

A review of recent studies on the risk assessment from repetitive movements in agriculture

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Introduction

The aim of this paper is to carry out a review about recent studies concerning risks coming from repetitive movements in some agricultural activities (WMSDs, Work related Musculoskeletal Disorders). In agriculture, as in other sectors, the ergonomic studies take into account numerous factors such as the interactions man - machine (hardware ergonomics), the interactions man-environment (environmental ergonomics), the interactions man-organization. Over the years, the aims of ergonomics have gradually changed moving from improving the working conditions to the most complete idea of improving the efficiency of the production system.

Agricultural mechanization involves work organization, safety and wellness aspects, human resources, and also machinery, equipment and materials utilized, as well as the characteristics of the workplace; consequently, we can consider agricultural mechanization as a sort of meeting point between rural activities and ergonomics.

As concerns agricultural activities, Ergonomics deals with the dimensional and functional design of the jobs, taking in account techniques and work time (working shifts, working hours), the analysis of posture, of the movements and the physical demands.

In Italy, risk assessment for biomechanical overload of the upper limbs due to repetitive movements is performed using the OCRA method (Occupational Repetitive Actions). The OCRA method, which has been updated and modified over the years, it is recommended by ISO 11228/3, EN 1005-5, and its application is mandatory in Italy in the assessment of such risks (Art. 28 D. Lgs. 81/08). The OCRA method on one hand involves a highly detailed description of the work process and on the other makes possible to summarize the data derived from the analyses and to present a global vision of the work. The force is usually estimated by means of the Borg CR10 scale, which is used to evaluate the subjective perception of the strain level involved from the work.

Studies presented in the paper involve viticulture, tomato growing, nurseries in greenhouses, She – ass milking. Involved aspects are the influence of the frequency concerning manual operations, the strength concerning the various part of the hand measured by instrumented scissors specifically assembled.

Manual Pruning in Vineyards

Vineyard winter pruning is still carried out manually even when preceded by mechanized pre-pruning. Although facilitating equipment is becoming more widespread, traditional manual secateurs and long handled shears remain the most often utilized tools.

During manual pruning cuts follow on from one another regularly and rapidly, particularly when the pruning is preceded by a pre-pruning machine. Manual operations, which is characterized by high frequency and a stereotypic load on the upper limbs, can in time put the muscular skeletal system at risk and cause WMSDs.

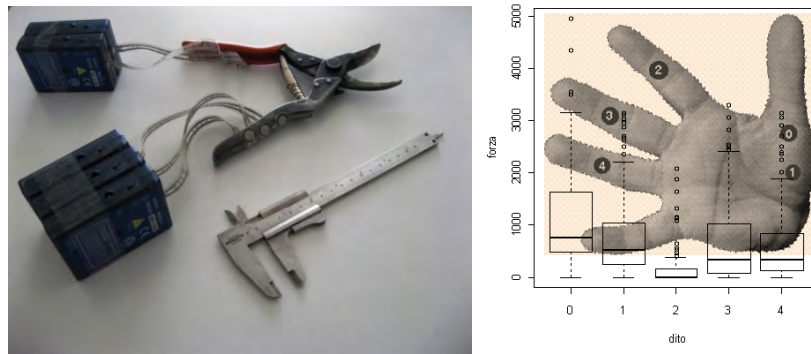
Preliminary studies were carried out by observing some agricultural jobs with the aim of enhancing risks indicators (repetitiveness, frequency, posture, strength), if they were. The results obtained led to focus on the level of risk due to repetitive movements of the upper limbs and trials were consequentially conducted. They involved most cultivars and the risk evaluation was conducted using the method OCRA.

So, seven vineyards sited in eastern Sicily were preliminarily studied, involving 30 workers and 12 hours of observation for each, 5 vine species (*Nerello mascalese*, *Nero d’Avola*, *Nerello cappuccio*, *Chardonnay*, *Merlot*) and 3 vine training systems (goblet cultivation, spurred cordon cultivation, guyot cultivation).

Vine species	vine training systems	Tool	Score Ocra Index	Risk
<i>Nero d’Avola</i>	Spurred cordon cultivation	Secateurs	5,56	medium
<i>Nerello Cappuccio</i>	Spurred cordon cultivation	Secateurs	6,22	medium
<i>Nerello Mascalese</i>	Spurred cordon cultivation	Long handled shears	5,52	medium
<i>Nerello Mascalese</i>	Sapling	Secateurs	5,55	medium
<i>Nerello Mascalese</i>	Sapling	Secateurs	4,92	medium
<i>Merlot</i>	Guyot cultivation	Secateurs	4,12	borderline
<i>Chardonnay</i>	Guyot cultivation	Secateurs	6,11	medium

The results have highlighted the presence of musculo - skeletal diseases factors related to manual pruning in viticulture. In addition, they led to investigate some aspects related to methodology OCRA. In particular, the experimental study involved two risk factors of primary importance, such as the strength and frequency.

As regards the strength, an instrumented scissor with sensors able to detect the stresses exerted by the hand during the cutting vine shoots has been developed in collaboration with the CRA-ING (Treviglio, Milan-EN) and utilized in laboratory. In according to the goals, the tool has proven useful to detect the stresses exerted by the different parts of the hand.

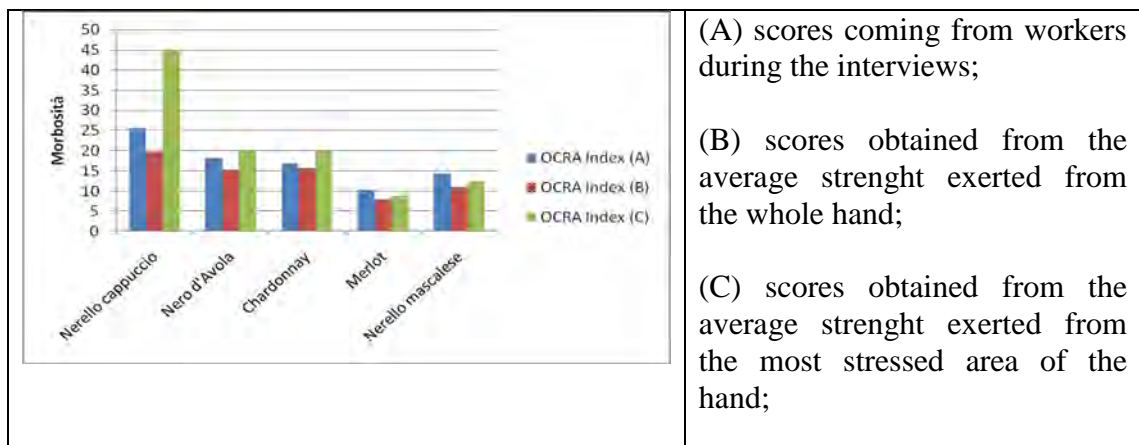


In parallel, a panel of operators was interviewed to verify the correspondence of the data provided by the scissors with the subjective evaluations of strength provided from each of the operators according to the Borg CR10 scale normally used for these kind of researches.

First of all, the instrument was able to reproduce measures consistent with the experimental plan; then, the interviews have allowed us to validate the instrument or, in other words, allowed us to correlate the values, obtained by the instrumented scissors, with the evaluations coming from the operators during the cutting operations.

The average values of the force derived from scissors tests, both those related to the entire hand and those concerning on the most stressed region of the hand, were converted in scores on the Borg scale using the procedure suggested by EN 1005-3.

The results of some simulations, conducted using those average values, confirm that during the cutting operation performed with common scissors some regions of the hand are more stressed than others. The methodology and the instrumentation used were able to highlight this phenomenon.

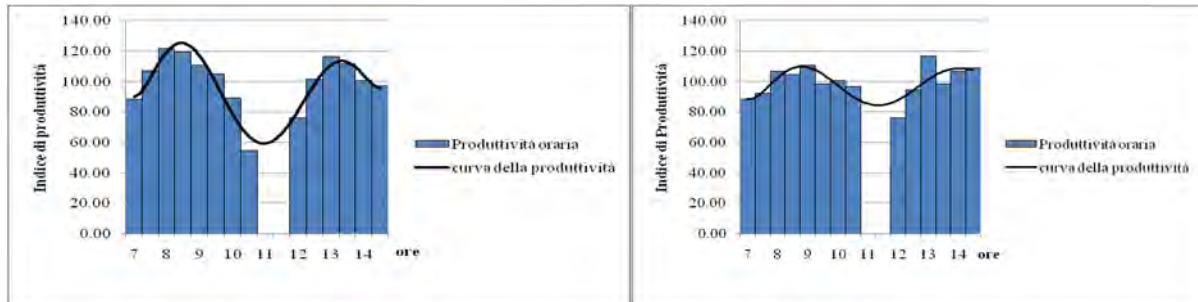


(A) scores coming from workers during the interviews;

(B) scores obtained from the average strenght exerted from the whole hand;

(C) scores obtained from the average strenght exerted from the most stressed area of the hand;

Trials enhance the cutting frequency changes during the day, but by drawing a curve fairly regular and characterized by two peaks and a minimum before the lunch, that is very similar to the variability showed in manual citrus harvesting. It means that surveys about frequency have to be carry out along the whole day if we don't want underestimate or overestimate the connected risks.



Tying the tomatoes in greenhouse

Growing vegetables in greenhouse obliges to perform the operations manually with risks due to in manual handling of loads and repetitive movements. Greenhouse tomato growing involves specific cultivation operations, such as green pruning, tying the plants and distribution of pesticides and fertilizers, manual harvest. Although they do not require particular effort, they involve repetitive movements of the upper limbs and often they induce the operator to assume incorrect postures.

The preliminary survey has revealed the presence of indicators of muscle - skeletal risks, such as the repetitiveness and the high frequency of the movements. They led it to investigate in particular the binding operations and the tomato topping. The investigations involved tying the plants on vertical support wires, and green pruning that can be done at the same time. The tying consists in manually twisting the stem of the tomato plant around a vertical support wire. The work of two sites was timed, each comprising 2 workers positioned on a mobile caterpillar platform.

The risk assessment was conducted by OCRA index, showing a value of 4.1, and proving that operations commonly performed in greenhouses can lead to the employee a medium risk of exposure to biomechanical overload.



Tying the tomatoes

First evaluation of the risk from repetitive movements in greenhouse nurseries: annual cycle and multitask analysis

The aim of this study was to develop an appropriate methodology in the field of musculoskeletal risk in horticultural greenhouse nurseries. This study was the starting point of a national work group made up of doctors and experts in the field of work organization, whose aim is to put together simplified methods (database, software) permitting the monitoring and management of biomechanical overloading risk in such complex situations as cultivation in protected environments.

Measurements were carried out in different nurseries located in eastern Sicily. The first part of the work consisted of the identification of the main sectors and tasks characterizing the activities in the (plant) nursery. The measurements were conducted using the technique of breaking the work into its elementary phases. The tasks were later filmed. Subsequently, the use of the OCRA checklist made it possible to assess the postural requirement (shoulder, elbow, wrist, hand) for each task and to quantify the biomechanical overloading of the upper limbs.

There are several activities in the nurseries where there is a risk of biomechanical overload due to repetitive movements of upper limbs and the manual movement of loads. The observations confirmed that nursery activities show a considerable risk and should be considered throughout the annual cycle.

								
Manual sowing “operator seated”			Transplanting			Spraying		
Checklist OCRA	DX	20	Checklist OCRA	DX	14	Checklist OCRA	DX	16
	SX	20		SX	14		SX	4

Assesment of ergonomics studies concerning she-ass milking

In the farms in eastern Sicily the milking is either carried out manually or by means of a milking machine designed for sheep and goats but with some modifications made by adapting the type of milking liners.

As already demonstrated by research on cows milking is an activity characterized by repetitive movements, which in time can cause musculoskeletal stress. If the milker is at the same level as the cows, the back is bent and the trunk must bend for the udders to be reached; if the milker is in the milking pit the muscoloskeletal risk is mainly to the upper limbs. Workers involved in the care of animals are subject to musculoskeletal disorders because of their work.

Recent applications of the Ocra method have concerned the risks deriving from repetitive upper limb movements of the workers during the milking of she-asses, given the demand for she-asses milk is increasing because of its recognized anti-allergic qualities. The evaluation was carried out in three typical farms situated in Sicily, through the analysis of the positions taken by the milker, of the times of the work phases and the subsequent processing of the checklist OCRA.



Farm 1



Farm 2



Farm 3

	Heads	In lactation	Type of milking		Duration	Checklist Score
Farm 1	80	18 – 20	A trolley milking machine	A milking parlour with milking pit	30 min	7.50 (dx)
Farm 2	70	12 – 14	A bucket milking machine	A milking parlour	30 min	5.75 (sx) 2.25 (dx)
Farm 3	40	8 – 10	Manual milking	Outdoor	40 min	16,25 (sx) 18,50 (dx)

The research shows that in she-asses farming workers are exposed to musculoskeletal risks due to repetitive movements and incorrect postures. Those equipped with a milking parlour with pit parlour show the same problems observed in cow farming, but the small number of head per farm makes small the connected health problems. More than 8 -10 heads shouldn't be manually milked but only by a bucket machine. As concerns the case studied, great part of the inconvenient (maintaining grip and incorrect postures) are due to the use of cluster not suitable for she- ass, but for sheep and goats. A simulation has shown that, in the meantime, breeders with milking parlour with pit parlour and trolley machine can reach number of heads able to increase net profits (around 50 – 55 heads in lactation) maintain low the biomechanical overload risks.

Conclusion

In the agricultural sector, the WMSDs risk evaluation was hampered by many factors: the lack of attention by the employers in the evaluation of risk, the lack of sensibility against the ergonomics specifically concerning workstations. Moreover, there are some general difficulties in the application of the methods (OCRA and or another) in open field that, as is well known, it's a very different environment from industry and manufacturing.

In addition, season factors influences the risk and the exposure of workers to biomechanical overloading depending on the task carried out; moreover, the risk varies for the same task according to intensity and duration. For the assessment of the risk should be considered throughout the annual cycle.

Instrumented scissors allow to recognize the strength exerted on different parts of the hand. The strength intensity reported by the instrument was correlated to the strength evaluation coming from a group of people and when necessary it can be converted in the Borg CR10 scale normally used for these kind of researches. Physicians could now utilize the measured strength intensity exerted in different parts of the hand with the aim to foresee the development of disabilities involving workers' arm and hand.

Results obtained from surveys on vine cutting frequency suggest that the daily curve that represents the cuts per min has to be identify correctly, otherwise the risk could be wrongly evaluated.

Obtained results highlight how is important a multi-disciplinary approach, putting together the competences coming from agricultural mechanization (that includes work organisation), ergonomics and occupational medicine.

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