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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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National foreword

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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

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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).

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

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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.

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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).

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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).

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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/

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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).

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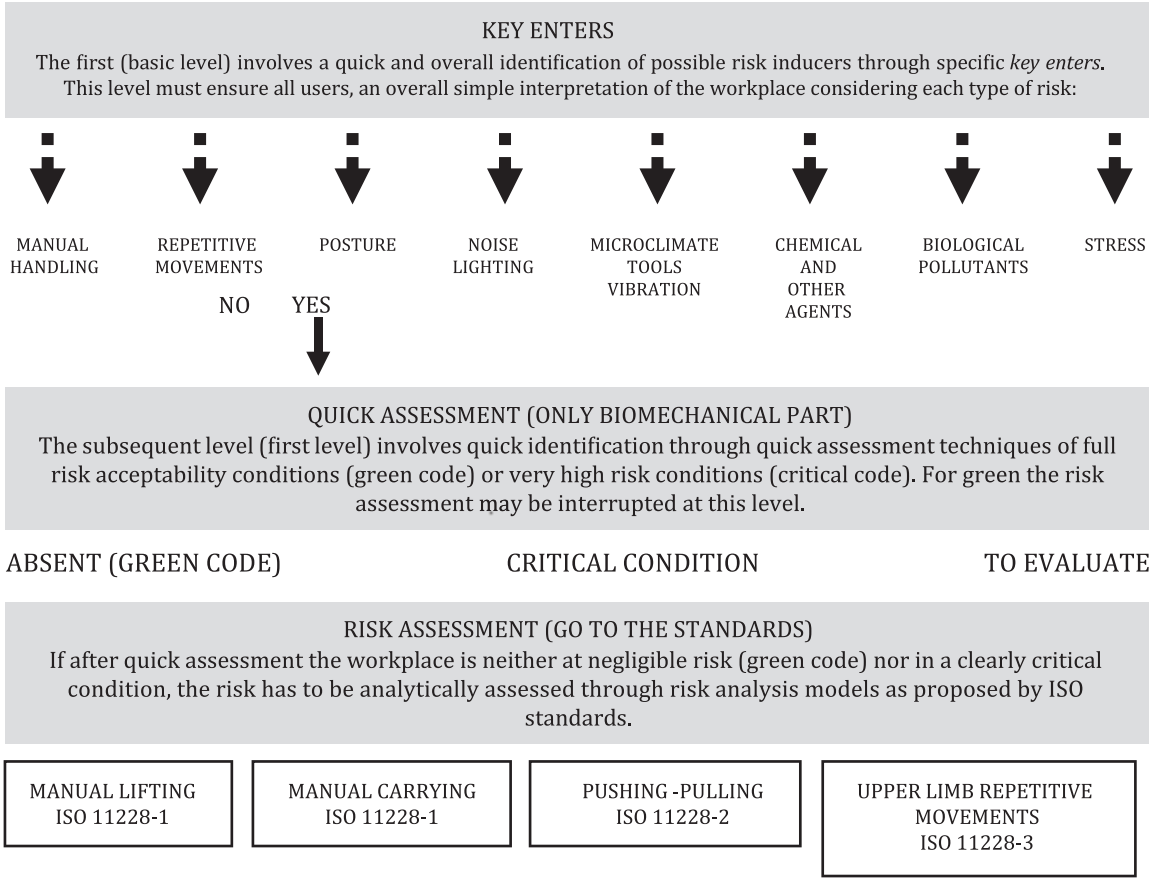

Figure 1 — Different risk assessment levels according to ISO/TR 12295 for biomechanical overload estimation

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

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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).

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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)

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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												

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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)												

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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 fertilizer												
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;

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— 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].

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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".

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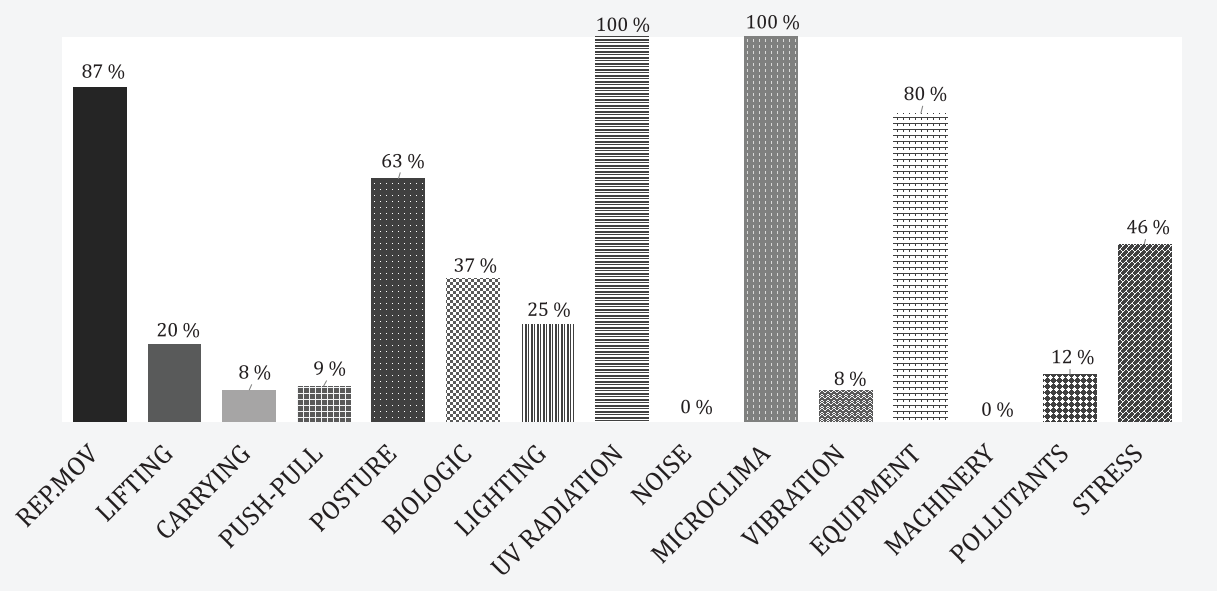
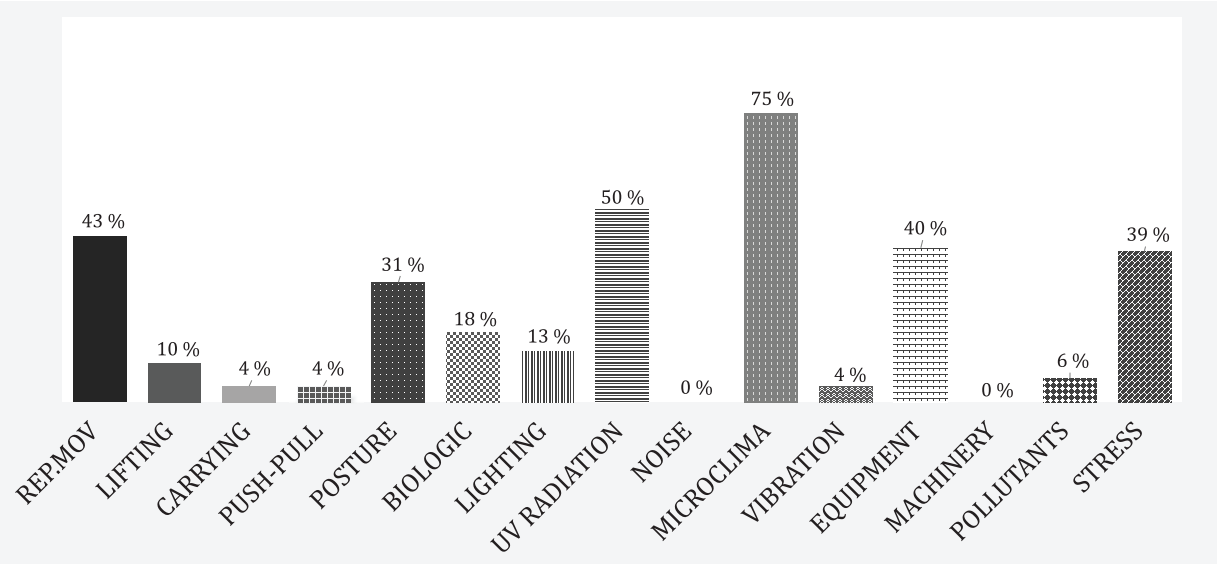


a) Homogeneous group 1 — full-time (data from Table 2)



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

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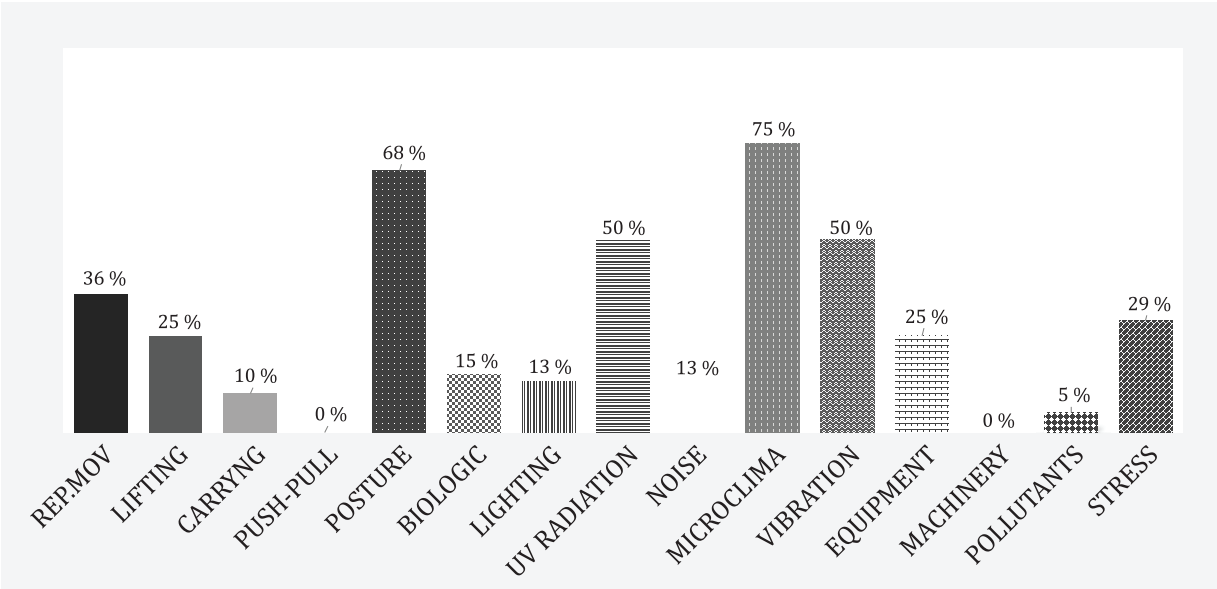

Figure 3 — Final summary of results, depicting histograms for all possible risks for homogeneous group 2 (see example in Table 3)

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

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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

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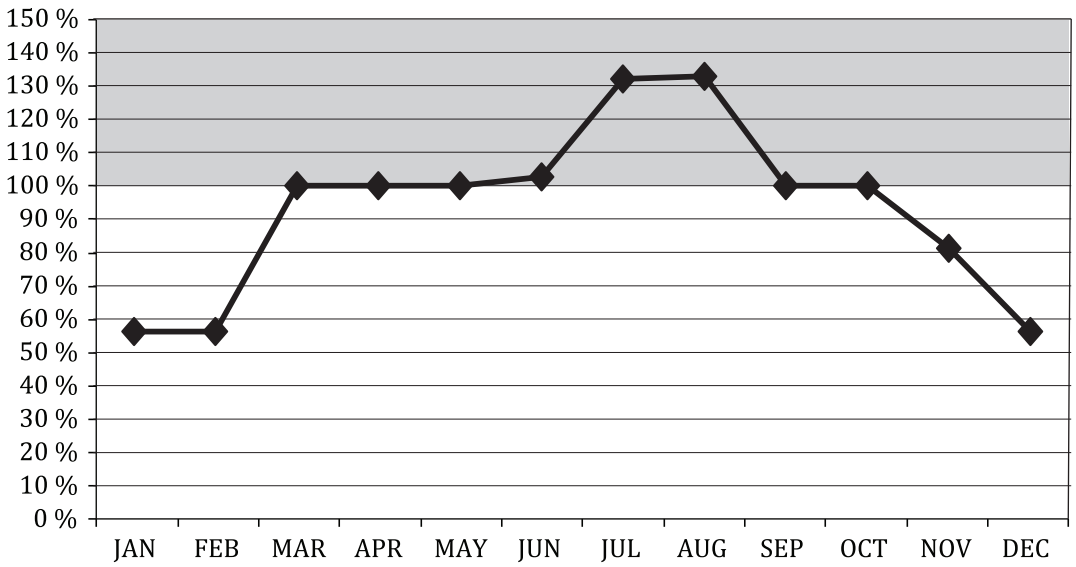
Table 6 *(continued)*

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

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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 %

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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).

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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

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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.

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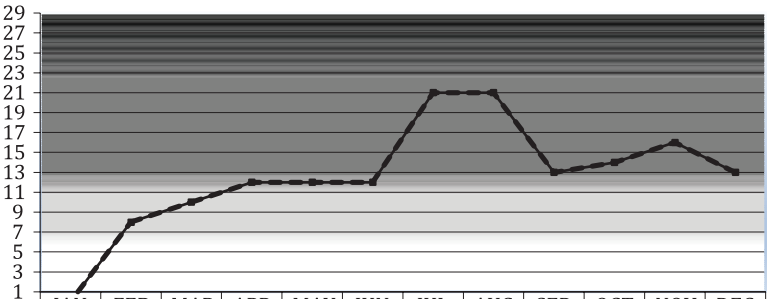
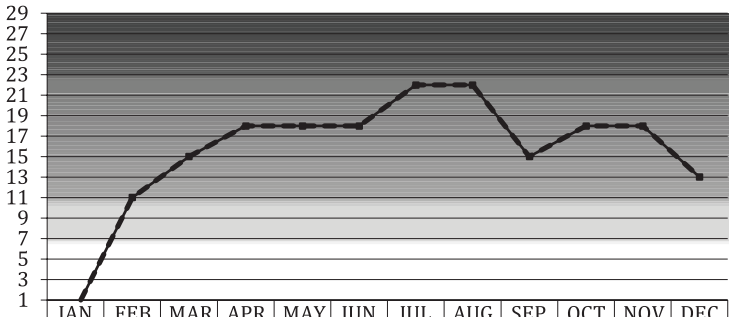
Figure 6 shows a scenario where a homogeneous group cultivates a crop for half the year but working very few hours and at very low risk for three out of the six months. The discrepancy between the scores obtained using the "time-weighted average" versus the "MultiGEI" is quite remarkable. The first formula 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.



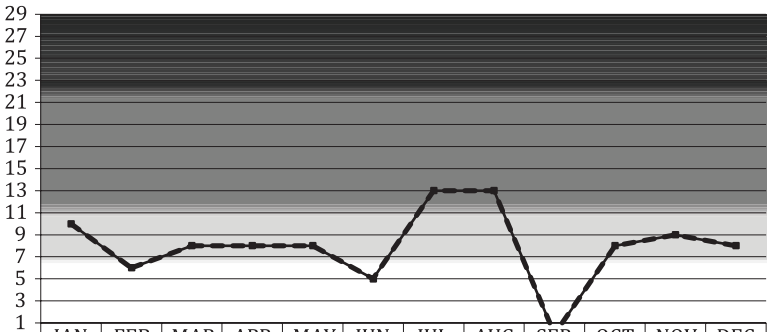
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RIGHT	0	8	10	12	12	12	21	21	13	14	16	13
LEFT	0	8	10	12	12	12	21	21	13	14	16	13

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)

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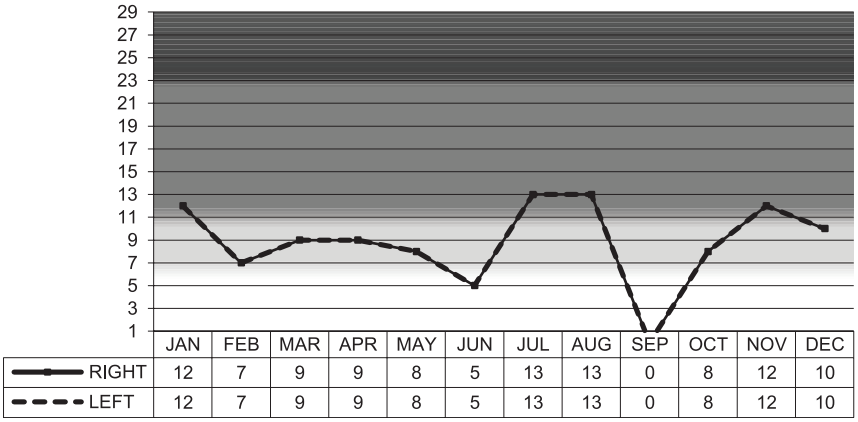

d) MultiGEI formula evaluation: Right 12,4 in homogeneous group 2 (11 months, working full-time – 7 h/shift)

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).

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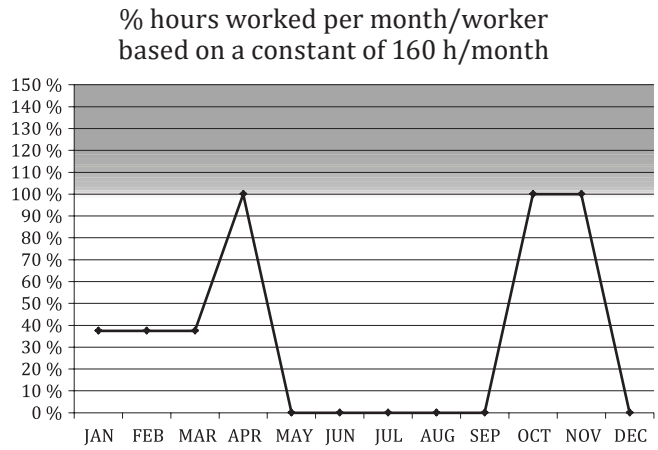
Distribution of hours/shift/worker performing different tasks each month of the year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Plowing (tractor)	0	0	0	0	0	0	0	0	0	0	0	0
Installing irrigation system	0	0	0	0	0	0	0	0	0			0
Planting (manual)	0	0	0	0	0	0	0	0	0	0	64	
Planting (mechanical)	0	0	0	0	0	0	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



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.

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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);

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— 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).

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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).

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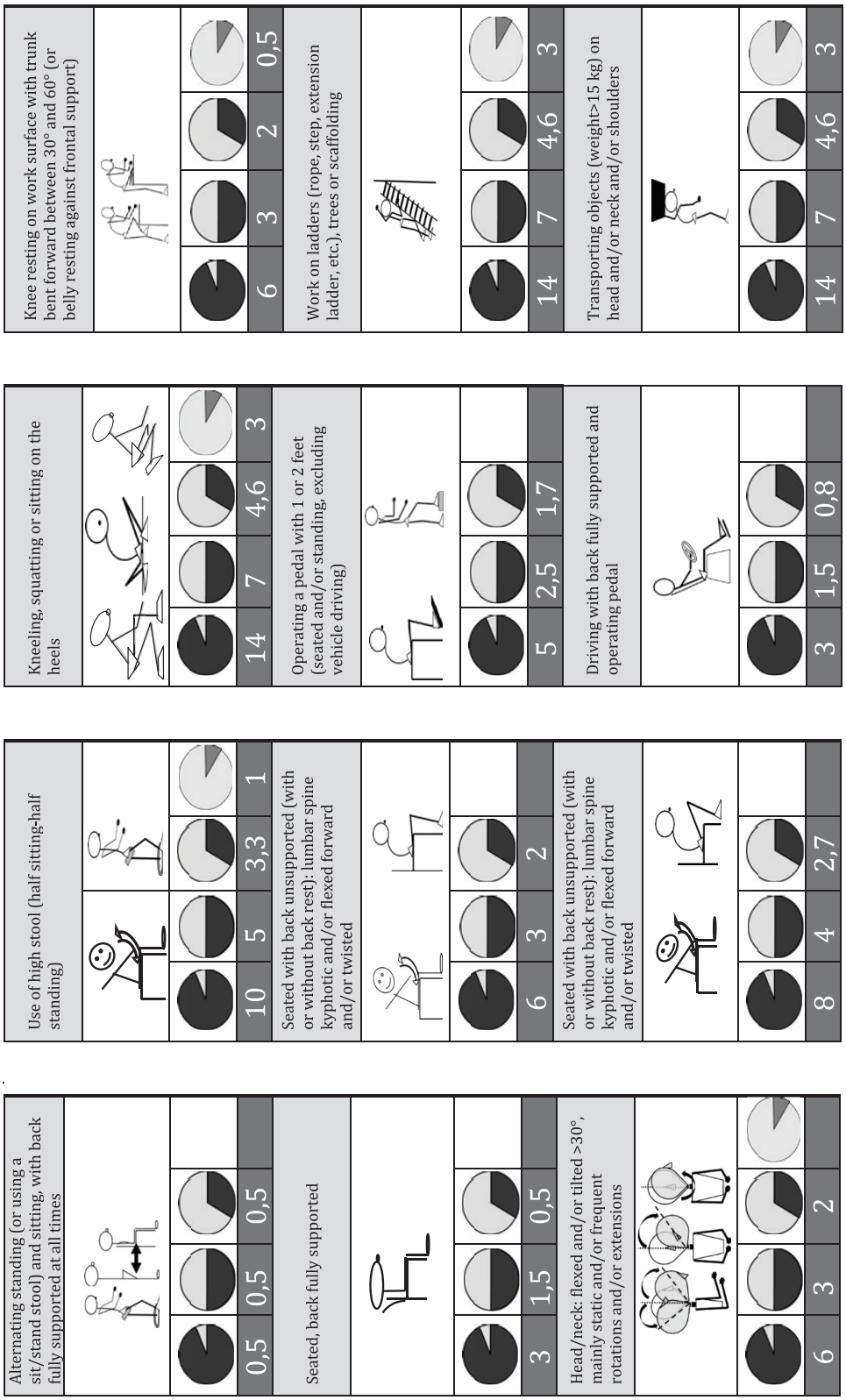

Figure 7 — Main postures analysed using the TACOS method, indicating pre-aggregated body postures and specific scores based on duration

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	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.

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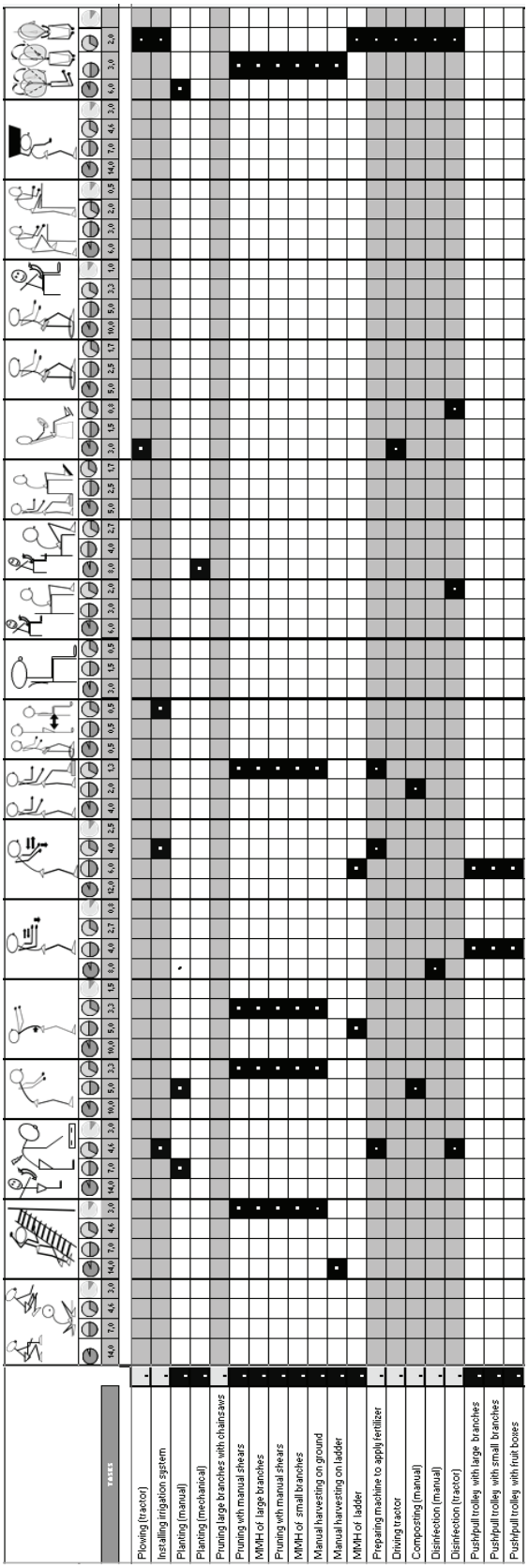

NOTE For estimation of exposure index, when a task is characterized by many postures, the sum, on horizontal lines, of the percentage duration has to always be equal to 100 %, except when there are awkward postures of the head and pedals are used.

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

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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).

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	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

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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.

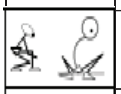
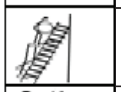
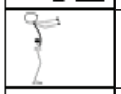
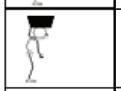
	Posture	Hours	% duration
	Kneeling, squatting or sitting on the heels	0	0 %
	Work on ladders (rope, step, extension ladder, etc.), trees or scaffolding	253	15 %
	Lumbar tract fully flexed (trunk flexed >60°) and/or trunk twisted	26	2 %
	Back in extension with upper limbs over the height of the head	311	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

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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]).

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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 %

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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.					

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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;

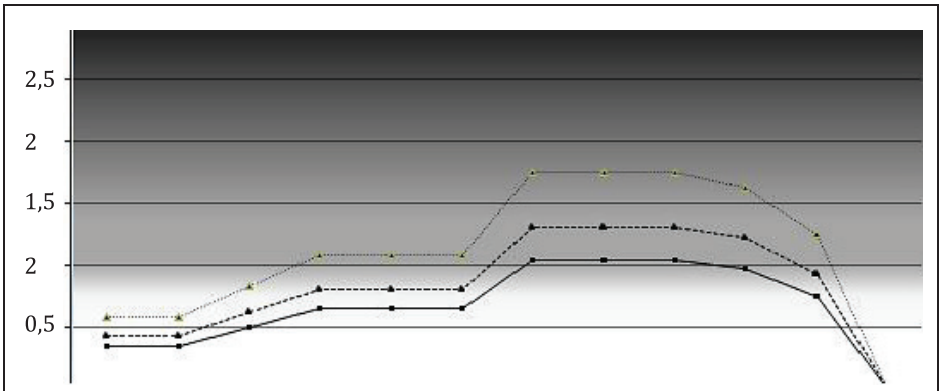
H_{My} is worked hours per year with manual lifting;

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)

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