,0	0,0	**8,7 %**	**148**	**8,4 %**
Total	118	176	166	137	167	180	212	107	209	112	30	100	**100 %**	**1715**	**97 %**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of total hours worked per month (by the whole group or individual worker) including any seasonal or casual workers	1 180	1 765	1 649	1 377	1 674	1 798	2 125	1 077	2 087	1 126	301	993
% reduction considering the total duration of shift and the net tasks duration	83 %	83 %	83 %	83 %	83 %	83 %	83 %	83 %	83 %	83 %	83 %	83 %
No., total hours worked per month/worker	118	177	165	138	167	180	213	108	209	113	30	99
No. net hours worked per month/worker	98,3	147,1	137,4	114,8	139,5	149,8	177,1	89,8	173,9	93,8	25,1	82,8
No. of workers versus total workers	10	10	10	10	10	10	10	10	10	10	10	10
No., of seasonal or casual workers												
Total working hours/worker/year	1715											
Constant working hours/worker/year	1760											

a) Total working hours per year/worker



b) % hours worked per month/worker based on costant of 160 hour/month



c) No. hours worked per worker/month/year

NOTE When 100 % of the constant is exceeded, the lines in the figures enter the grey colour.

Figure B.3 — Determination of hours of repetitive tasks performed by each member of the first homogeneous group during each month of the year with respect to the constant 160 h/month, indicated as 100 %

This organizational data forms the basis for constructing the "artificial working day representative of the year"; it is used to analyse multi-task exposure when the turnover cycle is annual. Table B.10 shows the first step needed to draft the intrinsic scores used to calculate the annual exposure score.

The duration of the “artificial working day representative of the year” is calculated based on 1 428 net hours worked/year, using Formula (B.8):

$$M_{\text{fwd}}=P \times H_{y/}\,C_{Dy} \times 60 \qquad \text{(B.8)}$$

where

M_{fwd} is “artificial working day” in minutes;

H_y is worked hours per year;

P is percentage of repetitive task duration versus total worked hours;

C_{Dy} is percentage of repetitive task duration versus total worked hours.

Table B.10 — First homogeneous group – Intrinsic risk scores calculated with the OCRA checklist and recalculated using the effective duration and recovery multipliers for the “artificial working day representative of the year”

Tasks	OCRA checklist intrinsic value (8 hours with canteen and two breaks of 10 min)		Worked hours considering their net duration	% on total	OCRA checklist intrinsic values re-evaluated considering their real duration	
Preparation of trellises, posts, stakes and wires	26,60	25,27	42,8	3 %	25,27	24,01
Maintenance (replacement) of trellis and wire stretching: with tools	21,28	21,28	61,6	4 %	20,22	20,22
Manual hoeing	45,89	45,89	26,3	2 %	43,59	43,59
Tractor-mounted tilling driving tractor	9,31	9,31	5,3	0 %	8,84	8,84
Mechanical irrigation: driving tractor	9,31	9,31	186,3	13 %	8,84	8,84
Treatment of vines with pesticides: driving tractor	9,31	9,31	24,4	2 %	8,84	8,84
Cutting and bundling mother-vines	21,95	21,95	98,7	7 %	20,85	20,85
Mechanical planting: driving tractor	9,31	9,31	14,8	1 %	8,84	8,84
Mechanical planting (of seedlings into the ground)	9,31	14,63	49,7	3 %	8,84	13,90
Collection and manual transport of material or tools (weight 3 kg to 5kg)	6,65	0,00	18,7	1 %	6,32	0,00
Collection and manual transport of material or tools (weight 6 kg to 10kg)	9,31	0,00	14,7	1 %	8,84	0,00
Collection and manual transport of material or tools (weight more than 20 kg)	35,91	0,00	2,7	0 %	34,11	0,00
Tasks with manual pushing-pulling moderate force	17,29	17,29	6,5	0 %	16,43	16,43
Dry pruning and removal of vine shoots (with manual, pneumatic and electric shears): low vines	22,61	8,65	278,9	20 %	21,48	8,21
Tying and dry training, cutting back: low vines	19,29	12,64	56,7	4 %	18,32	12,00
NOTE Considering the result of the intrinsic values of OCRA checklist, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk.						

Table B.10 *(continued)*

Tasks	OCRA checklist intrinsic value (8 hours with canteen and two breaks of 10 min)		Worked hours considering their net duration	% on total	OCRA checklist intrinsic values re-evaluated considering their real duration	
Green pruning (suckering, disbudding, stripping, leaf thinning), tying, training and staking: low vines	**17,29**	**14,63**	267,2	19 %	**16,43**	**13,90**
Collection and manual transport of material cut from vines (weight 3 kg to 5 kg)	**8,65**	**8,65**	18,3	1 %	**8,21**	**8,21**
Manual grape picking (cutting clusters):low vines	**15,96**	**12,64**	130,8	9 %	**15,16**	**12,00**
Manually collecting and carrying 1 or 2 baskets (5 kg to 8 kg)	**16,63**	**16,63**	123,7	9 %	**15,79**	**15,79**
	RIGHT	**LEFT**	1428	100 %	**RIGHT**	**LEFT**
Duration of artificial (fictitious) working day representative of the year (total hours/220*60)	**389,5**		**Duration multiplier**			**0,95**
NOTE Considering the result of the intrinsic values of OCRA checklist, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk.						

The duration of the repetitive work performed by the first homogeneous group during the "artificial working day representative of the year" is 389,5 min (1428/220*60), with a duration multiplier of 0,95 and an average recovery multiplier/year of 1,33 as indicated in Figure B.7.

These two multipliers are used to recalculate the intrinsic scores and adjust them in relation to the real duration and distribution of recovery times for the relevant homogeneous group.

The recalculation is performed by dividing the intrinsic risk scores of each task by the standard duration and standard recovery multipliers used to obtain the intrinsic risk scores (equal to 1 and 1,33, respectively) and re-multiplying them by the new multipliers describing the artificial working day/year.

Table B.10 shows each task with the starting intrinsic risk scores on the left column of the figure (for both the right and left arm, for each task performed by the first homogeneous group) and the corresponding scores on the right column of the figure, reformulated with the two new multipliers for the "total duration" of the artificial day representative of the year

The values are in this example lower, since the duration of the artificial day representative of the year is now 389,5 min with a duration multiplier of 0,95.

This data forms the basis for calculating the final OCRA checklist score using the time-weighted average model [Formula (B.1)].

To use the "MultiGEI" model [Formula B.6], the individual intrinsic risk scores for each individual task have still to be recalculated versus their "actual or effective duration". Therefore, the individual duration of each task in the artificial working day representative of the year has to be estimated, and consequently the corresponding duration multiplier for the "actual or effective duration".

By applying the percentage duration of each task in the year to the duration of the fictitious working day representative of the year (in minutes), it is possible to obtain the artificial duration in minutes of each task in the artificial working day; with this, the corresponding duration multiplier for each task for the effective duration can be found and thus the effective checklist risk score for each task recalculated on the basis of its effective duration (Table B.10).

Table B.11 — OCRA checklist scores recalculated on the basis of duration and recovery multipliers on the "artificial day representative of the year", for the total duration of tasks in the shift and for their individual actual duration in the shift for right limb

Tasks	Worked hours considering their net duration	% on total	OCRA checklist intrinsic values re-evaluated considering their real total duration	Artificial minutes for each task representative of the hours	Corresponding duration multiplier per tasks	OCRA checklist ocra values calculated considering the actual duration
Preparation of trellises, posts, stakes and wires	42,8	3 %	25,27	12	0,100	2,7
Maintenance (replacement) of trellis and wire stretching: with tools	61,6	4 %	20,22	17	0,200	4,3
Manual hoeing	26,3	2 %	43,59	7	0,050	2,3
Tractor-mounted tilling driving tractor	5,3	0 %	8,84	1	0,007	0,1
Mechanical irrigation: driving tractor	186,3	13 %	8,84	51	0,350	3,3
Treatment of vines with pesticides: driving tractor	24,4	2 %	8,84	7	0,050	0,5
Cutting and bundling mother-vines	98,7	7 %	20,85	27	0,200	4,4
Mechanical planting: driving tractor	14,8	1 %	8,84	4	0,050	0,5
Mechanical planting (of seedlings into the ground)	49,7	3 %	8,84	14	0,100	0,9
Collection and manual transport of material or tools (weight 3 kg to 5 kg)	18,7	1 %	6,32	5	0,050	0,3
Collection and manual transport of material or tools (weight 6 kg to 10 kg)	14,7	1 %	8,84	4	0,050	0,5
Collection and manual transport of material or tools (weight more than 20 kg)	2,7	0 %	34,11	1	0,007	0,3
Tasks with manual pushing-pulling moderate force	6,5	0 %	16,43	2	0,007	0,1
Dry pruning and removal of vine shoots (with manual, pneumatic and electric shears): low vines	278,9	20 %	21,48	76	0,500	11,3
Tying and dry training, cutting back: low vines	56,7	4 %	18,32	15	0,200	3,9
Green pruning (suckering, disbudding, stripping, leaf thinning), tying, training and staking: low vines	267,2	19 %	16,43	73	0,500	8,6
Collection and manual transport of material cut from vines (weight 3 kg to 5 kg)	18,3	1 %	8,21	5	0,050	0,4
Manual grape picking (cutting clusters):low vines	130,8	9 %	15,16	36	0,350	5,6
Manually collecting and carrying one or two baskets (5 kg to 8 kg)	123,7	9 %	15,79	34	0,350	5,8
	1 428	100 %	Right			

NOTE Considering the result of the intrinsic values of OCRA checklist, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk.

Table B.11 *(continued)*

Tasks	Worked hours considering their net duration	% on total	OCRA checklist intrinsic values re-evaluated considering their real total duration	Artificial minutes for each task representative of the hours	Corresponding duration multiplier per tasks	OCRA checklist ocra values calculated considering the actual duration
Duration of artificial (fictitious) working day representative of the year (total hours/220*60)	**389,46**			**Duration Multiplier**		**0,95**
NOTE Considering the result of the intrinsic values of OCRA checklist, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk.						

All the calculation elements of the “MultiGEI” [Formula (B.6)], are now available, i.e. (for the right limb):

— the score for the worst task ($E_{I\cdot 1\ eff}$), considering its actual duration = 11,3;

— the score for the worst task ($E_{I1\ max}$), considering overall duration = 43,5;

— the sum/product ($\sum_P$) of all the other maximum scores $E_{I\cdot,2,3,j\ max}$ for the various tasks, except for the worst one, for their % duration = 14,7;

$K = \sum_P / E_{I1\ max} = 0{,}34$;

$\text{MultiGEI} = E_{I\cdot 1\ eff} + (E_{I1\ max} - E_{I1\ max}) \times K = 22{,}19$

This calculation procedure was also applied to each month of the year, and always to both the right and left limb. Moreover, the calculation procedure for the whole year was also carried out by grouping the results of the various tasks into six categories of results, using as key values the “sextile” of the distribution of the results ($E_{I1\ max}$).

Figure B.4 presents all the results. As the OCRA checklist intrinsic risk scores for each task include both very high and very low figures, the “time-weighted average” mathematical model proposes the lowest final annual exposure indices (box C: “time-weighted average” = 15,8 right). It is interesting to note the difference between the results of the “MultiGEI” model calculated on all the scores for the individual tasks, and those obtained when the scores were first grouped into six categories per sextiles, within each of which the representative value was obtained, on which the final exposure value was calculated. As already mentioned, this second calculation model is preferable when there is a large number of tasks (more than 10).

Since the worst task, calculated on the basis of its duration, is the task driving the formula, if there are many active tasks, it is advisable to choose the “driving task” as the worst value derived by the six categories, rather than the value of a single task based on its actual duration, which determines either an over- or an underestimation. In the example, the calculation including all the tasks leads to a significant overestimation (box A: final exposure value = 22,9 right) compared to the value calculated for six aggregate categories of tasks (box B: final exposure value = 18,3 right). There is in fact only one peak value but of very short duration (on the artificial day, lasting only a few minutes) which, in this case, has an excessively powerful “driving” effect.

It is also worth noting that the OCRA checklist scores, divided into the six categories extrapolated from the sextiles, are distributed in percentage terms in each of the six predetermined risk areas, for the whole year and, again by sextile, in each month of the year (Table B.12).

Table B.13 and Figure B.5 show the assessment of exposure to repetitive movements of a second homogeneous group working on the farm: a homogeneous group of 10 seasonal pruners and harvesters. More specifically, Table B.13 shows the organization of the work carried out by these new 10 workers, present in this new homogeneous group, both qualitatively (what tasks and when) and quantitatively (how many hours worked per month). This second homogeneous group in fact works only 6 months and does only pruning and harvesting work.

Figure B.5 shows, for the second homogeneous group, the results of the analysis using the OCRA checklist, month by month and for the whole year, for both upper limbs. The results obtained using the different formulas are provided. It can be seen that the assessment carried out with the "time-weighted average" formula is always much lower. Conversely, the results obtained with the "MultiGEI" classic and with sextiles are identical (bearing in mind that there are only four tasks).

In this case, taking the shortest exposure duration, the annual "risk" level sits comfortably in the yellow zone. However, the exposure level calculated on the basis of each individual month is not to be overlooked, because for some the exposure level is close to the red.

For reasons of space, it is not possible to describe other homogeneous groups still working at the vineyard.

Some workers are also hired only one month a year for the grape harvest, and others carry out only maintenance work on the vines, including disinfecting and fertilizing the vineyards. Different groups of workers are also assigned to perform different tasks in different seasons, as is typical in agricultural settings. In order to accurately estimate overall exposure over longer periods, the use of the aforementioned assessment criteria is therefore essential.

Table B.12 — Percentage distribution of OCRA checklist risk scores, grouped into six levels of exposure, for the whole year and in each month of the year

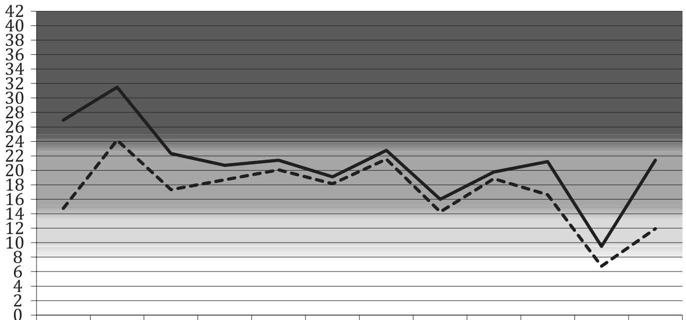
Jan		Feb		Mar		Apr		May	
Right		Right		Right		Right		Right	
37	5 %	**35**	19 %	**29**	12 %	**25**	11 %	**28**	12 %
19	63 %	**23**	51 %	**21**	24 %	**20**	17 %	**21**	18 %
18	20 %	**21**	15 %	**18**	23 %	**17**	33 %	**16**	27 %
8	10 %	**17**	1 %	**9**	36 %	**9**	33 %	**9**	35 %
0	0 %	**9**	12 %	**0**	0 %	**0**	0 %	**0**	0 %
7	2 %	**9**	2 %	**7**	5 %	**7**	7 %	**7**	8 %
Left		Left		Left		Left		Left	
22	24 %	**34**	19 %	**28**	12 %	**24**	11 %	**24**	21 %
8	10 %	**21**	11 %	**18**	2 %	**19**	18 %	**18**	2 %
0	0 %	**14**	5 %	**12**	27 %	**14**	25 %	**14**	41 %
0	0 %	**9**	12 %	**9**	31 %	**10**	39 %	**9**	18 %
7	65 %	**0**	0 %	**8**	26 %	**8**	4 %	**8**	10 %
0	1 %	**9**	53 %	**0**	2 %	**0**	4 %	**0**	8 %

Jun		July		Aug		Sep		Oct		Nov		Dec	
Right		Right		Right		Right		Right		Right		Right	
18	69 %	**26**	20 %	**19**	20 %	**20**	59 %	**36**	2 %	**11**	64 %	**19**	83 %
9	27 %	**26**	1 %	**15**	41 %	**0**	0 %	**19**	16 %	**11**	3 %	**18**	1 %
0	0 %	**21**	56 %	**14**	7 %	**0**	0 %	**14**	15 %	**0**	0 %	**8**	15 %
0	0 %	**0**	0 %	**14**	15 %	**0**	0 %	**12**	66 %	**5**	32 %	**0**	0 %
9	2 %	**11**	23 %	**8**	17 %	**0**	0 %	**0**	0 %	**0**	0 %	**0**	0 %
7	2 %	**0**	0 %	**0**	0 %	**19**	41 %	**0**	0 %	**0**	0 %	**0**	0 %
Left		Left		Left		Left		Left		Left		Left	
16	74 %	**26**	20 %	**19**	20 %	**20**	59 %	**29**	3 %	**11**	3 %	**16**	2 %
0	0 %	**26**	1 %	**14**	7 %	**0**	0 %	**12**	65 %	**5**	32 %	**8**	14 %
9	20 %	**18**	56 %	**12**	41 %	**0**	0 %	**8**	16 %	**0**	0 %	**0**	0 %
9	2 %	**0**	0 %	**11**	15 %	**0**	0 %	**0**	0 %	**0**	0 %	**0**	0 %
0	4 %	**11**	19 %	**8**	15 %	**0**	0 %	**0**	0 %	**0**	0 %	**7**	82 %
0	0 %	**0**	4 %	**0**	2 %	**15**	41 %	**7**	16 %	**4**	64 %	**0**	1 %

B.5.3 Evaluation of risk associated with manual load lifting in annual multitask

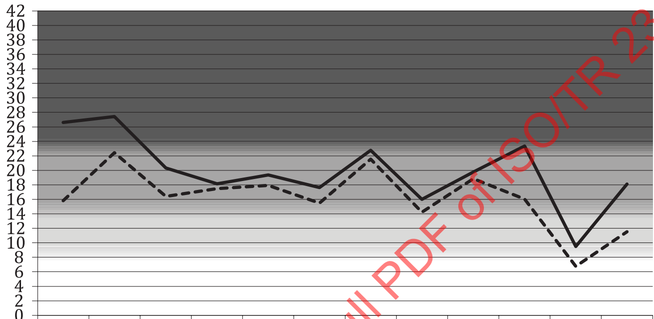
In order to complete the biomechanical overload analysis, the next step involves assessing the result of the exposure assessment in the presence of manual load lifting. The procedure is identical to the detailed analysis conducted for repetitive movements.

Table B.14 shows the intrinsic lifting index scores for tasks with manual lifting (A), present in viticulture, which are the starting point for the calculation. All tasks with manual lifting are defined according to the “key-enters” provided by ISO/TR 12295. Every single task analysed can be a mono task, a composite or a variable. Note that to calculate the intrinsic lifting index of each task, it is assumed to last the whole shift and therefore has always a long duration. All the intrinsic lifting index scores are broken down by gender and age, as recommended by ISO/TR 12295.



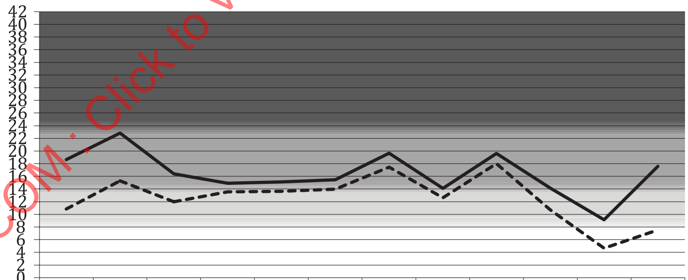
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RIGHT	27	31	22	21	21	19	23	16	20	21	9	21
LEFT	15	24	17	19	20	18	22	14	19	17	7	12

a) MultiGEI model: right 22,9; left 18



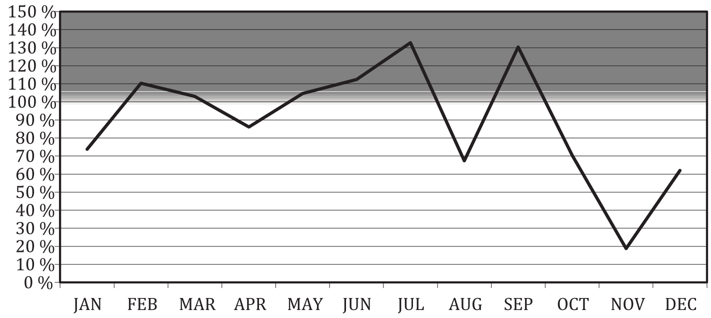
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RIGHT	27	27	20	18	19	18	23	16	20	23	9	18
LEFT	16	22	16	17	18	15	22	14	19	16	7	12

b) MultiGEI model for sextiles: right 18,3 left 17



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RIGHT	19	23	16	15	15	15	20	14	20	14	9	18
LEFT	11	15	12	14	14	14	17	13	18	11	5	8

c) Time-weighted average: right 15,8; left 13



d) Hours worked/month based on a constant

NOTE 1 Considering the result of the intrinsic values of OCRA checklist, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk (a,b,c).

NOTE 2 When 100 % of the constant is exceeded, the lines in the figures enter the grey colour (d).

Figure B.4 — Final OCRA checklist exposure index for the right and left limb, for each month of the year and for the whole year

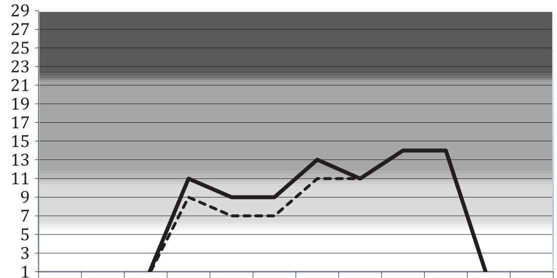
Table B.13 — Organizational data for the second homogeneous group: pruners/harvesters (a, b, c)

a – Description of working shifts representative of the month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. pauses actual duration equal or higher than 8 min (excluding lunch break)				2	2	2	2	2	2			
Actual duration of the pauses (minutes) (excluding lunch break)				20	20	20	20	20	20			
Duration (minutes) of lunch break if this inside the shift (paid)				30	30	30	30	30	30			
Total actual pause duration present in working time	0	0	0	50	50	50	50	50	50	0	0	0
Total minutes of non-repetitive tasks in shift	0	0	0	30	30	30	30	30	30	0	0	0
Net repetitive working time (in minutes)	0	0	0	400	400	400	400	400	400	0	0	0

b – Hours worked/month by the second homogeneous group Total working hours per year/worker	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of hours worked per month (by the whole group or individual worker) including any seasonal or casual workers				689	305	306	800	539	1044			
% reduction (net duration), considering the total duration of shift and the repetitive tasks duration	0 %	0 %	0 %	83 %	83 %	83 %	83 %	83 %	83 %	0 %	0 %	0 %
Total working hours/worker	736											

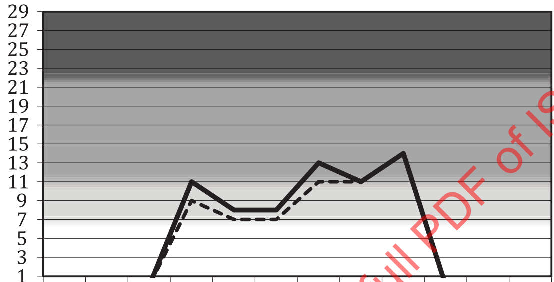
c – Tasks performed by the second homogeneous group with qualitative and quantitative time distribution over the various months of the year

All the repetitive tasks	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		% hours per year	No. Hours per year	% on con-stant
Green pruning (suckering, disbudding, stripping, leaf thinning), tying, training and staking: low vines				90 %	90 %	90 %	100 %							0	0	0	124	55	55	160	0	0	0	0	0		5,5 %	394	22,4 %
collection and manual transport of material cut from vines (weight 3 kg to 5 kg)				10 %	10 %	10 %								0	0	0	14	6	6	0	0	0	0	0	0		3,5 %	26	1,5 %
Manual grape picking (cutting clusters): low vines								70 %	70 %					0	0	0	0	0	0	0	75	146	0	0	0		30,1 %	221	12,6 %
Manually collecting and carrying one or two baskets (5 kg to 8 kg)								30 %	30 %					0	0	0	0	0	0	0	32	63	0	0	0		12,9 %	95	5,4 %
	0 %	0 %	0 %	100 %	100 %	100 %	100 %	100 %	100 %	0 %	0 %	0 %		0	0	0	138	61	61	160	108	209	0	0	0		100 %	736	42 %



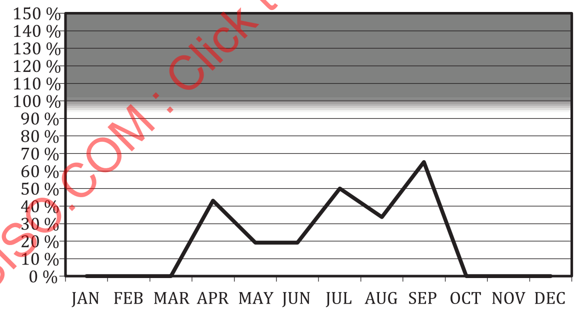
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RIGHT	0	0	0	11	9	9	13	11	14	14	0	0
LEFT	0	0	0	9	7	7	11	11	14	14	0	0

a) Second homogeneous group (6 months, working full-time 8 h/shift): MUltiGEI model: 8,4 (right side)



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RIGHT	0	0	0	11	8	8	13	11	14	0	0	0
LEFT	0	0	0	9	7	7	11	11	14	0	0	0

b) Second homogeneous group (6 months, full-time 8 h/shift): time-weighted average: 6,1 (right side)



c) % hours worked/month based on a constant

NOTE 1 Considering the result of the intrinsic values of OCRA checklist, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk (a,b).

NOTE 2 When 100 % of the constant is exceeded, the lines in the figures enter the grey colour in c).

Figure B.5 — Results of the monthly and yearly exposure analysis for the second homogeneous group of pruners and harvesters

Table B.14 — First homogeneous group: Intrinsic exposure scores (LI or CLI or VLI) for tasks with manual load lifting

List of tasks, present in viticulture, with manual lifting	Adult males	Adult females	Older and younger males	Older and younger females
Soil fertilization: unloading bags	3,0	3,8	3,8	5,0
Collection and manual transport of material or tools (weight 3 kg to 5kg)	0,85	1,06	1,06	1,42
Collection and manual transport of material or tools (weight 6 kg to 10kg)	1,00	1,25	1,25	1,67
Collection and manual transport of material or tools (weight 11 kg to 20 kg)	1,50	1,88	1,88	2,50
Collection and manual transport of material or tools (weight more than 20 kg)	2,00	2,50	2,50	3,33
Collection and manual transport of material cut from vines (weight 3 kg to 5 kg)	0,85	1,06	1,06	1,42
Collection and manual transport of material cut from vines (weight 6 kg to 8 kg)	1,20	1,50	1,50	2,00
Manually carrying full baskets at a time (5 kg to 8 kg)	1,20	1,50	1,50	2,00
Manually carrying full baskets at a time (5 kg to 8 kg) across the shoulders or on the head	1,20	1,50	1,50	2,00
Manually carrying full baskets at a time (9 kg to 16 kg)	1,80	2,25	2,25	3,00
Manually carrying full baskets at a time (9 kg to 16 kg) across the shoulders or on the head	1,80	2,25	2,25	3,00
Manually carrying full baskets at a time (more than16 kg)	2,00	2,50	2,50	3,33
Manually carrying full baskets at a time (more than16 kg) across the shoulders or on the head	2,00	2,50	2,50	3,33

Table B.15 shows organizational data for the first homogeneous group when assigned to handling loads.

While the repetitive movements (or the biomechanical upper limbs overload) are in any case present in all the task present in a cultivation (as for manual lifting, the upper limbs have to be used), the real number of manual lifting tasks (with positive "key-enters") and their real duration as lifting tasks in the macro-cycle has to be taken, in parallel, into due consideration.

For this reason, it is necessary to create a specific artificial intrinsic day for the manual lifting of loads, representative, in this example, of the year.

The tasks present in viticulture with manual lifting are 13 (Table B.14) but the active tasks that the first homogeneous group actually carries out during the year, with manual lifting, are only five, with a total duration of 178 net hours. This value corresponds to an "artificial representative day specific for manual lifting" of only 48 minutes of the year, where the corresponding duration multiplier is 0,350 (Table B.15).

Figure B.6 shows the results of the assessment of exposure to manual lifting for the first homogeneous group. The annual lifting index remains low, while in September and October (during the grape harvest), the exposure level shows significant peaks

B.5.4 Examples of task rotations in weekly/monthly macro-cycles

When turnover is weekly or monthly, the same criteria are applied for the year, i.e. the weekly or monthly rotation period (macro-cycle) is converted into an artificial day.

Table B.16 and Table B.17 illustrate the recommended structure for optimizing the collection of organizational data relating to the relevant homogeneous group.

Table B.16 shows the structure used to collect the shift duration and daily distribution data for each day of the week/month. These data are used to identify the net repetitive work time and thus the duration and recovery multipliers needed to apply the "MultiGEI" model for studying the biomechanical overload of the upper limbs.

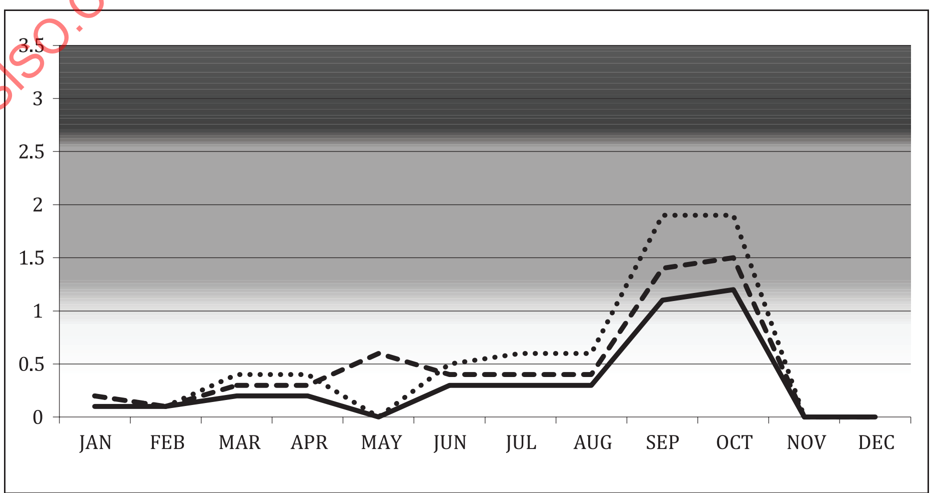
For reasons of space, Table B.17 presents a qualitative and quantitative description for only one week of the tasks actually carried out by the homogeneous group on each day of that week.

With this data it is possible to obtain the duration of each task in the period, whether it be weekly or monthly, and thus to reconstruct the "artificial working day representative of the period" under consideration.

Figure B.7 provides an example of the result with the scores indicating exposure to repetitive work for each day of the month, each week and for the whole month. The same kind of graph is also obtained for manual handling of loads and pushing/pulling.

Table B.15 — Organizational data for the first homogeneous group, when assigned to manual lifting of loads: which tasks, when they are performed, and their monthly and annual duration

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	% of total hours worked per year at mmh	Hours worked per year per task	Net hours worked per year per task	% on a year constant (1 760 work hours per year)
Collection and manual transport of material or tools (weight 3 kg to 5 kg)			3,3	5,5	10,0	3,6							10,5 %	22,4	19	1,3 %
Collection and manual transport of material or tools (weight 6 kg to 10 kg)					3,3	3,6	8,5	2,2					8,2 %	17,6	15	1,0 %
Collection and manual transport of material or tools (weight more than 20 kg)	1,2									1,1		1,0	1,5 %	3,3	3	0,2 %
Collection and manual transport of material cut from vines (weight 3 kg to 5 kg)	2,4	3,5	4,9	4,1	3,3	3,6							10,3 %	21,9	18	1,2 %
Manually carrying full baskets at a time (5 kg to 8 kg)								7,9	123,7	16,9			69,5 %	148,5	124	8,4 %
Artificial working day for manual lifting = 48 min. (178/220*60): duration multiplier = 0,350													100 %		178	



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Male	0.1	0.1	0.2	0.2	0.5	0.3	0.3	0.3	1.1	1.2	0	0.1
Female-older/younger male	0.2	0.1	0.3	0.3	0.6	0.4	0.4	0.4	1.4	1.5	0	0.1
Older/younger female	0.2	0.1	0.4	0.4	0.8	0.5	0.6	0.6	1.9	1.9	0	0.1

a) NIOSH manual lifting: distribution of risk indexes in different months of the year obtained using the MultiGEI model

0,73	Adult male (19-45 years old)
0,91	Adult female (19-45 years old)
0,91	Younger and older male (>45 years old)
1,22	Younger and older female (<19years old)

b) First homogeneous group/full-time

NOTE Considering the result of the intrinsic values of NIOSH method, the colours used mean: white = no risk; light grey: borderline risk; medium grey: risk present; dark grey = high risk.

Figure B.6 — First homogeneous group: final exposure levels for manual lifting tasks broken down by gender and age, monthly and annual

Table B.16 — Structure used to collect the shift duration and daily distribution data for each day of the week/month in order to identify the net repetitive work time

Shift 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shift 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shift 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mon	**Tue**	**Wen**	**Thu**	**Fri**	**Sat**	**Sun**	**Mon**	**Tue**	**Wen**	**Thu**	**Fri**	**Sat**	**Sun**	**Mon**	**Tue**	**Wen**	**Thu**	**Fri**	**Sat**	**Sun**	**Mon**	**Tue**	**Wen**	**Thu**	**Fri**	**Sat**	**Sun**
Shift duration (min)	180	240	240	360	420	420		180			240	420	480	240		240		240	420	480		180				420	480	180
No. of official breaks (without lunch)		0	0	1	0	0					0	0	0			0		0	0	0						0	0	
No. pauses actual duration equal or higher than 8 min (excluding lunch break)		1	1	1	2	2					1	2	2			1		1	2	2						2	2	
Actual duration of the pauses (minutes) (excluding lunch break)		10	10	20	20	20					10	20	20			10		10	20	20						20	20	
If the shift is not held consecutively because of breaks for change of working site (or for unpaid lunch break) mark the number of interruptions only if the duration equal or higher than half an hour					1	1						1	1						1	1						1	1	

Table B.17 — Qualitative and quantitative description of the tasks actually carried out by a homogeneous group on each day of that week

	Monday			Tuesday			Wednesday			Thursday			Friday			Saturday			Sunday		
Tasks	Shift 1	Shift 2	Shift 3	Shift 1	Shift 2	Shift 3	Shift 1	Shift 2	Shift 3	Shift 1	Shift 2	Shift 3	Shift 1	Shift 2	Shift 3	Shift 1	Shift 2	Shift 3	Shift 1	Shift 2	Shift 3
X	100 %			50 %			50 %			25 %			20 %			30 %					
Y				50 %			50 %			25 %						20 %					
Z													20 %			10 %					
K										25 %			30 %			10 %					
J										25 %			20 %			20 %					
H													20 %			10 %					
Total	100 %			100 %			100 %			100 %			100 %			100 %					