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Hand Forces Measured During Vine Shoot Cutting

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FOREWORD 1/6

Some studies have shown that during winter manual pruning **workers** are exposed to medium and or low level of biomechanical overloading risks;(*Schillaci et al.*, 2009, *Romano et al*., 2010).

IX Convegno Nazionale dell'Associazione Italiana di Ingegneria Agraria
Ischia Porto, 12-16 settembre 2009
memoria n.

VALUTAZIONE DEL RISCHIO DA ESPOSIZIONE A MOVIMENTI RIPETITIVI DEGLI ARTI SUPERIORI NELLA POTATURA MANUALE DEL VIGNETO

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Foreword - Italian Law 2/6

In Italy there is an obligation on the part of the employer (also in the field of agriculture) to assess all the risks present in the work place. Such risks include those arising from upper limb biomechanical overloading (*Legislative Decree 81/08 and successive modifications and integrations*).

Under Italian law (*Legislative Decree 81/08, which refers to the international standards EN 1005-5, ISO 11228-3*), the **OCRA method** (*Occupational Repetitive Action*) is the procedure to be used for risk assessment of musculoskeletal disorders upper limbs, although other methods are proposed in the literature (*ACGIH-TLV - Strain Index*).

Foreword - The OCRA method 3/6

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.

FOREWORD 4/6

Other researches have shown that **when** cutting vine shoots the forces exerted on the scissors vary (**sometimes greatly**) in function of the different regions of the hand (*Schillaci et al.*, 2010).

International Conference Ragusa SHWA2010 - September 16-18, 2010 Ragusa Ibla Campus- Italy
"Work Safety and Risk Prevention in Agro-food and Forest Systems"

Evaluation of Hand Forces During Manual Vine Branches Cutting

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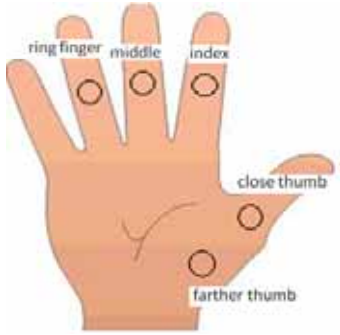

Foreword 5/6

In a research presented at Ragusa SHWA 2010 we showed the great weight of the “Strain” as concern OCRA Index

International Conference Ragusa SHWA2010 - September 16-18, 2010 Ragusa Ibla Campus- Italy
“Work Safety and Risk Prevention in Agro-food and Forest Systems”

Assessment of the “Strain” Parameter in the Calculation of the Biomechanical Risk Index as Regards the Upper Limbs in Vineyard Manual Pruning

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Foreword – OCRA Factors 6/6

As concerning risks assessment OCRA ***uses the average value of each involved factors*** *as frequency and repetitiveness of the upper limb movements,* **strenght** *and other factors.*

We think that calculating OCRA Index by using the average value of the strength referred to the whole hand might cause a biomechanical overloading risks underestimation as concern the risks that the most involved part of the hand run

Aims

We intend to verify:

- **if there are regions of the hand that are continuously more involved in strength than other;**

-**if the average value of the forces referred to the most stressed part of the hand could be dramatically higher than the average value of the whole hand**

Results will be available to physicians with the aim to correlate hand pathologies with measured stresses in localized hand regions.

Methodology

OCRA Strength Assessment

Preamble.
OCRA Method uses the **Borg Scale** to assess the strength factor.
The Borg scale takes in account the judgment of the worker
(The Borg scale is validated through statistical analysis)

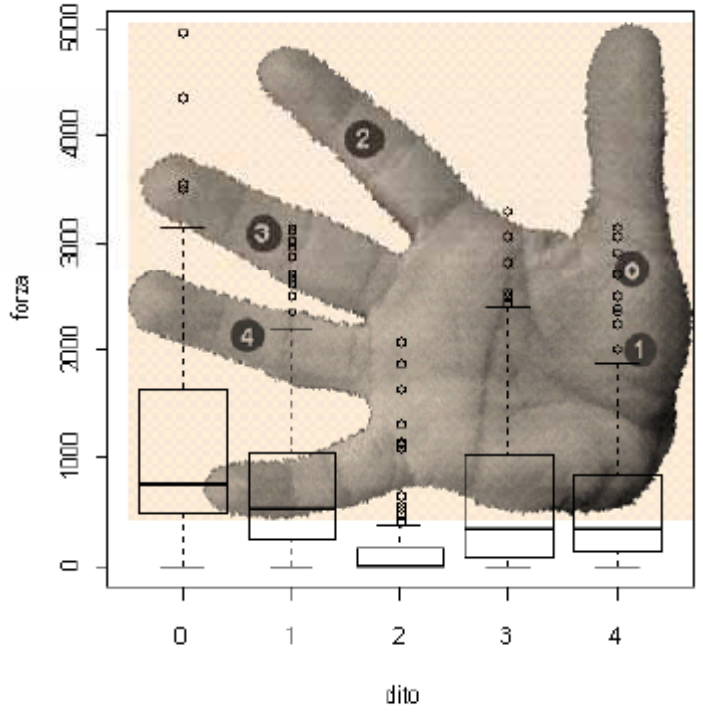
OCRA **admits the use of instruments** in measuring the strength (electromyography)

In that case OCRA converts the data obtained to Borg score

Methodology

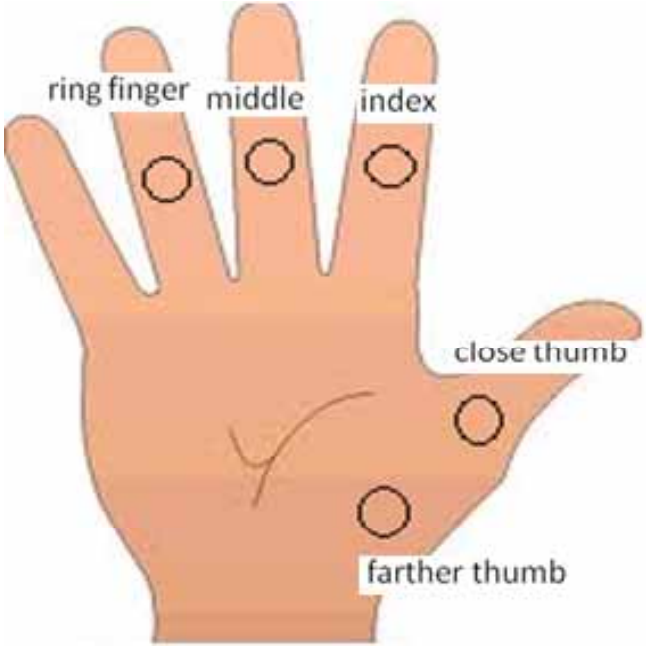
A scissor equipped with 5 sensors was able to detect forces exerted and the duration of the effort during the cut, with regard to different cultivar and diameters of the shoots.

Regions of the hand observed by wireless sensors.



Methodology

In the laboratory a staff usually not lead to pruning was been specially trained to use traditional scissors. One-year-old shoots of grape varieties that are commonly spread in eastern Sicily were cut, 5 force sensors were placed on the handles of the scissors, corresponding to 5 regions of the hand.



Methodology

OCRA Strength Assessment – Instrumented data conversion

FIRST STEP
It is necessary first to derive the maximum force FL (EN 1005-3) exercisable by a hand job generated by the opposition between the thumb and fingers (typical of the taking of a scissors)

$$F_L = F_b * mv * mf * md \text{ [N]}$$

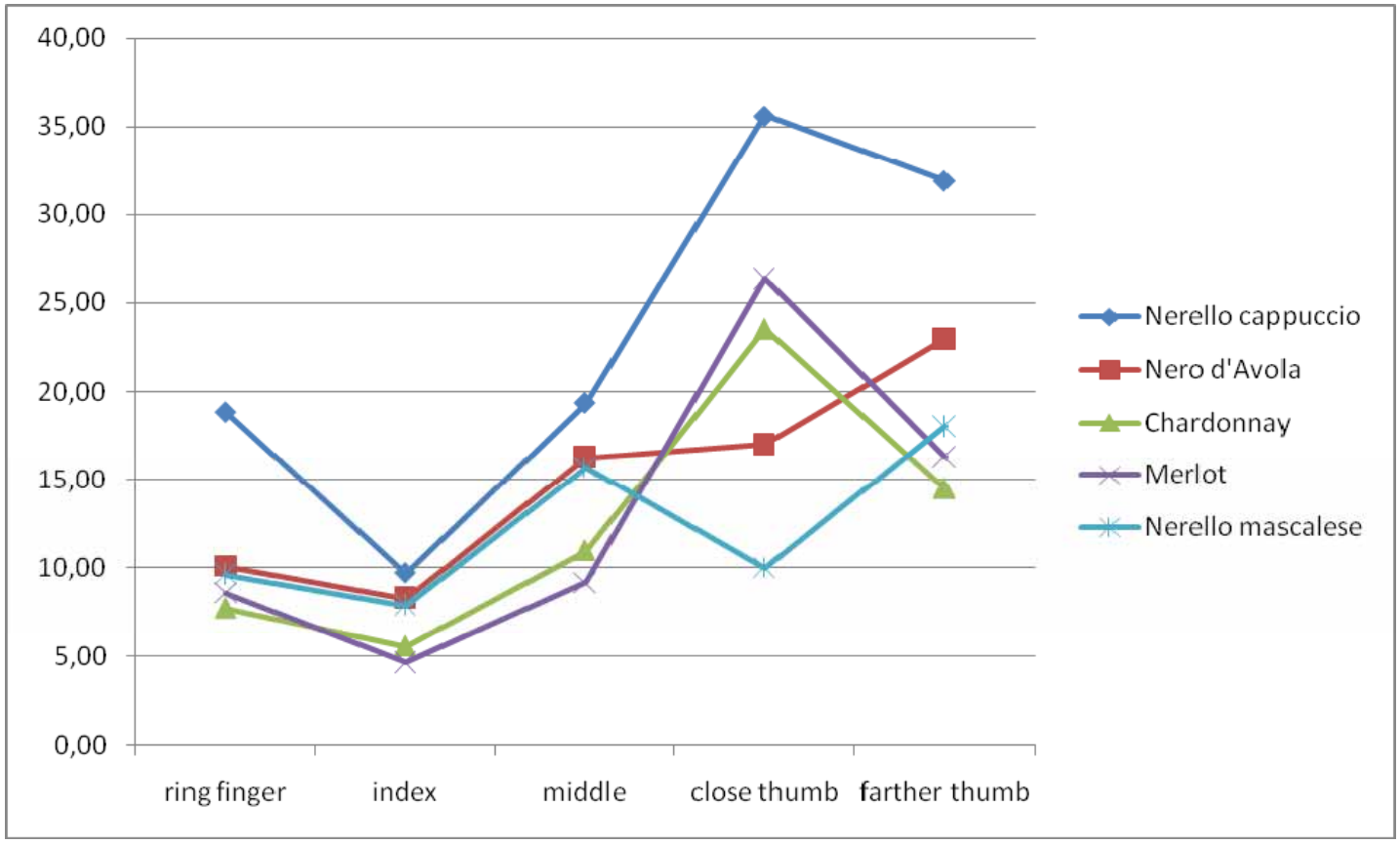
where: Fb = 250 N (EN 1005-3) and (*mv, mf, md)* are coefficients which take into account the speed, frequency and duration of the activity. Their numeric values derived from experimental trials carried out on field during winter pruning (in according to EN 1005-3)
(where: Fb = 250 N, *mv* = 0.8, *mf* = 0.3, *md* = 0.5)

Methodology

In this work, the average score of force used by employees is **not** assigned by using the **force average over the entire hand**, but the **average force referred the region most subject**. For the purposes of this study this force will be called “**maximum force**”.

Results – *Values*

Average values of force for each region of the hand.



Results – *Values*

For each cultivar was calculated by the total score of force, using the Borg CR10.

The Table shows the calculations for the cultivar Nero d'Avola, with an average time measured to prune a plant of 24 seconds and the "percentage level" ***calculated from the "maximum force" (average values recorded for close thumb) rather than the average values*** of the whole hand).

Scoring by Borg method (Colombini e Occhipinti, 2005) in Nero d'Avola cultivar.

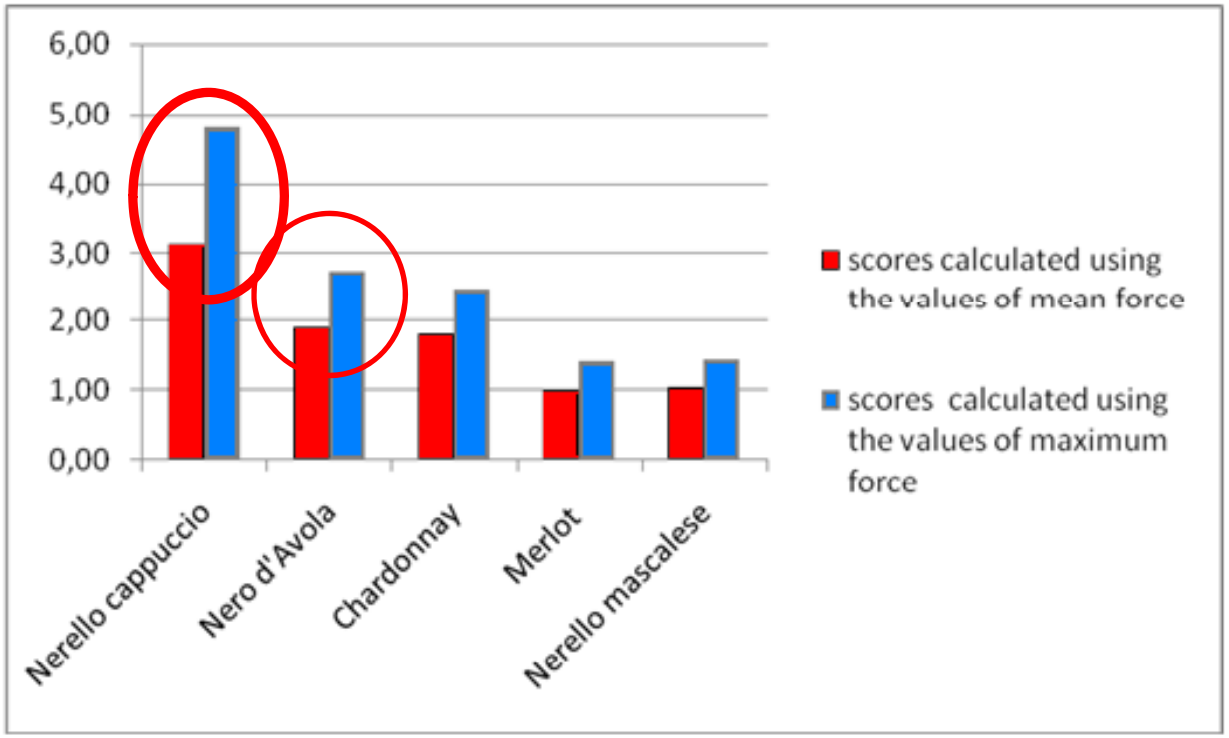
	A	B_1	B_2[1]	A x B_2
Distribution of average time of pruning [s]	Distribution of percentage time of pruning [%]	F_M/F_L*100	Borg's scoring	Weighted Borg's scoring
Cuts = 7.5	31	77	7.7	2.41
Displacement = 16.5	69	5[2]	0.5	0.34
TOT = 24	100		Totale score	2.75

[1] $B_2 = B_1/10$

[2] For displacements: $B_1 = F_L * 5/100$

Results – *Values*

Comparisons between the values of force. The graph shows the Borg's scores of the 5 cultivars, calculated using the values of maximum force and compared with scores calculated using the values of mean force used in previous research.



Weighted Borg's scores of 5 cultivars.

Results – *Values*

From the figure to a table. (Comparisons among the values of forces). The Table in the next slide presents the ratings on the force provided by the workers [A] and the Borg CR10 scale scores (on average efforts [B] and the "maximum stresses" [C]).

Borg's values: evaluations of workers, calculated scores, positioning in the scale

	Evaluations of workers score level	Measured values score level	
Cultivar	A	B	C
Nerello cappuccio	3.5 --- Moderate	3.13 --- Moderate	4.82 --- Strong
Nero d'Avola	2.5 --- Light- moderate	1.91 --- Light	2.75 --- Light - moderate
Chardonnay	2 --- Light	1.82 --- Light	2.49 --- Light - moderate
Merlot	2 --- Light	0.99 --- Very light	1.41 --- Very light – light
Nerello mascalese	2 --- Light	1.04 --- Very light	1.45 --- Very light - light

Borg's values: evaluations of workers, calculated scores, positioning in the scale

Results – *Values*

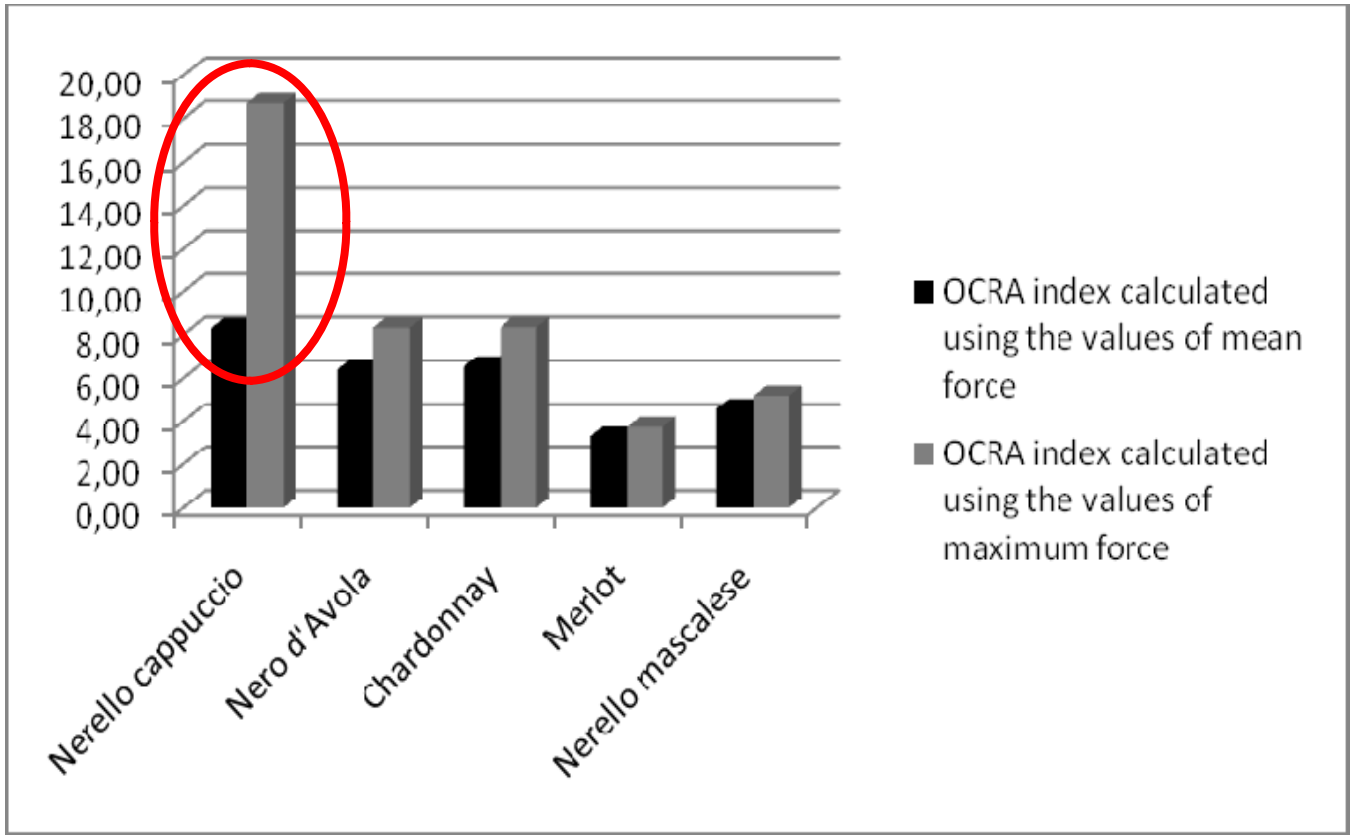
Comparisons among the OCRA index. Here are reported relatively to the 5 cultivars OCRA indexes calculated using the values of maximum force compared with the scores obtained with the values of OCRA mean force.

Cultivar	Actions n./min	Mean Force Ocra Index Risk	Maximum Force Ocra Index Risk
Nerello cappuccio	44	8.3 medium	18.7 high
Nero d'Avola	49	6.4 medium	8.3 medium
Chardonnay	54	6.5 medium	8.3 medium
Merlot	33	3.3 borderline	3.7 low
Nerello mascalese	46	4.6 Medium	5.2 medium

Results Ocra Index simulations.

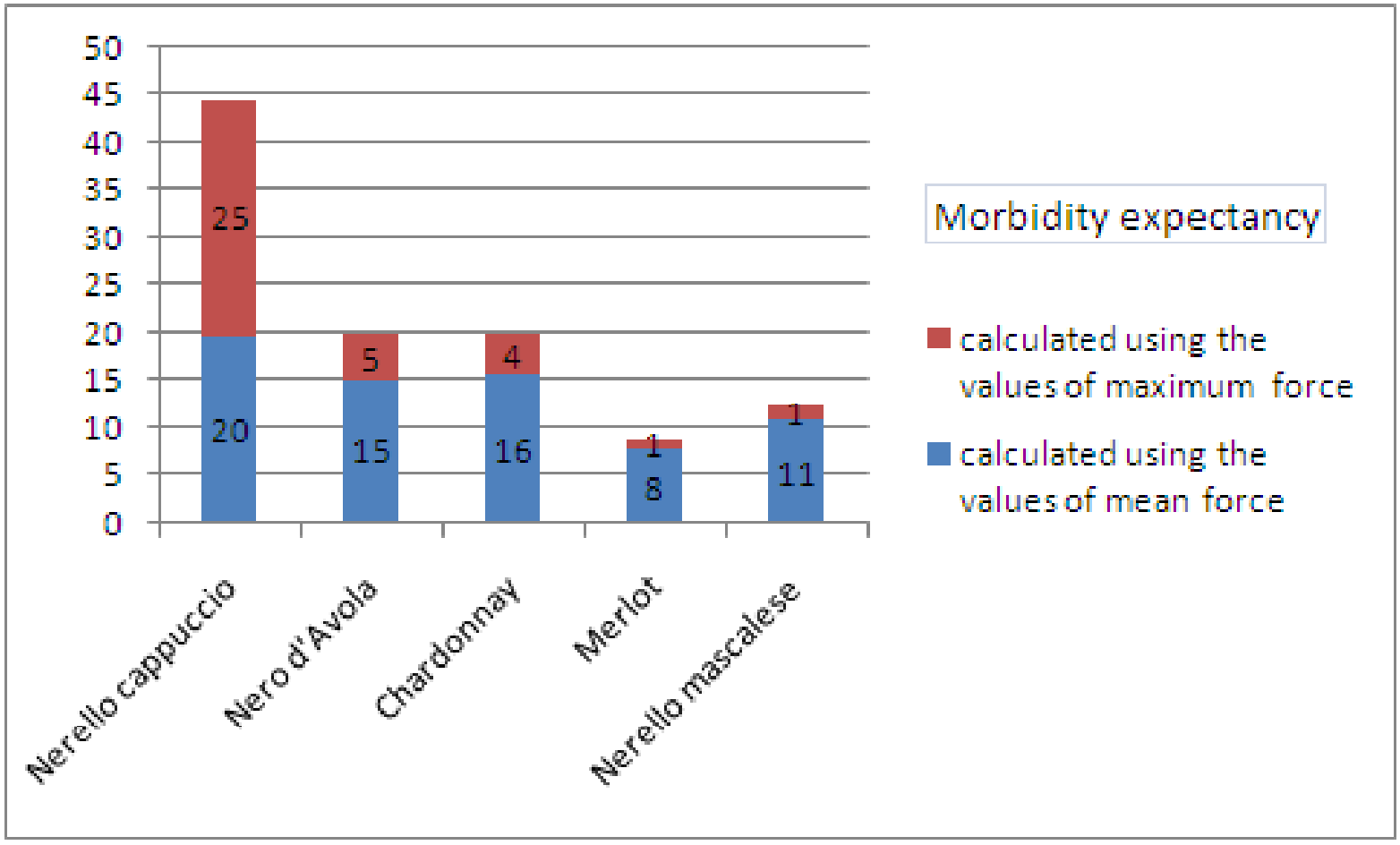
Results – *Differences ofValues*

Comparisons between the OCRA index. In Table and Fig. are reported relative to the 5 cultivars OCRA index calculated using the values of maximum force compared with the scores obtained with the values of OCRA mean force.



Results Ocra Index simulations.

Results – *Morbidity*



Morbidity (number of subjects suffering from one or more musculoskeletal disorders per 100 exposed)

Conclusions and perspectives

-**The risk of musculo-skeletal system with the calculated values of "maximum force"** was on average 42% higher than the risk calculated with the values of mean force (the OCRA procedure involves the use of the mean values of the strength referred to the whole hand) and **as concern the OCRA index we find a peak of 125%** for the cultivar Nerello cappuccio.

-**These results indicate the need to monitor** for any diseases that could affect various regions of the hand, even when the average values cover the whole hand were not particularly alarming.

- The information derived from the research seem to point towards the need to conduct investigations of ergonomic in respect of transactions involving the hand grips with pinch-type and, therefore, to conduct detailed observations and screening of a medical nature in respect of the category of pruners and more generally, of all those who perform similar tasks.

- *Results will be available to physicians with the aim to correlate hand pathologies with measured stress in localised hand regions.*

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prospetto 1 **Forza isometrica massimale F_B. Limiti di capacità della forza isometrica precalcolati per alcune attività comuni per l'uso professionale e domestico. I valori si applicano a condizioni lavorative ottimali**

Attività		Uso professionale F_B in N	Uso domestico F_B in N
	Lavoro della mano (una mano): Presa di forza	250	184

Moltiplicatore di velocità m_v, correlato alla velocità di movimento

Velocità	no l'azione non implica alcun movimento, o movimenti molto lenti	sì l'azione implica un movimento evidente
m_v	1,0	0,8

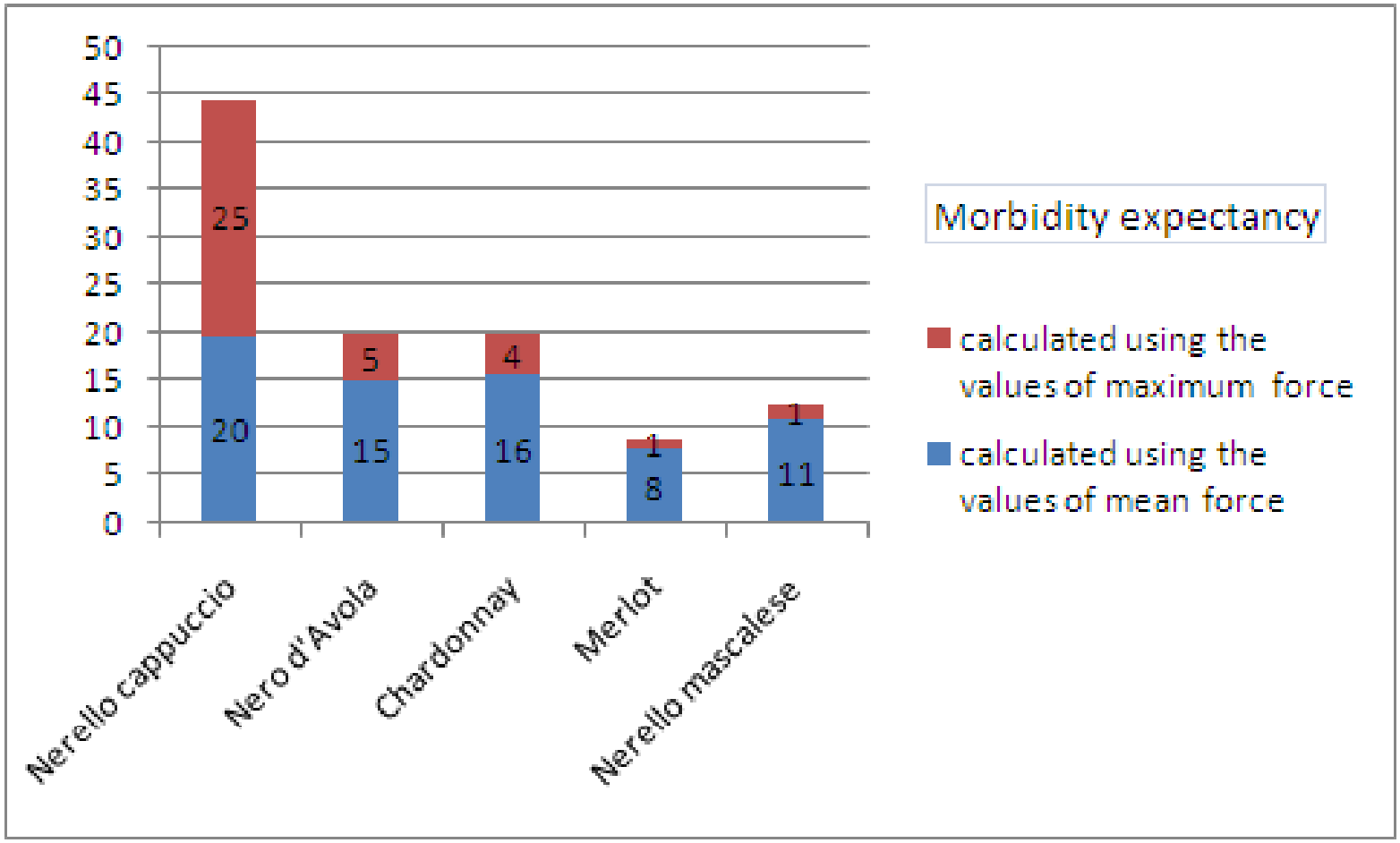
Moltiplicatore di frequenza m_f, correlato alla durata delle singole azioni ("tempo di azione") e alla loro relativa frequenza

Tempo di azione	Frequenza delle azioni (min^{-1})			
min	≤0,2	>0,2 - 2	>2 - 20	>20
≤0,05	1,0	0,8	0,5	0,3
>0,05	0,6	0,4	0,2	non applicabile

Moltiplicatore di durata m_d, correlato alla durata totale (h) di azioni simili

Durata (h)	≤1	>1 - 2	>2 - 8
m_d	1,0	0,8	0,5

Results – *Morbidity*



Morbidity (number of subjects suffering from one or more musculoskeletal disorders per 100 exposed)
Italiano: morbosità = popolazione colpita - - morbilità = popolazione rimasta a casa dal lavoro

Methodology

To allow comparison with previous work, we used the same values used to calculate the average strength of the entire hand (Schillaci et al., 2010) and therefore:

$$F_L = F_b * mv * mf * md = 30 \ [N],$$

(where: F_b = 250 N, mv = 0.8, mf = 0.3, md = 0.5)

Results – *Values*

The Table shows the "maximum force" F_M derived from shear tests and the "percentage level" necessary for calculating the Borg score (Colombini & Occhipinti, 2005).

"Maximum Force" F_m and "percentage level".

Cultivar	Maximum Force F_M [N]	Percentage level (most stressed part of the hand) F_M/F_L*100 [%]	Percentage level (whole hand) F_M/F_L*100 [%]
Nerello cappuccio	37.50	125	78
Nero d'Avola	23.00	77	50
Chardonnay	20.00	67	46
Merlot	23.00	77	44
Nerello mascalese	20.50	68	41