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Reducing the Risk From Manual Handling of Loads in Agriculture: Proposal and Assessment of Easily Achievable Preventive Measures

Massimo Cecchini*, Andrea Colantoni, Danilo Monarca, Leonardo Longo, Simone Riccioni

University of Tuscia. DAFNE, Via San Camillo De Lellis, snc - 01100 Viterbo, Italy
cecchini@unitus.it

The link between musculoskeletal disorders (especially those affecting the bones, nerves, joints, muscles, tendons and blood vessels) and manual handling of loads, is nowadays worldwide recognized.
The related disease mainly concerns the alteration of the lumbar spine. Agricultural activities often involve the manual handling of loads and agricultural sector often shows indexes above the warning threshold. Factors such as the mass and size of the object being handled, working posture, the frequency and duration of manual handling can lead to a hazardous handling activity and correspond to the risk of musculoskeletal disorders.
There are several empirical methods for the risk assessment, but each one considers some variables omitting some other variables; so the combined effects due to the interaction of many variables are often underestimated. A risk assessment method taking into account a large number of variables is described in ISO 11228-1 standard. This method is in compliance with criteria laid down by Annex XXXIII of the Italian Legislative Decree n. 81/2008 (transposition of several European Directives including 90/269/EEC about manual handling of loads). The model integrates in a single spreadsheet, several evaluation methodological techniques. These allow the inclusion of multiplying factors, assessing the interaction with more boundary variables, and generating appropriate risk index weighted according to gender and age of those involved in manual handling of loads.
This research was conducted on a sample of 20 farms in central Italy, using the above cited risk assessment method. Moreover, appropriate methodologies were designed by authors to make a quantification of the efficiency and effectiveness made by the procedural and organizational redesign proposal, presenting concretely and economically feasible measures, useful in the short term.
The proposed improvements show a decreasing of risk index of about 59 %. The factor examined, whose absence contributes significantly to increase risk indexes, is the training, that, although present in only 27.3 % of the companies observed, show a risk reduction of approximately 12÷13 %. The measures which determine, in general, a risk reduction refer to the correct procedures for manual handling of loads (correct posture, objects handled with both limbs, objects handled in two or more persons, etc.): they can be easily feasible with a proper training of workers.

1. Introduction

“Manual handling of loads” (MHL) is defined as any transporting or supporting of a load, by one or more workers, including lifting, putting down, pushing, pulling, carrying or moving of a load, which, by reason of its characteristics or of unfavourable ergonomic conditions, involves a risk particularly of back injury to workers (90/269/EEC). The biomechanical overload can cause diseases to: bones, joints, muscles, tendons, nerves, blood vessels (Colombini et al., 2003). The agricultural sector is one of those most affected by this kind of risk: the environments in which workers operate, working times often imposed by the weather conditions and the increasing demands for seasonal non-specialized staff (Cecchini et al., 2013; Proto and Zimbalatti, 2010, 2015) are “competitors” to the possible onset of biomechanical overload pathologies especially of the lumbar spine section.

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The mere presence of the above mentioned factors makes it difficult to implement structural and organizational measures aimed at eliminating or reducing the risk of biomechanical overload diseases.

2. Materials and methods

Annex XXXIII of Italian Legislative Decree n. 81/2008, provides the reference elements that the employer should consider to perform a proper risk assessment. The references are divided into four sub-groups called: 1.specifications of the load; 2. required physical force; 3. characteristics of the working environment; 4. needing of related activity.
With regard to the characteristics of the load these aspects should be considered: the load is too heavy, unwieldy or difficult to grasp; it is unstable or has contents likely to shift, is placed in a position such that must be held or manipulated at a distance from the trunk or with a bending or twisting of the trunk; by mean of the external structure and / or consistency, can result in injury for workers, in particular in case of collision.
The diseases due to biomechanical overload may arise if the physical force: is excessive; can be only achieved by a twisting movement of the trunk; may result in a sudden movement of the load; is made with the body in an unstable position.
The characteristics of the work environment that can increase the risk are: an insufficient free space (in particular vertical) for carrying out the activity; the floor is uneven, thus presenting tripping hazards, or is slippery; the place or the working environment prevents the worker the manual handling of loads at a safe height or with good posture; the floor or the work surface has unevenness that involve the manipulation of the load at different levels; the floor or foot rest is unstable; the temperature, humidity or ventilation are inadequate.
The activities that may involve a risk due to biomechanical overload are: physical effort involving in particular the spine, too frequent or too long; insufficient breaks and physiological recovery periods; too long lifting, lowering or transportation distances; working rhythm imposed by a process which cannot be altered by the worker. The same Annex specifies that, in order to make a correct risk assessment, the employer should consider the individual risk factors of each potentially exposed person, in particular: physically unsuitability in carrying out the task, also taking into account the gender and age (maternity, childbirth, young age, old age, etc.); inadequate clothing, footwear or other worn by the worker; adequate knowledge and training.
Legislative Decree 81/08 refers to ISO 11228 standards as "benchmarks" to operate a proper risk assessment, and also to design effective prevention and protection measures in order to eliminate or reduce this risk. The reference values of the object's mass for non-repetitive manual lifting in ideal conditions are defined by ISO 11228. This standard can be applied for objects with a mass equal or greater than 3 kilograms, and provides: a) reference values (also for occasional lifting - Waters et al., 2016); b) limit values for lifting under ideal conditions according to the single frequency / duration; c) criteria for evaluating transportation actions. Taking into account gender and age differences, some uncertainties of ISO 11228-1 table in the range of values related to the feminine gender, young workers and elderly, considering the tables of EN 1005-2 and the data in literature, the limits indicated in Table 1 have been proposed.

Table 1: Maximum mass limits lifted by gender and age (Occhipinti, 2008)

Working population		m_{ref} (kg)
Male	18 ÷ 45 years	25
Female	18 ÷ 45 years	20
Male	< 18 years and > 45 years	20
Female	< 18 years and > 45 years	15

In the observed companies, for the MHL risk assessment the Microsoft Excel model for composite tasks and variables provided by EPM - Research Unit ergonomics of posture and movement called "ERGOepm_CLV-VLI_ita_v2 (06.12.26)" was used (EPM, 2017). This model makes it possible a risk assessment by providing risk indexes (RI) in accordance with the requirements of NIOSH method (NIOSH, 1997) and as established in the technical standards EN 1005-2 and ISO 11228-1.
Depending on the score obtained for each worker (or group of workers) investigated, prevention and protection measures have to be activated: RI <0.85 no action required; RI 0.86 ÷ 1.00 level of attention (information); RI > 1.01 presence of risk (interventions to reduce the risk, education, health surveillance).
In addition to the value of lifting indexes the model associates the RI with a color: green - risk below the threshold; yellow - values close to attention limits; red - presence of risk; purple - high presence of risk.
The observations, made by means of appropriate farm inspections, were carried out during the second half of 2014 on a sample of 20 farms in central Italy.

During the investigation, the fundamental data considered for proper risk assessment, as required by the technical standards, and additional information in order to operate on time considerations on the efficiency and effectiveness of proposed preventive measures were detected. The data required for MHL risk assessment were: 1. age and sex of the workers: sex and age are fundamental data considered in the process of risk assessment; 2. performed tasks: this information is also useful for testing whether a set of workers can be classified as a homogenous group (a group of people who perform the same task by moving the same number of objects in the same mass class); 3. weekly working hours including breaks (for rest, meals and other physiological events): such information is essential for the estimation of risk ratings because they affect the lifting frequency; 4. number of raised objects, mass class and number of lifts performed for each object (normally and occasionally handled): this indication is necessary in order to determine the cumulative mass raised by the worker or by homogeneous group of workers; 5. regarding the moved objects, it was also determined which were raised by more than one worker and which were raised using only one limb; 6. lift time spent on each mass class including any transportation by mechanical means: this parameter, such as pauses and stops, affects the lifting frequency; 7. gripper and lifting height of the object storage during various stages: these data affect the defined vertical displacement factor; 8. distance of the object from the body and torso rotation during handling phases: even these factors are multiplicative risk indices respectively since they both contribute to the increasing of the horizontal displacement and asymmetry angle.
At the aim of allowing the feedback on the effectiveness of proposed preventive measures, the following data were evaluated: a) presence of proper training in line with the provisions of the Italian Legislative Decree 81/08; this parameter is very important for the correction of postural attitudes in the MHL operations; b) response to the questions mentioned by only employer or in cooperation with the worker; this aspect is useful to highlight any differences in assessment and to consider how they may affect the final result; c) presence of internal or external prevention and protection service manager (PPSM); this parameter is put in relation with the risk indexes of each farm in order to evaluate any differences between the two situations; d) the presence or absence of the workers' representative for safety (WRS) inside the farm: this factor, as the previous one, aims to highlight if and how much WRS influences the risk assessment.

2.1 Aims

The data on the evolution of reported occupational diseases in Italy show an increasing common to all activities including agriculture. The age group that includes a greater number of cases of disease is between 50 and 64 years followed from that between 35 and 49 (except for the year 2012); the least affected class is that between 18 and 34, followed by 65 years and over (except for the year 2012) (Table 2). Table 2 also shows the data related to occupational diseases by age, filtered to central Italy since the studies that will be presented in subsequent chapters of this work have been carried out on a sample of farms in central Italy.

Table 2: Trend of occupational disease reported by age group and year in Italy and central Italy (INAIL)

Age group (years)	Italy					Central Italy				
	Year of event									
	2009	2010	2011	2012	2013	2009	2010	2011	2012	2013
18 ÷ 34	88	162	164	119	122	17	33	32	22	19
35 ÷ 49	1,005	1,532	1,799	1,666	1,777	148	239	293	258	317
50 ÷ 64	2,220	3,583	4,398	4,250	5,267	392	655	907	914	1,082
65 and over	615	1,112	1,613	1,714	2,328	166	284	469	500	718
Total	3,928	6,389	7,974	7,749	9,494	723	1,211	1,701	1,694	2,136

Compared with the national trend, the data relating to the central regions show different trends. The most affected age group is always from 50 to 64 years followed by over 65, while workers between 35 and 49 years appear to be the second lowest (Table 2). No difference however, was found with worker group ranging from 18 to 34 years.
As it regards the trend of complaints of occupational diseases in agriculture in central Italy, it should be emphasized that, in the same years, the percentage of herniated disk on the total is decreasing (from 16.6 to 13.4 %) while the percentage of diseases of the upper limbs due to biomechanical overload is increasing (from 40.3 to 40.5 of the total) (data from the online statistical database INAIL).
The current provisions require employers not only to assess the risks faced by workers, but also to look for solutions able to eliminate risks at source or, where this is not applicable, minimize them with proper and targeted implementation of preventive and protective measures. Research purpose was to make a thorough investigation, based on interviews and on-site observations, on the working methods used by workers, especially during operations involving the manual handling of loads higher than 3 kg.

This assessment has not been operated for the sole purpose of discovering possible problems in the obtained risk indexes, but especially in order to propose a suitable redesign of procedural and organizational measures aimed at reduction of risk ratings also trying to assess their efficiency and effectiveness. The proposed measures which determine in general a reduction of risk ratings, as the correct handling procedures (postures, lifting objects with both the limbs, handling of objects in two or more persons, etc.) can be easily feasible with proper training. To assess how the designed preventive measures (optimized) have acted on the initial risk, the ratio of the post optimization average risk index, and risk mean index before optimization is calculated. The result is the percentage of risk reduction. As an example: the initial average risk index is 1.98; optimized is 1.35; to estimate risk reduction compared to baseline, you apply the following formula: (1.35 / 1.98) * 100 = 68.18 %. Thus obtained value indicates that, with the optimization measures, the risk is reduced to 68.18 % compared to the initial one. The efficiency of the optimization measures can be calculated as a percentage by subtracting at 100 the value obtained in percent; example 100 - 68.18 = 31.82 %. Thus obtained percentage value indicates how the proposed optimizations are potentially capable of reducing the risk indexes. By these efficiency values, it was possible to estimate how certain factors such as training, the presence of some figures in the company (internal PPSM, WRS, etc.) are effective in the overall risk reduction of MHL.

3. Results

The data processing has identified a first overall analysis of the same, highlighting the differences between the risk values obtained by applying the European standard EN 1005-2, the ISO standard 11228-1, and the National Institute for Occupational Safety and Health equation (NIOSH, 1994, 1997, Ergonomics Plus, 2016). Data were acquired previously and after the application of organizational and structural prevention measures.
Moreover the research focused on a more detailed analysis about the influence on the detected risk indexes of some aspects such as the presence or absence of training, the presence of internal or external prevention and protection service manager, the presence of internal WRS, etc. on measured risk values.
Figure 1 shows the results of a first general analysis that compares the change in risk between assessed actual conditions and estimated conditions after the application of the proposed prevention measures. We notice that these improvements could potentially lead to a reduction of risk ratings: the average RI values (RI_{av}) after application of the suggested measures appear to be of 59 % of the initial risk values.

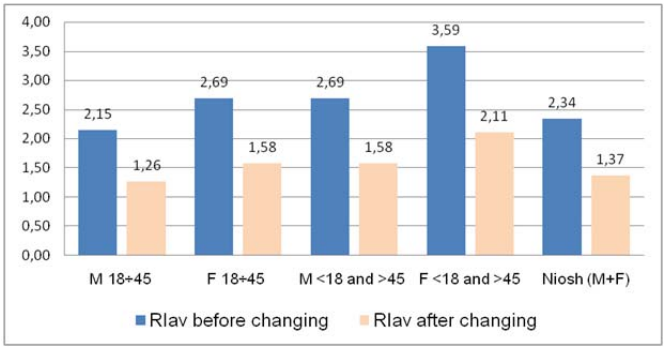

Figure 1: Risk reduction after the proposed prevention measures (M = male; F = female)

With regard to training Figure 2 shows that, in farms where it is still absent or not is carried out as required by law, there is an increasing risk (average about 12 %). We emphasize that companies where training is done are 27.3 % of the sample. The figure also compares the risk indexes of farms in which the employer is the prevention and protection service manager (PPSM) (23.8 % of the sample) and farms where this task is carried out by an external technician. In this last case we observe an increased risk (+ 20 %).
Regarding the persons interviewed for the acquisition of the necessary data for the risk assessment, it was considered whether the assessment had been involved only the employer (68.2 % of the sample) or at least one worker. The analysis shows that if the worker participates in the data collection, the average value of RI increases by 36÷37 % compared to the value associated with the assessment done by the employer alone (Figure 3). Moreover, in farms where there is a WRS (13.6 % of the sample) the analysis shows an increasing of assessed risk indexes of 21÷22 % compared to farms without a WRS (Figure 3).
Other research findings show that the risk indexes are greatest for workers under 45 years age (on average +36÷37 %). In addition, in farms with no female staff the value of risk ratings increased on average by 33 %.
Table 3 shows the results in terms of effectiveness of designed technical and procedural preventive measures, in relation to different aspects.

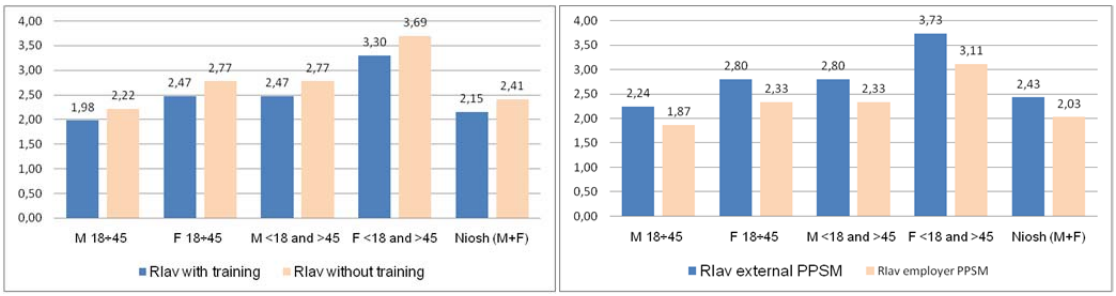

Figure 2: Comparing risk indexes among farms with properly trained workers and not (left) and in farms where employer is the PPS manager and farms with external PPS manager (right)

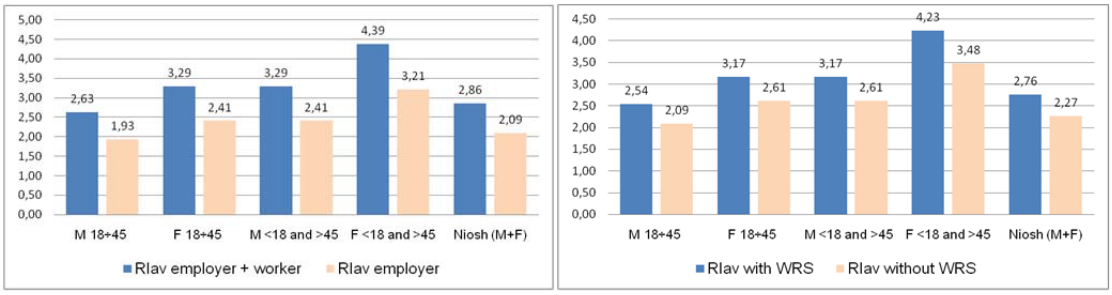

Figure 3: RI_{av} in case of risk assessment done by employer or by employer and workers (left) and in farms with and without WRS (right)

Table 3: Estimated effectiveness based on the presence of previously analyzed factors and figures

Situation	M 18÷45	F 18÷45	M <18 and >45	F <18 and >45	Niosh (M+F)
Training done	12.78 %	13.23 %	13.23 %	12.93 %	12.77 %
Employer is the PPSM	4.44 %	4.73 %	4.73 %	5.01 %	4.46 %
Worker participation in risk assessment	7.67 %	8.03 %	8.03 %	8.24 %	8.35 %
Presence of a WRS	5.10 %	5.55 %	5.55 %	5.07 %	4.89 %

4. Conclusions

The proposed prevention measures are meant to reduce the risk indexes obtained in order to protect workers from the onset of occupational accidents and diseases. The efficiency of the proposed improvements is accounted for a decrease in observed average risk by about 59 %. Some factors whose absence significantly contributes to the increase of risk ratings were observed in more depth. The first factor examined was the presence of training, that though it is present only in 27.27 % of observed farms, showed a reduction in risk of approximately 12÷13 %. It is believed that the information and formation affect in a direct manner on risk reduction as regards especially the postural attitude (bending of the legs, twisting of the torso, etc.) and also the use of both the limbs or the lifting of bulky or too heavy objects in more than one people. The comparison between the obtained indexes before and after the optimizations, comparatively among the farms with relevant training done and those still deprived of training, pointed out that the efficiency of operations in the first type of farms is approximately 31 %, while in farms with no training the influence of the optimizations is around 44 %. Absolutely worrying and not negligible is the absence of training in over 70 % of cases, since this is considered an effective prevention measure, for this and other kinds of risks.

The second controlled factor showed an increase of risk ratings of about 20 % in the farms where the external PPSM is present, circumstance presented in over 70 % of cases. The efficiency of the interventions was greater in such circumstances, amounting to approximately 42.5 % compared to the efficiency estimated in the farms where the tasks of PPSM are done by employer (in this case the efficiency is about 38 % and the effectiveness about 5 %). This data can be explained by the fact that the employer who take on the PPSM duties has a better perception of risk as by law he has to follow specific training courses. He better knows

about the law, the obligations and penalties, and tends to apply the rule with greater attention. In addition, in most of the studied farms with external PPSM, the employer does not participate in farm work operations as he generally performs other profession. This condition leads him to have little understanding of the processes, but also a reduced risk perception and less supervision on workers behavior.
The participation of workers in MHL risk assessment (condition detected in 32 % of cases) shows risk indexes increased by 36÷37 % compared to the status of worker not involved. The efficiency of optimization is higher in farms where the worker participated in the MHL risk assessment (46 %) as opposed to farms where the assessment is done only by employer (about 38 %). The estimated efficacy in the evaluation carried out without worker participation is about 8 %. This figure can be explained by the lack of training in more than 70 % of cases, as well as by the varying sensitivity between employers and workers in the perception of workloads, probably due to their different roles in the farm. The presence of a WRS showed a lesser efficiency of the interventions (37 %) compared to the condition in which this figure had not been appointed in the farm (42 %). The efficacy observed with the presence of WRS during the MHL risk assessment is 5.23 %. The data is consistent with the presence in the farm of a person with higher education on the risks, which leads him to possess a greater knowledge on the proper handling, the most correct farm layout and a keener perception of the risks. The analyzes regarding the classes of age showed a 36÷37 % risk increasing for the class under 45 years, although the most representative class in the sample was the one with age greater of 45 (59 % compared to 27 % of workers under 45 years).

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