Evaluation of the Risk Arising From Repetitive Movements During Manual Pruning in Vineyards by Using Measured Forces

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Abstract
Winter vineyard pruning is mainly manual (*Schillaci et al.*, 2009), with the use of traditional secateurs. During pruning cuts follow on from one another in rapid succession and with a certain regularity and hence this operation characterised by high frequency and a stereotypic load on the upper limbs can in time cause *WMSDs*, (*Work related Muscular Skeletal Disorders*). The aim of the work was to assess the risk arising from repetitive movements of the upper limbs during manual pruning in vineyards. The Ocra Index (*Colombini & Occhipinti, 2005, 2007*) was used. The research was carried out in a vineyard situated on the north face of Etna. Seven sites were studied, this involving 30 pruning operators and 12 hours of observation. The process was broken down into component phases and the times and method of execution were recorded for the various operations. The number of cuts per trunk was also noted. Besides data collecting and observations in the field, examination of the video film shot during the work made it possible to obtain or confirm further information about the frequency, stereotypic nature and posture. To assess the force used, a questionnaire on the perception of force required was given to each worker at the end of the survey. Also the health problems correlated with the various tasks were found by means of a questionnaire. The evaluations show that the dominant limb that holds the shears and makes the cut is at risk. This is confirmed by the answers to the questionnaire, as nearly all those interviewed stated they suffered from pain in their upper limbs. The most important factor, besides frequency and posture is the lack or inadequate distribution of rest periods together with the force required, as although the latter is not excessive, it is repeated throughout the work shift. The simulations showed that redesign of workstations can lead to OCRA indices reflecting a low or borderline risk level.

Keywords: OCRA, WMSDs, vine cultivation, health, safety

Introduction
Vineyard winter pruning is still carried out manually even when preceded by mechanised pre-pruning. Although facilitating equipment is becoming more widespread, traditional manual secateurs and long handled shears remain the tools most often utilised. During pruning cuts follow on from one another rapidly and with a certain regularity, particularly when the manual pruning is preceded by use of a pre-pruning machine. These operations, which are characterised by high frequency and a stereotypic load on the upper limbs, can in time, put the muscular skeletal system at risk and cause WMSDs (*Work related Muscular Skeletal Disorders*). In order to describe and assess tasks involving a potential biomechanical overloading of the upper limbs, given that individual movements must be examined, a synthetic analytical index is used (the OCRA Index) as recommended by regulations EN 1005-5 and ISO 11228-3. The method, which was proposed in 1996 and subsequently updated (*Colombini & Occhipinti, 2005, 2007*), on one hand involves a highly detailed description of the work process and on the other makes it possible to summarise the data derived from the analyses and present a global vision of the work. With reference to activities

in the Agro-Food industry, the OCRA method has been used to assess the risk to the muscular skeletal system in poultry slaughter houses (*Caso et al.*, 2007), in dairy production plants (*Porceddu et al.*, 2008) and in field operations such as pruning, harvesting and transplanting (*Colombini & Occhipinti*, 2008). As far as protected crops are concerned OCRA has been used to assess risks run by operators during spraying (*Schillaci*, *Rapisarda et al.*, 2008) and while tying tomato plants (*Schillaci et al*., 2009).
Recent studies have also been carried out on the clinical risk of upper limb biomechanical overloading in vine and olive cultivation (*Montomoli et al*., 2008), and on the assessment of muscular skeletal risk during manual vine pruning (*Schillaci et al*., 2009). From both studies it emerged that the cuts made by the operator during manual pruning follow on from one another rapidly for the whole work shift and are characterised by great repetitiveness and frequency, this putting the muscular skeletal system of the upper limbs at risk.
This work uses the OCRA Index to assess the risk involved in repetitive upper limb movements during manual vine pruning, using as strain values both the average values measured by sensorised secateurs weighted on the Borg CR10 scale and subjective values of the effort (*Schillaci et al., 2010*).

Materials and methods

A questionnaire about any muscular skeletal disorders they had noticed during the pruning season was given to the operators to fill in. "MidaOCRAmulticompiti" software (*Colombini & Occhipinti*, 2005) was used to assess muscular skeletal risk.
Data was collected by breaking down the task into component phases. The method used and times taken for the execution of the operations were recorded and the cuts per trunk were counted. From the sites studied a typical day was 'extracted'. This was made up of 7 non-consecutive hours (420 minutes), that is to say 4 hours in the morning (from 7.00 to 11.00), a lunch break of one hour (between 11.00 and 12.00) and three hours in the afternoon (from 12.00 to 15.00).
Besides the data recorded and field observations, video films shot during the work period made it possible to deduce or confirm information about frequency, posture and the stereotypic nature of the work.
Seven sites in eastern Sicily were studied, this involving 30 operators and 12 hours of observation (Tab. 1).

Tab. 1 – Characteristics of the sites assessed.

Site	Vine species	Year planted	Type of cultivation	Vine spacing [m]	Number of operators	Tool
1	Nerello mascalese	2003	Sapling	0,80 x 1,10	3	Secateurs
2	Nerello mascalese	1950	Sapling	1,10 x 1,20	3	Secateurs
3	Nerello mascalese	1984	Spurred cordon	1,20 x 2,10	10	Long handled shears
4	Nero d'Avola	2000	Spurred cordon	1,00 x 2,20	6	Secateurs
5	Nerello cappuccio	1997	Spurred cordon	0,90 x 2,00	2	Secateurs
6	Chardonnay	2003	Guyot	0,90 x 2,00	2	Secateurs
7	Merlot	2004	Guyot	0,80 x 1,80	4	Secateurs + hacksaw

For each cultivar the number of cuts per minute was counted and from this the technical actions per minute could be seen. The work period consists of 420 minutes per day and the

movements are repeated the whole time. In the case of the secateurs the Ocra Index was calculated considering only the dominant limb as it is this that is subject to most strain while in the case of the long handled shears a single Ocra index was calculated taking both limbs into consideration as they both carry out the same movements. As regards both the subjective and measured strain values, the ones considered are those deduced from cutting trials using sensorised secateurs and weighted according to the Borg CR10 scale (*Colombini e Occhipinti, 2005*). For each vine cvv 2 indices were calculated using the values for the measured forces (case A) and the subjective values obtained from the operators' questionnaires respectively (case B). These were then compared.

Results and discussion

Muscular skeletal disorders. From the questionnaire it emerged that during the pruning period, the operators suffer from pain, above all in the shoulder and hand of the limb carrying out the cut. The pain is felt during both the first minutes of work and in rest periods some hours after the work shift.

Work description. The operation is carried out by workers who move along the row holding the secateurs in their right hand, using their left to hold the vegetation and at times (when the cut is more difficult) to help the right grip the cutters. Each operator uses the right and left limb differently. Unlike the secateurs, the shears require simultaneous use of both limbs. The activity is characterised by stereotyped movements repeated for more than 2/3 of the time cycle. Besides the lunch break no other breaks are programmed. Although at times the operators stop pruning to sharpen the blades, this interruption cannot be considered a 'rest' period.

Goblet vines. When pruning goblet (*Fig. 1*) the operator carries out manual pruning with traditional secateurs and while pruning also removes the cut shoots. The tool are held in a 'pinch' mode, characterised by opposition between the thumb and the other fingers. The left hand holds back the vegetation with a wide grip requiring slight effort. The operator extends his left arm to grip the shoot to be pruned and with his right reaches the vegetation and makes the cut. Subsequently he uses his left arm to throw the cut shoot to the ground or grips another to be pruned, which is again cut by the right hand. In the latter case, when he has several shoots in his hand he throws them to the ground. As soon as the pruning of one plant is complete he moves on to the next one. At times he cuts without using the left limb to hold the plant, for example when pruning a small shoot. The low goblet vine (0,4-0,50 m) obliges the operator to work with his back bent.

Fig. 1 – Goblet cultivation

Guyot vines. the operator grips the cutters with his right hand, reaches the vegetation by extending his arm, makes the cut while holding the shoot with his left hand (*Fig. 2*). Having pruned the new growth, the operator uses a hacksaw to cut the residual spur. The tool is held in a 'pinch grip' while the hacksaw requires a 'power grip'. Because of the height of the spur, the operator is obliged to work with his back bent.

Fig. 2 – Guyot cultivation

Spurred cordon vines (*Figs. 3 and 4*). The operator grips the tool with his right hand, reaches the vegetation by extending his arm and makes the cut. According to the consistency of the wood he either cuts using only the right hand (Nero d'Avola) or uses both hands (Nerello Cappuccio), meaning that the latter cultivar requires more effort (*Schillaci et al*, 2009, 2010). The tool is held in a 'pinch grip'. In the case of pruning with long handled shears, the operator uses both hands to grip the shears and make the cut. Both arms continually make bending movements and the height of the work means the operator's back is bent.

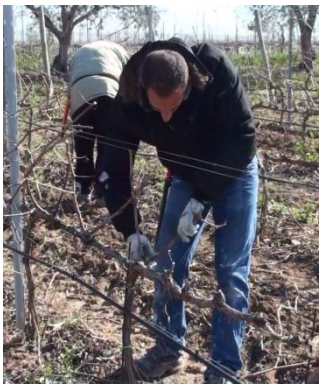

Fig. 3 – Spurred cordon cultivation

Fig.4 – Spurred cordon cultivation

OCRA Index calculation. Table 2 shows the indices calculated for each species in the two cases studied (A and B).
In the case of the risk index calculated using the measured force values (case A), it is possible to state that the indices fall into the red zone, except for sites 2 and 7. The spurred cordon

Nerello cappuccio pruning carried out with traditional secateurs gave the highest risk index, this being determined mainly by the force necessary to make the cut.
As regards the tool employed, in general use of shears in Nerello mascalese pruning reduces the effort required for each cut but does not reduce the risk index as it worsens the posture and increases the precision (attention) necessary to carry out the work. The risk indices relative to goblet pruning of Nerello mascalese are not significantly different from those for spurred cordon pruning. It should, however, be pointed out that work on the goblet vines requires the use of the left limb, which during pruning often holds the shoots and removes them once cut.
Figure 5 shows all the Ocra indices calculated for each site.

Tab. 2 – Average Ocra Indices for pruning sites.

Cantiere	Species	Technical actions no./min	Case A* Ocra Risk Index	Case B** Ocra Risk Index
1	Nerello mascalese	49	4.8 **medium**	7.6 **medium**
2	Nerello mascalese	44	4.3 **Low**	6.4 **medium**
3	Nerello mascalese	49	4.9 **medium**	6.4 **medium**
4	Nero d'Avola	49	6.4 **medium**	7.6 **medium**
5	Nerello cappuccio	44	8.3 **medium**	10.7 **high**
6	Chardonnay	54	6.5 **medium**	7.1 **medium**
7	Merlot	33	3.3 **borderline**	4.3 **low**

* *case A* Ocra Indices with measured force values
** *case B* Ocra Indices with subjective force values

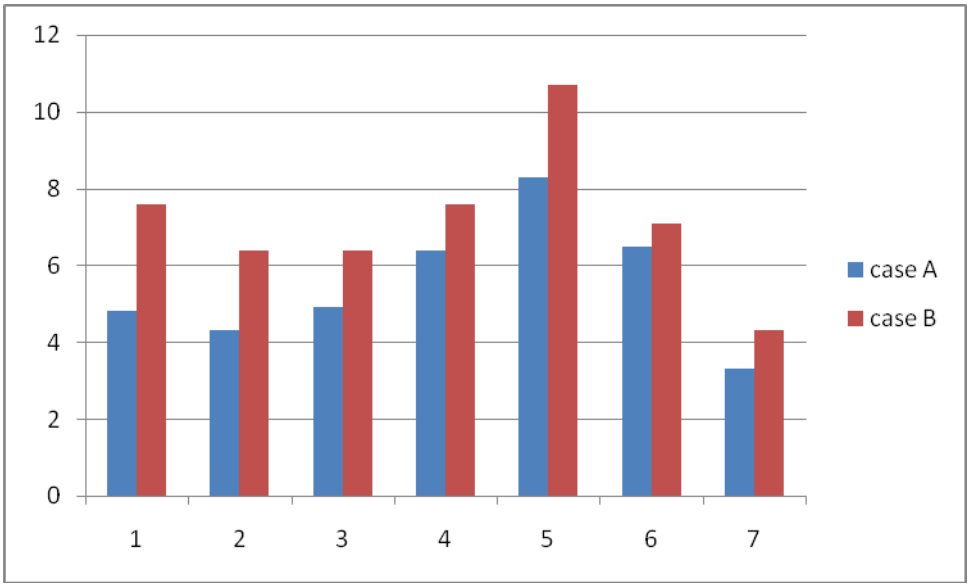

Fig.5 – Ocra Indices calculated for each site

Conclusions

It is significant that in the questionnaire nearly all the workers stated they suffered from discomfort or pain or during the pruning period.

The results obtained in the sites examined show that the dominant limb gripping the tool is at risk. In the case of the long handled shears both limbs are at risk. Factors contributing to the risk besides frequency of the same movement and posture, are the lack of or poorly scheduled rest periods and the effort repeatedly required during the entire work shift. The use of facilitating tools (as electronic ones) should be carefully considered in the light of the loads, the muscular skeletal system involved and the posture required.

As regards the indices calculated with the two methods of measuring the forces – the one based on Borg and the one based on measuring the forces by means of sensorised tool, it was seen that the latter always gave lower values. For this reason it might be prudent to always use the conventional index, as this protects the workers from underestimation of their effort. However, in further studies, the indices will be calculated again, this time using the maximum values given by the shears as opposed to the average ones. The aim will be to show more clearly which parts of the body are constantly involved in the greatest effort and must therefore be considered at risk. It is foreseeable that the use of the maximum values measured - as opposed to the average values measured and the average Borg (subjective) values – will provide more indication of the muscular skeletal areas actually at risk.

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