IEA 2009
17TH WORLD CONGRESS ON ERGONOMICS AUGUST 9-14
BEIJIN, CHINA

Repetitive movements of upper limbs in viticulture: set up of annual exposure level assessment models with OCRA checklist comparing with the first results of clinical data

E. Álvarez-Casado, Centre Específic de Recerca per a la millora i Innovació de les Empreses - Universitat Politècnica de Catalunya - Barcelona (Spain) *

A. Hernández-Soto, Centre Específic de Recerca per a la millora i Innovació de les Empreses - Universitat Politècnica de Catalunya - Barcelona (Spain)

D. Colombini, Research Unit EPM - Foundation Policlinico Mangiagalli - Milano (Italy)

* Corresponding author : e-mail : mailto:enrique.alvarez@upc.edu. CerPIE-UPC. Av. Diagonal, 647. Pl 10. 08028 Barcelona (Spain)

Wine production is an important activity in South of Europe, where 70% of the world's vineyards are located.

Studies of ergonomic analysis at pruning and harvesting wine grape vines have already been published. But pruning and harvesting are only part of several other tasks that the worker performs in the field over the annual cycle of crop, with estimates showing that a worker operates around 12 times a year at each vine. Additionally, every task implies significant differences in biomechanical demand, depending on the variety of grapes planted, the desired quality of the wine, the level of mechanization, the tools used, and the ground characteristics, among others.

This study performed a complete tasks analysis during the annual cycle in 11 vineyard farms, located in different regions of Catalunya with a total of 162 farm workers.

The intrinsic risk index of upper limb injury was calculated for every task, specifying the temporal patterns of annual exposure for each professional profile.

As a final point, we present preliminary results obtained from clinical data using different analytic methods based on OCRA check list in order to measure the cumulative risk level of upper limbs.

INTRODUCTION

Work in viticulture

Viticulture in Europe represents the 45% of the area of vineyards, the 65% of production, the 57% of consumption and the 70% of exports in the world (Funes & Andrade, 2007). Wine production is an important activity in South of Europe, where 70% of the world's vineyards are located.

In Europe, agriculture is the fifth largest sector in terms of men, about 5% of the workforce, and the seventh in women, it employs about 3% of women workers (European Agency for Safety and Health at Work [OSHA], 2007). In Catalunya, the work of agriculture is developed mainly by men. Working women represent just fewer than 20% (Institut d'Estadístiques de Catalunya [IDESCAT], 2009).

WMSDs in vineyard workers

An European study (Wakula, 2000) argues that tenosynovitis and carpal tunnel syndrome injuries are very common WMSDs in pruning and harvesting wine grape vines tasks and should take into account other changes in the structure-hand wrist.

The study conducted in the region of Champagne (Roquelaure et al., 2001) emphasized a prevalence of nocturnal hand paresthesias in dominant upper limb of 37%, although in many cases is a temporal problem.

More recent published studies conducted in California also draws the problem of musculoskeletal disorders in vineyard workers. In (Meyers et al., 2006), is estimated an average of 3350 injuries in the lumbar area reported each year in California agriculture and an estimated annual cost for these disorders is approximately $ 30 million. In (Davis & Kotowski, 2007), a prevalence of 28% of hand-wrist and 14% of shoulders musculoskeletal disorders in farmers is indicated.

The problem of WMSDs in vineyard workers is well known but the study of the relationship between diseases and work has not been well addressed yet.

Exposure to biomechanical demands

Studies of ergonomic analysis at pruning and harvesting wine grape vines have already been published. But pruning and harvesting are only part of several other tasks that the worker performs in the field over the annual growth cycle.

It is estimated that each crop needs an average time of dedication of 5 minutes per year, depending on the expected quality of wine, and that the employee works at the plant around, both in direct and indirect, about 12 times a year (Sánchez, 1999).

In agriculture, biomechanical demand of tasks varies over the annual cycle and exposure of farmers varies in duration and in intensity every month.

This study performed a complete tasks analysis during the annual cycle in 11 vineyard farms, located in different regions of Catalunya.

First, the analysis of the tasks and variations that may influence the biomechanics demand in viticulture will be exposed.

Secondly, case studies will be described. The intrinsic risk index of upper limb injury calculated for every task will be detailed, specifying the temporal patterns of annual exposure for each professional profile.

As a final point, preliminary results obtained from clinical data using different analytic methods based on OCRA check list in order to measure the cumulative risk level of upper limbs will be exposed.

TASKS ANALYSIS IN VITICULTURE

Tasks in the annual cycle

Tasks performed in the vineyards farm work are very seasonal. There are few tasks that are performed throughout the year.

In Table 2 the main tasks are detailed. But it must taken into account that additional tasks may appear, for example in a new planting of vines or in the case of plants suffering from some disease.

Conduction system of the plant

The conduction system of the plant determines the production per unit area and the demands of work. Mainly, there are two types of planting: Espalier system and gobelet style.

The espalier system is the most widely used in wine grape plantings in the whole world. Comparing to gobelet style, the espalier system allows a previous mechanized pruning, increases from 1000 to 7000 vines per hectare and twice the growing area that can work a person.

There are two types of espalier system: the Guyot cordon system (single and double) and the Royat pruning. In espalier system, the bunch is at a height of 65 cm.

Also, to know if there is more grape varieties in a farm can be relevant, because each varietal has a harvest period. If in the farm only growth one type of grape, harvest must be done in a few days.

Level of mechanization

In vineyards farms, there are some tasks that can be mechanized. Companies can save up to 100 workers per day with the use of mechanized harvesting.

However, the mechanized harvesting does not have widespread use, because quality in the wine is lost.

Type of pruning tool

Throughout the annual cycle, there are several manual tasks to be performed with a cutting tool such as tie vine shoots, spring pruning, pruning, remove grapes, harvesting. These tools can be manual, electric or pneumatic (progressive cut or not).

Obviously, hand tools require more effort than the others, but it is not possible provide an overall assessment by type of tool. In a pilot study conducted by the authors of this paper (not yet published), EMG measurements were made of various tools, found significant differences between brands of tool, but not by type.

CASE STUDIES

Farms

This study was conducted in 11 vineyard farms from Catalunya. As seen in Table 1, the predominant type of pruning on these farms is Royat cordon system of pruning.

The grape varieties grown are very diverse. Most vineyards are aimed at producing high quality wine, so 80% of the cultivated area is manual harvesting and 20% mechanized harvesting.

Workers exposed selected

The total number of workers in these 11 farms are 162. They are organized in 4 professional categories: Supervisor, pawn, cat-skinner and specialist. In this study, the tasks done by pawns and specialists are considered, due to they are the workers with higher exposure to manual tasks in the farm.

Workers working for less than 2 years in these farms were rejected. Finally, a group of 81pawns and specialists workers was selected as exposed group, with a mean age of 39 years.

Pattern of annual exposure

The average The precise pattern of temporary assignment to tasks throughout the year has been determined (see Table 2). Monthly saturation time of the tasks performed on the farm is 80%.

To find a simple pattern of exposure, only the relevant tasks have been considered. A task has been considered as a “relevant task” if the task duration in a month is more than 4% of the net working time in one month. Therefore, tasks performed for less than 8 hours in the month are not considered. Monthly saturation time of the “relevant tasks“ which are performed on the farm is 80%.

In Table 3, the pattern of qualitative annual exposure to relevant tasks of pawn and specialists workers is represented. The cells with number 3 are common tasks to both, the cells with number 2, are tasks done only by pawns workers, and the

cells with number 1 are tasks done only by specialists workers. The temporary assignments which differ pawns and specialists have duration of 5%. Therefore, given the small difference in exposure between pawns and specialists, a single pattern of exposure has been considered (cells with a gray background in Table 2).

Intrinsic upper-limb risk level of every task

The OCRA method is the reference method chosen in ISO (ISO11228-3, 2007) and CEN (EN 1005-5) standards regarding risk assessment and management of upper limbs repetitive movements and exertions. The method consists of two specific tools : OCRA index and OCRA checklist. In this study, the OCRA checklist method will be applied because it is more appropriate to do the first estimate of the presence of risk.

Intrinsic risk level of a task is defined as the risk level of a worker who performs a task during the entire shift every day.

In the cases studied, the duration of the shift is 8 hours, with a break for lunch (not included in the shift) and a break for breakfast of 30 minutes in the morning. Hence, the recovery time multiplier taken is 5.

Every task was filmed in several farms to ensure they do not have significant differences on biomechanical demand. Subsequently, cycles and/or temporary representative sequences were identified for assessment.

Intrinsic risk values of right upper limb obtained are detailed in Table 4.

ANNUAL EXPOSURE ANALYSIS

Annual exposure index

To date, no model for the estimation of risk in an annual exposure has been validated.

In (Colombini et al, in press) four models have been proposed:

(a) Weighted average (classical daily evaluation)
(b) Hyperbolic qualitative average weighted index
(c) Quantitative weighted average index
(d) Multitask complex OCRA method index

The four models proposed have been applied to the right upper limb, using the intrinsic risk values calculated (Table 4) and the temporal assignments obtained (cells with a gray background in Table 2).

The results are as follow:

Table 5. Annual exposure index values obtained

	Model applied			
	a	b	c	d
Index value	18,4	12,1	12,2	20,7

Clinical data

The clinical data used in this study were provided by the medical service of mutual labour. The data listed in Table 6, are the cases of workers with a diagnosed disease in the upper limb.

The prevalence of exposed workers is 19.8% affected by one or more UL WMSDs.

These are the first clinical data obtained, but a complete medical examination of workers is necessary to complete the study.

Predictivity assessment of annual exposure models

The four models applied have obtained different risk index value. To assess the ability of each model to predict the occurrence of UL WMSDs, the known association between OCRA checklist index and the prevalence of exposed workers (%PA) can be used (see Formula 1).

$$\text{OCRA checklist} = \%PA^{(1/1,004)} \quad (1)$$

The OCRA checklist score expected obtained is 19,9.

According to this result, models (a), (b) and (c) proposed under estimate the risk level, while model (d) over estimate the risk level. But, the models (a) and (d) seems a good approximation.

DISCUSION

In this study, a full methodology to analyze the organization of work in vineyard farms have been defined, and it has been applied in 11 farms to assess the biomechanical demand for a year.

The variables related to mechanization level, tools and type of pruning that must be considered in a biomechanical study have been described.

The identified tasks can be a reference framework to develop further research on biomechanical assessment in vineyard farms.

Additionally, from the preliminary clinical data obtained, different models to estimate the risk in an annual exposure have been tested.

The results obtained indicate that the weighted average (classical daily evaluation) and the multitask complex OCRA method index are the best indicators to estimate the prevalence. However, as quoted before, a complete medical examination of workers is necessary to complete the study.

REFERENCES

Funes, R., & Andrade, M. (2007) Ergonomia e Agricultura. Faculdade de Engenharia Agrícola. Universidade Estadual de Campinas. Brasil.

Colombini, D., Occhipinti, E., & Grieco, A. (2002). Risk assessment and management of repetitive movements and exertions of upper limbs, Elsevier Science, Amsterdam.

Colombini, D., Occhipinti, E., & Montomoli, L. (in press). Repetitive movements of upper limbs in agriculture: set up of annual exposure level assessment models starting from OCRA checklist via simple and practical tools. Proceedings of the 17th World Congress on Ergonomics. Beijing, China.

Sánchez, J.C., González, F.L., & Tena A.M. (1999). Cultivo de la vid en espaldera. Dirección general de estructuras agrarias. Gobierno de Canarias. Consejeria de agricultura, ganadería, pesca y alimentación. Santa Cruz de Tenerife.

Institut d'Estadística de Catalunya. (2009). Enquesta de Població Activa. Retrieved February 23, 2009, from: http://www.idescat.cat/treball/epa?tc=4&id=xc130701

European Agency for Safety and Health at Work (2002). La agricultura en la UE: información estadística. Retrieved October 14, 2008, from: http://osha.europa.eu.

Davis, K., Kotowski, S. (2007). Understanding the Ergonomic Risk for Musculoskeletal Disorders in the United States Agricultural Sector. p. 502-510. American Journal of Industrial medicine.

Roquelaure, Y., et al. (2001). Transient Hand Paresthesias in Champagne Vineyard Workers. American Journal of Industrial Medicine, vol. 40, pp 639-645.

Wakula, J., Beckman, T., Hett, M. et al. (2000). Ergonomic analysis of grapevine pruning and wine harvesting to define work and hand tools design requirements. Occupational Biomechanics 2, pp. 151–161.

Meyers, J.M., Miles, J.A., & Faucett, J.(2006). Smaller loads reduce risk of back injuries during wine grape harvest. California Agriculture. Vol. 60, N 1, pp. 25-31.

ISO 11228-3. (2007). Manual handling. Part 3: Handling of low loads at high frequency. International Organization for Standardization, Geneva, Switzerland.

Table 1. Hectares of farms analyzed and type of pruning.

Farm	Ha	Ha Espalier system	Ha Guyot pruning	Ha Royat pruning	Ha Gobelet style
Juneda	145,8	100,0%	0%	100%	0%
Mediona	141,8	99,6%	0%	100%	0%
Fransola	190,9	100,0%	2%	98%	0%
Pacs	81,6	96,9%	0%	97%	3%
Poblet	105,9	100,0%	0%	100%	0%
Montagut	105,8	100,0%	34%	66%	0%
Porrera	154,4	91,3%	0%	91%	9%
Selva	88,6	100,0%	0%	100%	0%
Tremp	121,0	100,0%	10%	90%	0%
Vimbodi	181,3	97,3%	0%	97%	3%
Can Gomà	111,6	100,0%	0%	100%	0%
Total Ha	1428,7	1407,3	52,3	1355,6	21,4
Average %		**99%**	**4%**	**95%**	**1%**

Table 2. Quantitative Temporary assignments pattern

NET TIME AVERAGED	MONTHS												
TASKS	1	2	3	4	5	6	7	8	9	10	11	12	
Soil											0%		
Clean between vines			0%	0%			1%			0%			
Plough				1%	1%	0%	3%	1%	0%	1%	1%		
Plant health treatment				0%	0%	1%	0%		0%	0%			
Manual treatment			5%	2%			1%						
Fertilize		0%		1%	0%								
Previous mechanical pruning			0%	0%									
Mark field and planting	0%	4%	3%	1%	0%								
Put cane to wire	0%	1%	4%	3%	0%		2%	2%		4%	2%		
Formation vine	15%	7%	6%	4%	4%	4%	4%	3%	4%	14%	22%	10%	
Nailing canes			1%	1%	1%	2%	2%	3%	1%	1%	2%	3%	
Replant	3%	2%	6%	4%	2%			1%	1%				
Pruning manual tool	2%	4%	3%	0%							4%	2%	
Royat pruning pneumatic tool	48%	37%	16%	5%	0%					0%	33%	37%	
Royat pruning electric tool	10%	8%	3%	1%	0%					0%	7%	7%	
Guyot pruning	0%	0%	1%								0%	0%	
Tie vine shoots	1%	3%	4%	8%	3%	0%	2%	1%	0%	3%	4%	2%	
Tie vines (Guyot pruning)		0%	1%	1%									
Gobelet pruning	1%	1%	1%	0%	0%						0%	0%	
Placing wires below	3%	2%	12%	15%	1%						2%	2%	
Review espalier system	1%	3%	5%	4%	2%	1%	0%	3%	1%	3%	1%	1%	
Remove vine shoots	4%	12%	5%	1%							3%	5%	
Clear of weeds				6%	51%	19%	2%	1%					
Placing wires above	0%	0%	1%	1%	12%	46%	8%	0%				1%	
Put wires		0%	2%	1%	1%	3%	1%	2%	2%	1%	1%	1%	
Remove leaves						1%	3%	2%					
Remove grapes						5%	26%	19%	6%	2%			
Tear bunch vines			2%	5%	5%	1%	1%	0%	1%	7%	8%		
Dig vines		0%	7%	3%	2%	2%	6%	2%	0%	1%	0%		
Trim green vine shoots							1%	2%		4%			
Manual harvesting espalier							1%	3%	55%	27%			
Manual harvesting gobelet							0%	0%	1%	1%			
Tractor trailer with grapes							0%	1%	2%	1%			
Select grapes in conveyor									3%				
Remove regrowth						3%	13%	8%	10%	8%	1%		
Fix graft				1%	1%					0%	2%		
% TOTAL SATURATION	87%	83%	87%	71%	87%	88%	78%	54%	87%	78%	93%	72%	**80%**
% RELEVANT TASKS SAT.	76%	64%	63%	44%	72%	70%	54%	27%	75%	56%	69%	59%	**61%**
% NON RELEVANT TASKS	11%	20%	24%	27%	15%	18%	24%	27%	12%	22%	23%	12%	**20%**

Table 3. Qualitative annual exposure to relevant tasks of pawn and specialists workers.

	MONTHS											
TASKS	1	2	3	4	5	6	7	8	9	10	11	12
Manual treatment			3									
Formation vine	3	3	3	3	3				3	3	3	3
Replant			3									
Royal pruning pneumatic tool	3	3	3	3							3	3
Royal pruning electric tool	3	3									3	3
Tie vine shoots				3								
Placing wires below			3	3								
Review espalier system			3									
Remove vine shoots	3	3	3									2
Clear of weeds				3	3	3						
Placing wires above					3	3	3					
Remove grapes						3	3	3	3			
Tear bunch vines				1	1					3	3	
Dig vines			3				3					
Manual harvesting (espalier)									3	3		
Remove regrowth							3	3	3	3		

Table 4. Check-list OCRA Intrinsic Value (duration 8 h with break for lunch and 1 break of 30min)

TASKS	Recovery time Multiplier	Frequency Multiplier	Force Multiplier	Shoulder	Elbow	Wrist	Hand	Repetitiveness Multiplier	Posture Multiplier	Check-list OCRA Intrinsic Value
Manual treatment	5	6	2	1	0	0	0	1,5	2,5	15,5
Formation vine	5	8	2	4	2	4	8	1,5	9,5	24,5
Replant	5	2	2	4	0	2	6	0	6	15
Royal pruning pneum. tool	5	2	1	6	0	2	8	1,5	9,5	17,5
Royal pruning electric tool	5	2	1	6	0	2	8	1,5	9,5	17,5
Tie vine shoots	5	6	1	12	0	0	6	3	15	27
Placing wires below	5	2	0	4	0	0	2	1,5	5,5	12,5
Review espalier system	5	2	0	1	0	0	2	0	2	9
Remove vine shoots	5	6	2	1	6	0	3	1,5	7,5	20,5
Clear of weeds	5	6	0	9	6	0	3	1,5	10,5	21,5
Placing wires above	5	0	0	4	0	0	0	3	7	12
Remove grapes	5	1	0	4	2	2	8	1,5	9,5	15,5
Tear bunch vines	5	8	2	2	0	4	0	3	7	22
Dig vines	5	3	6	6	0	4	0	3	9	23

Manual harvesting (espalier)	5	1	0	4	2	2	8	1,5	9,5	15,5
Remove regrowth	5	3	0	12	0	4	0	3	15	23

Table 6. Cases of upper limb WMSDs by articulation

Age	**Elbow**	**Wrist**	**Hand**
32	1		
53			1
29			1
29			1
36			1
31			1
43	1		
35		1	
46	1		
44		1	
42		1	
53	1		
53	1		
31	1		
48			1
52	1		