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Upper Limb Work-Related Musculoskeletal Disorders in the Manufacturing Industry

Mauro Carino¹, Chiara Giorgio², Daniela Martino² and Sergio Nicoletti¹

¹*Occupational Health Unit*

²*Department of Rehabilitation,
National Health Service, Bari
Italy*

1. Introduction

Light and heavy manufacturing contribute a great deal to the Italian economy and the products manufactured in this sector form a major part of the exports. Most of the manufacturing industries center around small or medium-sized firms, but there are some larger companies too. Although automation will characterize work in the future, manual labour will remain important for Italian manufacturing products whose quality is recognised worldwide.

The etiologic importance of occupational ergonomic stressors for the occurrence of musculoskeletal disorders of upper extremities has been demonstrated. The epidemiologic literature on work-related musculoskeletal disorders in combination with extensive laboratory evidence of pathomechanisms related to work stressors is convincing (Punnett & Wegman, 2004). Trends in work-related upper limb musculoskeletal disorders appear to be constantly increasing in industrialized countries (Morse et al., 2005, Waters et al., 2011) and effectiveness of ergonomic interventions achieve significant results on productivity loss at work caused by upper-extremity disorders (Martimo et al., 2010).

If the exposure is concentrated in specific industries and occupations, the industry-based cohort study is the most efficient approach to identify a causal association between occupational exposure and diseases. Industrial districts are a specific production model characterized by the agglomeration of large, small and medium-sized firms integrated through a complex network of buyer-supplier relationships and managed by both cooperative and competitive policies. Industrial districts are not just an Italian phenomenon but similar local production models are widespread all over the world.

Italy is a leading player in the upholstered furniture industry with production concentrated mainly in Lombardy (Northern Italy) and in Puglia and Basilicata regions (Southern Italy). A recent survey in the manufacturing sector investigated the largest cohort ever studied of the upholstered furniture industry in the so called "sofa district". In cooperation with the Ergonomics of Posture and Movement Research Unit in Milan, supported by a grant from the Italian Ministry of Health, the National Health Service in Bari, Italy has carried out a project on upper extremity work-related musculoskeletal disorders in a wide production

district of the upholstered furniture industry. At the time of the recruitment of the cohort, the district was represented with near fourteen thousand workers and five hundred plants in a large geographic area of Southern Italy producing sixteen percent of the world upholstered furniture production. A recent government investment addressed new funds to support the production of the district in this territory to face increasing global competition.

Advanced technology in the cycle of production is combined with performance of the workers with arm-hand intensive tasks and high labour demand. The aim of the study included: a) risk assessment to repetitive strain and movements of the upper limb in a representative sample of the plants b) analysis of prevalence and incidence annual rates over a four-year period in the groups of workers exposed at risk with normalized medical data collected by a network of occupational health physicians c) definition of possible interventions with improvement of ergonomics solutions d) education and information programs shared in the whole district e) development of new simple tools of risk identification.

2. Work tasks in the upholstered manufacturing industry

The exposed groups considered in the survey were: preparatory workers, leather-cutting operators, sewing and upholstery-assembly workers. The webbing operators apply elastic straps on the frame in order to support the padding; in the manual webbing, every single strap is fixed to one extremity of the bottom or of the back of the frame, it is pulled manually and at the same time is fixed to the other extremity. In some plants the semi-automatic webbing is also present, reducing around fifty percent of the activity of manual traction of the straps. Therefore the webbing operator carries out the tasks of frame handling (before and after the webbing), stapling (with appropriate compressed air tool with metallic points) and manual traction of the straps. The duration of a cycle varies between 1 and 8 minutes. The webbed frames and packs with padding meet on the table of the frame outfitter that sticks the expanded polyurethane (EPU) padding on the frame. Typical tasks of the frame outfitter are: frame handling (before and after that the EPU has been fixed), EPU handling, distribution of the glue with spray-gun on the frame and on other pieces of EPU, application of single pieces of EPU that is fixed to the frame also with pressure of the hands. The duration of a preparation-outfitting cycle can vary (based on complexity of the sofa model) with an average of approximately eight min. In most plants the two work task are unified (webbing operator/frame outfitter).

Another production line supplies the sofa covering. For leather sofa, the job is still today mostly manual in all the plants. In the phase of search of the natural markings the leather is ironed with the hands in order to estimate the characteristics, then the leather cutting is made with one simple manual tool with vertical blade: the necessary exertion to this task is function of the thickness and the hardness of the skin.

The average life of the cutting cycle of one leather hide is approximately twenty minutes. The leather cutter captures the single hide from a support close to his own workstation and spreads it on the cut table. Then he checks all the hide in order to identify any natural marking. This phase implicates that the leather is ironed with the hands and the strain practiced from the operator depends upon thickness of the raw materials (soft skin, thick skin, crust) and from the qualitative level of the final product. Then the operator puts in the correct position the shape-support on the hide. The leather cutting is made with one simple manual tool with vertical blade: the necessary exertion to this task is once again function of the thickness and the hardness of the skin.



Fig. 1. The productive cycle in the upholstered manufacturing industry: the leather cutter.

The cut material (textile or leather) is then processed by the seamstresses in order to produce the definitive covering: this part of the cycle is made of separated phases that can be carried out from one single operator, or can be carried out in distinguished tasks. In this case the passage from one task to the others is made by the same (usually female) operator. The duration of a seam cycle is extremely variable. The effort of the operators depends on softness and thickness of the covering to be sewed (with one increasing progression from the woven to the microfiber, to soft leather, the thick leather until the crust) and from the complexity of the sofa model.

The frame covered with EPU and with covering converges finally to the worksite of the upholsterer / assembler that performs the final phase of cycle: dressing the frame with the covering, filling up backs or pillows with the padding, completing the assemblage of single parts, and, if requested, mounting accessories (nets for the sofa-bed, recliner mechanisms, etc.). He performs the actual “dressing up” of the sofa, when the covering is progressively forced on the padding for being definitively fixed to the base.

The average time of duration of the cycle is thirty minutes. This assembly job is characterized by a high number of technical actions in two tasks: dressing up and cushion filling. A remarkable use of strain is requested, with Borg index peaks exceeding values of five when handling hard rubber and thick leather. The remarkable exertion in the phase of dressing up is due to the covering resistance, to the uncomfortable pinch during the draft operations of the covering, to the friction between the covering and the rubber.

A total workforce of more than five thousands individuals described in tab.1 was studied. For workers employed in the years in different companies but with the same work task, the working seniority has been calculated from the date of the first enrolment in any company of the production district. In the three largest companies (large = more than five hundred employees) the voluntary dropout rate per year was four percent, with a further annual eight percent because of the leaving off the job relationship or for an unsuccessful test-period. Almost forty per cent of the workforce studied was involved in small-medium size companies as shown in tab. 2.



Fig. 2. Upholstery-assembly worker with arm-hand intensive work task.

work task	M	F	M+F	age (yrs, mean)	exposure (yrs, mean value)
upholstery workers	973	0	973	29,6	6,6
frame outfitters	309	4	313	32,0	7,6
seamstresses	13	1289	1302	30,0	8 (6,9*)
cutting operators	595	90	685	29,4	6,0
carpenters	182	0	182	34,2	10,0
worker controls	1402	196	1598	35,2	8,7
blue collar controls	531	192	723	35,4	7,8
total employees	4005	1771	5776	32,9	7,7
* adjusted for absence due to pregnancy					

Table 1. The study population

Plant size (employees)	< 50	51-100	101-500	>500
Number of plants	19	6	4	1
Total employees	423	437	1044	3261

Table 2. Characteristics of the plants

3. Assessment of exposure and epidemiological measures

Exposure assessment in the literature has too often been limited to crude indicators, such as job title. Worker self-report, investigator observation, and direct measurement each add to understanding, but the lack of standardized exposure metrics limits ability to compare findings among studies.

Different methods assessing biomechanical exposure at work are reported in the literature (Takala et al., 2010). Among main observational tools in the European Union the Occupational Repetitive Actions (OCRA) index is the reference method chosen for International Organization for Standardization (ISO) and European Committee for Standardization (CEN) standards and it was used in this survey as index for exposure assessment to repetitive strain and movements of the upper limb. The index obtained at the end of the evaluation is the ratio between the number of actions performed by upper limb during a single work shift and the corresponding number of recommended actions (Occhipinti, 1998). Main factors influencing the risk are frequency, strain, posture, complementary risk factors, pauses. The index predicts the onset of upper limb musculoskeletal disorders based on multiple linear regression functions, in which the independent variables are represented by both the OCRA exposure index and by parameters relative to the breakdown by gender and age of the groups of exposed workers (Occhipinti & Colombini, 2007). An index value higher than 4 (red area) implicates medical surveillance and work procedures interventions. To the control group it has been attributed a value of 2,2 that is a borderline value between absence of exposure and an uncertain or very light exposure (Nicoletti et al., 2008a).

The available epidemiologic evidence in the literature on work-related upper limb musculoskeletal disorders will benefit from longitudinal data to better evaluate gaps in knowledge concerning potential selection bias in the form of the healthy worker effect, natural history, latency of effect, prognosis.

All the data for the epidemiological cohort survey have been collected from individual medical records. For case definition the following criteria with objective findings were adopted: a) shoulder diseases, lateral and medial epicondylitis, wrist-hand tendinitis and tendon-related cysts have been documented at least through diagnostic ultrasound examinations. Magnetic resonance (MR) or computed tomography (CT) imaging were also considered if available; b) carpal tunnel syndrome was assessed through electrodiagnostic study. It was considered abnormal if a ≥ 2 SD reduction of conduction velocity of the

electromyographic (EMG) evaluation or of the motor/sensory nerve conduction velocities (MCV/SCV) was present. Adequate consideration in many cases was given to diagnostic ultrasound examinations documenting a simultaneous tendon-related disorder. The following epidemiological measures were used: a) incidence (onset of new cases per year) in the four-year period of the study , new case = worker affected for the first time by at least one disorder during a year-around frame time. New cases annual incidence rate (I) = number of new cases x 100/ workforce at December 31 of each year; b) new cases mean annual incidence rate = arithmetic mean of new cases annual incidence rates in a four-year period; c) prevalence: % of cases at Dec 31, case = worker who got at least one disorder during his working history, with actual job activity, cumulative prevalence rate (P) = n. of cases x 100/ total number of subjects at Dec 31 of the year.

The results of the survey with gender differentiation in the total population studied are reported in table 3. It is possible to identify the extent to which the outcome upper limb musculoskeletal disorders occurs more frequently in the exposed group than in the unexposed. The annual mean incidence rate in the four year period and cumulative prevalence rate in the various working tasks are showed.

	work tasks	n. employees	OCRA index *	I	P
M	tot. employees	3236		2.0%	8.5%
	upholstery workers	840	10.9	5.5%	22.6%
	frame outfitters	270	7.1	3.1%	12.5%
	leather cutter	502	8.4	2.2%	8.7%
	worker controls	1624	2.2	0.8%	3.6%
	correlation with OCRA index			0.89	0.88
F	tot employees	1427		1.8%	8.1%
	seamstresses	1148	11.0	2.1%	9.4%
	leather cutter	89	8.4	3.5%	15.1%
	worker controls	190	2.2	0.8%	4.4%
	corelation with OCRA index			0.68	0.66
* mean value among all plants adjusted for the number of employees					

Table 3. Annual incidence mean value (I), cumulative prevalence (P), gender, work task and correlation with OCRA index.

Correlation analysis between the two epidemiological rates and the OCRA index is reported (it was used the mean value of the index for each work task, adjusted for the number of the employees of each plant). Cumulative prevalence of diagnosed single disorders reached peak values of nineteen per cent as reported in table 4.

work task	shoulder diseases	epicondilitis	wrist tendinitis and tendon-cysts	carpal tunnel syndrome	hand tendinitis	others disorders
upholstery wkr	1,9%	5,1%	19,0%	1,8%	1,3%	0,0%
frame outfitter	1,1%	2,5%	7,2%	0,0%	2,9%	0,0%
leather cutter M	1,7%	2,1%	5,6%	0,4%	0,6%	0,0%
leather cutter F	2,2%	2,2%	7,8%	2,2%	0,0%	0,0%
seamstresses	0,8%	1,7%	7,9%	2,9%	0,3%	0,0%
carpenters	0,6%	0,0%	2,2%	0,6%	0,6%	0,0%
wrkr controls M	0,5%	1,0%	2,0%	0,3%	0,2%	0,0%
wrkr controls F	0,0%	0,5%	2,6%	0,5%	0,5%	1,0%
tot employees	1,0%	2,1%	7,3%	1,2%	0,6%	0,0%

Table 4. Cumulative prevalence of different upper limb musculoskeletal disorders in single work tasks.

Even though the female gender is considered a predisposing factor for the onset of upper limb musculoskeletal disorders (Islam et al., 2001), no significant differences were observed in our cumulative prevalence data. Probably gender differences are important for low-medium levels of exposure, but tend to be less important to increasing level of risk. About single diseases, the greatest prevalence of all disorders was observed in the group of the upholstery workers, except for shoulder disease that has a higher prevalence in the group of the cutters (with no gender-related differences). Furthermore a Poisson multiple regression analysis of persons/year incidence rates and OCRA index data in three large plants of the upholstered furniture industry did not show an association with female gender, with the single exception of the carpal tunnel syndrome (RR 3.08; 95% C.I. 1.64-5.79) (Nicoletti et al., 2008b), (Palmer et al., 2007). Among all the factors influencing the risk (frequency, strain, posture, complementary risk factors, pauses) posture seems to play a relevant role.

Task activities analyzed in the sofa industry are characterized mainly by cycles between five and sixty minutes. The sequence of the single tasks in the different cycles of production may vary with the sofa model, even all sub-tasks save their own characteristics. A correct

application of the method achieved a concise and accurate assessment of the risk, even though the tasks analyzed in the upholstered manufacturing industry were not always very repetitive and stereotyped.



Fig. 3. The seamstress work task showed the highest incidence rates of carpal tunnel syndrome with a gender association.

The OCRA index showed good correlation with prevalence and incidence rates. In particular the annual incidence rate, rarely investigated in the literature, showed even a better correlation than prevalence rates. For preventive purposes a reliable risk assessment does not exclude health surveillance programs. Standardized procedures of identification a sudden increase of the incidence of cases of work-related upper limb musculoskeletal disorders may be strategic in facing epidemic onset of the disorders that may occur in some circumstances such as highly intensive production of thick leather sofa.

4. Causation analysis and latency issues

In Europe claims and compensation for these disorders have significantly increased. In Italy there is a positive trend for the number of claims of suspected work-related upper limb musculoskeletal disorders that are compensated from the National Agency for Occupational Diseases. The reporting of these diseases is mandatory for the observing physician with a legislation that contains a detailed list of diseases subject to compensation.

The problem of proper quantification of the risk has been resolved because both the standard EN 1005-5 and ISO 11228-3 have indicated the Occupational Repetitive Actions index as method of risk assessment investigation. Defining the criteria for the association of these diseases with the occupational origin are aspects becoming increasingly important not only in relation to the growing number of recognized occupational diseases but also in relation to both economic and legal implications.

The main goal is to identify causal association between occupational exposure and disease and characterize the evidence that might be used to support work relatedness. A principle underlying the philosophy of science is that causality can only be inferred with different degrees of certainty, leaving open room to differences in its assessment. The need to secure contributions to help filling some gaps in the process of recognition of these diseases as work-related has been previously highlighted (Punnet & Wegman, 2004).

A first key element is the chronological (temporal) criteria. This term includes two time-related concepts: exposure must precede the onset of the disease and the time between start of exposure to specific risk and onset of illness must be plausible. This period is commonly referred as latency time.

A recent study investigated the temporal relationship between the beginning of occupational exposure to repetitive movements and exertions of upper limbs, assessed through the OCRA index, and the manifestation of the disorders (Nicoletti & Battevi, 2008). Clinical and questionnaire information about 557 cases of work-related upper limb musculoskeletal disorders in the upholstered furniture industry were analysed in order to investigate the mean latency period of the disorders and to verify to what extent different levels of exposure influence the latency time.

The latency of upper limb musculoskeletal disorders is influenced by the level of exposure to risk, measured with the OCRA index. Shorter latency times were found for wrist/hand tendonitis, with a mean latency time of 5.4 years and with a greater sensitivity to the level of exposure assessed with the index value. This might support a sort of predictive value with reference to other musculoskeletal disorders with longer latency. Probably a latency period of 12 years may be suggested as the cut-off limit to assess a causal relationship between tendon or canalicular diseases and occupational exposure to repetitive movements and exertions of upper limbs.

5. Preventive strategies: Information and education programs

Based on described evidence of occupational risk of upper limb musculoskeletal disorders in the sofa district, the Italian National Agency for Injuries and Occupational Diseases started a large education and training campaign in the whole district, taking into consideration that around five-ten percent of the total workforce per year may change company, still remaining in the same district (workforce mobility). Education and information play a fundamental role among strategies and initiatives taken in order to implement a set of standards of health and safety at work in the whole upholstered manufacturing industry district (Carino et al., 2008). A participated approach together with a network communication system is considered essential for a successful prevention. Training techniques using participatory methods and worker empowerment philosophy have proven value. There is demonstrated need for the use of

education for action, promoting the involvement of workers and unions in different levels of problem solving at workplace. Appropriate emphasis is given to the learner involvement and to train-the-trainer approaches.

A broad range of professionals are involved. First level educational programs are four-hours sessions and are addressed to homogenous groups of preparatory workers, leather-cutting operators, sewing and upholstery-assembly workers. In each session data about risk assessment on each task are presented and videotapes recorded during operating activity and commented with the same operators will be used in order to investigate incorrect behaviors and better solutions. Technical suggestions for the redesign of workstations with an interactive approach are collected. A second level course is programmed for unit foremen, safety managers and workers safety representative individuals. A total of sixteen hours session concerns twenty-person class and includes discussion on legislation, individual responsibility, risk assessment evaluation criteria for single tasks, consequences on health, discussion of compensated cases, technical solutions on cost/benefit analyses, hypotheses of redesign, videotapes recorded during operating activity. A third level course is scheduled for the management and is a four-hour workshop format with highly qualified speakers.

6. Ergonomics solutions and risk management in large companies

In order to manage the replacement of subjects affected from upper limb work-related musculoskeletal disorders in adequate tasks, different procedures were set up in large companies (Nicoletti et al., 2008c). A first risk assessment was realized through a joint evaluation of the occupational physician and of the human resources and production engineering departments. After this preliminary approach, concise and accurate methods such as the OCRA index and the OCRA check list were widely used for collecting maps of risk assessment of single task and possible replacement jobs. Subsequently, for the progressive saturation of tasks not at risk, it was necessary to redesign tasks for upper limb musculoskeletal disorders affected subjects. The insertion of structured pauses every hour and the redesign of single tasks concurred to obtain relevant decrease of the OCRA index (tab.5).

To face an employee health problem that can be aggravated from the occupational exposure, the occupational physician communicates through standardized procedures with the human resources department in order to promptly characterize feasible solutions (immediate or postponed). Affected individuals are excluded from the normal calculation of the productive performances of the team of the unit. Occupational therapy programs are considered in particular for shoulder and elbow disease in cutters and upholstery-assembly workers (Von der Heyde, 2011) (Bohr, 2011). Subjects with limitations because of upper limb work-related musculoskeletal disorders undergo through differentiated protocol of health surveillance: medical examination after 30 days (or even earlier on request of the worker) to verify the suitability of the new assigned tasks, health controls every six months, diagnostic check when no more symptoms are reported, progressive replacement to the previous task after three months of completely negative clinical (historical-objective) confirmation, further medical examination after 30 days (or earlier if requested from the worker), six month periodic surveillance. Functional tests for the upper limb are very helpful to give precise medical advice to prevent individual complaints. The results are also helpful for developing specific training programs before beginning new tasks as well as for rehabilitation reasons (Spallek et al., 2010). It is reported a high percentage of subjects

recovered to the earlier task (60%) and the leaving off figures are similar to regular turnover of the production district (13 % per year).

The greater part of the interventions concerned in particular the tasks of the upholsterer and of the leather cutter. Until today no automatic technology (water laser, high pressure jet, blade vertical alternative, etc.) has caught up levels of competitive qualities in comparison with the manual cut (in terms of leather consumption and of quality of the final product). The large companies acquired leather automatic cutting machines and the experimental program involved great part of affected and replaced workers. Recently it has been opened a new perspective pursuing the idea of the surgical-like ultrasound lancet and it seems very promising because eliminates strain of upper limb also with harder leather, without imposing changes in the usual way to operate (the final tool has quite the same shape of the traditional one), without demanding large economic investments and with no additional cost for training the operators.

For the task of the seamstress is more difficult to find technical solutions to reduce the overload of upper limbs. The adopted interventions concern more general ergonomic aspects of the task. The adoption of the automatic warehouse of the boxes and the conveyor tape has reduced some operations of load manual lifting. All the plants have adopted height-adjustable chairs in order to give chance to the seamstress to assume a correct posture. Padded chairs were chosen with lumbar reinforce in order to improve the posture. On request of the operator it has been activated an internal procedure that can personalize the height of the worktable.

<i>task</i>	<i>OCRA initial task</i>	<i>redesigned task</i>	<i>OCRA redesigned task-pause</i>
upholsterer	12.0	soft leather models only	4.7
		soft leather models only	3.9
leather cutting	8.9	no cutting operations	2.2
		soft leather and textile models only	4.4
seamstress	10.1	textile models only + decking sewing	4.2
		decking sewing only	2.3
		decking sewing only + textile piece sewing	3.1
frame outfitter			
indirect activ.	8.1		3.5
control group	2.2		2.2

Table 5. Occupational Repetitive Actions (OCRA) index values of initial and redesigned tasks for workers affected by upper limb musculoskeletal disorders.

For the upholsterer-assembler each assembly workstation is equipped with a polyethylene film coil that the upholsterer applies in the points of greater friction of the covering (usually in the angles) in order to facilitate the sliding. Furthermore the percentage of tight models production was reduced.

The most important result for reduction of strain has been the project of a self-locking clamp for the phase of dressing up that completely changes the pinch to wide grip. The held on the covering increases with the strain exercised from the operator. The clamp reduces the exertion with all kind of materials, but workers nearly exclusively use it for the thick leather or for the crust. A survey about the Borg index was carried out in 40 upholsterers: the strain without clamp was quantified medium with a value of 6,3 (value attributed to the task "to pull the hard skin" without the clamp); the use of the clamp reduced the value to 3,1 (in the same questionnaire tasks "to pull the soft skin" and "to pull the woven" were quantified respectively with 2,6 and 2,2 values).

During the dressing up of the sofa, the covering is "struck" tangentially in order to improve the sliding (the more expert upholsterers reports that it is sufficient "to caress it"). The strain applied in this operation can be reduced if the adhesion of the hand to the covering is greater. For this purpose it has been introduced a special glove with small "rubber buttons" on the palm surface that guarantee greater adhesion between the hand and the covering (in the case of leather covering). The effectiveness of the glove has been tested on all the type of covering but the upholsterers nearly use it exclusively on the coverings of hard leather. An investigation has documented that the use of the two devices is diffused among operators that have suffered in the past from upper limb work-related musculoskeletal disorders (80-100 %, in the different plants). The other task characterized from elevates indices of strain is the cushion filling, especially in the case of pillows in hard rubber. A machine for the semi-automatic filling of the pillows in hard rubber has been introduced only for the "flying pillows" not berthed to the structure of the sofa.

Another basic innovative idea for the reorganization of the task it was to introduce in one task other different tasks that somehow diluted the biomechanical overload for the upper limbs. It has been decided to unify tasks previously carried out from the frame outfitter, the upholsterer, the cleaner of the finished product and the quality control operator.

7. Development of simple tools of risk identification in small-medium size companies

One of the most common procedures for risk assessment of upper limb work-related musculoskeletal disorders in Italy is the OCRA synthetic index, which is the suggested method to measure biomechanical overload in the ISO 11228-3. Systematic reviews of different methods assessing biomechanical exposure at work are periodically reported in the literature, evaluating the possible use of more than one of them following job site and working characteristics analysis (Sala et al., 2010).

The aim of the described cohort survey was to assess the risk of those disorders due to repetitive strain and movements in thirty factories of the sofa industry located in a large geographic area of Southern Italy. The most characteristic working tasks of the manufacturing process were studied: filling preparation workers, leather-cutting operators, sewing and upholstery-assembly workers. The single tasks were carried out almost

exclusively manually, with features of a handicraft approach. Data were collected through questionnaires and video tape recordings in each factory for the OCRA index computation (ratio between the ATA-actual number of technical action carried out during the shift and the RTA-number of reference technical action for each upper limb in the shift). The mean value of the index of every group of the factories was calculated by weighting the values of the index of each single task group with the number of workers. To the control group it has been attributed a value of 2,2 that is a borderline value between absence of exposure and an uncertain or very light exposure. An index value higher than 4 implicates medical surveillance and work procedures interventions. Detailed figures obtained in the different factories showed values of the index ranging between 4 and 15 as reported in tab. 6.

task job	p l a n t c h a r a c t e r i s t i c s			total n. of subjects (2000-03)	O C R A i n d e x		
	size (n. of employees)	workday pauses	number of plants		employee - adjusted mean	min	max
upholstery workers	< 1 0 0	1	4	4 7 , 5	1 3 , 7	1 1 , 3	1 4 , 6
		2	1 5	7 4 , 5	1 0 , 3	8 , 5	1 1 , 0
		3	6	3 0	9 , 5	7 , 8	1 0 , 1
	1 0 0 - 5 0 0	1	2	7 0 , 8	1 2 , 8	1 0 , 4	1 5 , 2
		2	2	8 4 , 3	9 , 6	7 , 8	1 1 , 4
	> 5 0 0	1	1	5 8 3	1 0 , 9	1 0 , 9	1 0 , 9
frame outfitter	< 1 0 0	1	4	1 7	7 , 7	6 , 3	8 , 2
		2	1 5	3 1 , 1	5 , 8	4 , 7	6 , 1
		3	6	1 2 , 8	5 , 3	4 , 4	5 , 7
	1 0 0 - 5 0 0	1	2	5 3 , 3	7 , 4	6 , 1	8 , 8
		2	2	3 5 , 8	5 , 6	4 , 6	6 , 6
	> 5 0 0	1	1	1 4 2	7 , 7	7 , 7	7 , 7
cutting operators	< 1 0 0	1	4	4 1 , 5	9 , 9	8 , 2	1 0 , 6
		2	1 5	7 8	7 , 4	6 , 1	7 , 9
		3	6	3 0 , 8	6 , 9	5 , 7	7 , 3
	1 0 0 - 5 0 0	1	2	3 7 , 1	8 , 7	7 , 1	1 0 , 3
		2	2	3 7 , 5	6 , 5	5 , 3	7 , 7
	> 5 0 0	1	1	3 5 8	8 , 7	8 , 7	8 , 7
seamstresses	< 1 0 0	1	4	6 9 , 5	1 2 , 1	1 0 , 0	1 2 , 9
		2	1 5	1 6 0	9 , 1	7 , 5	9 , 7
		3	6	3 6 , 5	8 , 4	6 , 9	8 , 9
	1 0 0 - 5 0 0	1	2	1 0 9	1 0 , 7	8 , 7	1 2 , 6
		2	2	8 9 , 8	8 , 0	6 , 5	9 , 5
	> 5 0 0	1	1	7 0 8	1 1 , 9	1 1 , 9	1 1 , 9
worker controls	< 1 0 0	1	4	5 8 , 5	2 , 2	2 , 2	2 , 2
		2	1 5	1 5 2	2 , 2	2 , 2	2 , 2
		3	6	6 3 , 8	2 , 2	2 , 2	2 , 2
	1 0 0 - 5 0 0	1	2	1 6 4	2 , 2	2 , 2	2 , 2
		2	2	1 4 1	2 , 2	2 , 2	2 , 2
	> 5 0 0	1	1	1 2 8 0	2 , 2	2 , 2	2 , 2

Table 6. OCRA index values according to work tasks and plant characteristics.

Even though the work tasks analysed were characterized by long duration of the manufacturing cycle (between 5 and 60 min), a particular but rigorous application of the OCRA procedures made possible a detailed risk assessment for each of the working groups.

Main organizational variables influencing the same index such as work task, size of the plant and number of structured pauses during the working day were considered.

The OCRA method allows analytical in depth data (details are provided by video documentation and several interviews) and requires devoting time experienced personnel.

Because of the widespread presence of work-related musculoskeletal disorders in various work contexts there is a strong demand from occupational safety agencies and from operators to develop simple tools for risk assessment and management in particular in craft industries and small-medium manufacturing enterprises.

The World Health Organization promoted the development of toolkits for different occupational risks and diseases. They are defined as “a set of practical risk assessment procedures and related management guidance documents, including advice on simple risk control options”. The Ergonomics of Posture and Movement Research Unit in Milan is involved in the project for developing a toolkit for musculoskeletal disorders prevention.

Criteria for a “quick risk assessment” mainly aim at identifying three possible conditions: acceptable (no remedial actions needed); high risk present (redesign is urgently needed); more detailed analysis is necessary, using proper tools for risk estimation (derived from recognized literature, international standards and/or guidelines) in work sectors that are often not reported in the literature. It must be emphasized the importance of considering work organizational aspects such as recovery periods, rotations, action frequency, duration as much as traditional mechanical factors such as force, loading, non-neutral posture (Occhipinti & Colombini, 2011).

In line to the need of new and more easily applicable tools for risk assessment, it was recently developed the Occupational Repetitive Actions mini-checklist, a method to obtain a flexible and easy to handle risk assessment for upper limb repetitive movements. Experiences in different manufacturing industry contexts have been recently carried out and this instrument derives simplified and yet reliable evaluation results especially in sectors with production variability (Colombini & Occhipinti, 2011).

According to the Italian legislation on health and safety at work, cooperative effort to risk assessment, periodical inspection at worksite and definition of health surveillance protocols are specific obligations in the daily practice of the occupational physician. Possible users of toolkits are also members of committees, line supervisors, foremen, government representatives, health workers providing basic occupational health services.

8. Conclusion

Upper limb musculoskeletal disorders at worksite impose a substantial economic burden in compensation cost, lost wages and productivity in large areas of the Italian manufacturing industry. A cooperative effort of different institutions of research, national health insurance agency, territorial health surveillance departments and numerous privately owned firms may result to face a significant occupational risk. A participated approach together with a network communication system is considered essential for a successful prevention. Plants of different size may share information programs, cross training, insurance incentives and concur to the possibility of transferring best preventive practice from high quality risk

assessment and ergonomic interventions of larger companies to small-medium firms also through the use of simple tools for risk identification.

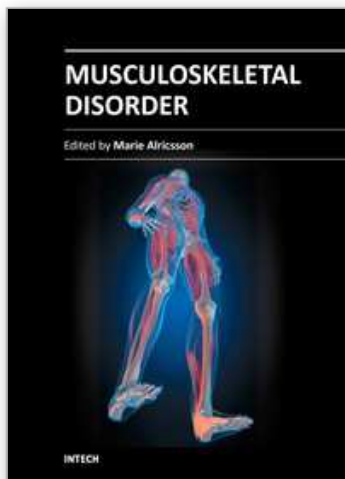
Ergonomic interventions not only concur in the management and control of negative events for workers health but also in achieving advantages in terms of lower costs and greater productivity. A complete intervention that uses all available instruments such as risk assessment, health surveillance, education, task analysis, reorganization and technological innovation can achieve appreciable results.

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Work-related musculoskeletal disorders are a significant problem throughout the world. The work environment has undergone rapid changes in recent years. With increasing number of workers being tied to man, machine systems, susceptibility to constrained postures, visual strain and mental and physical stresses have increased. This book is a collaboration among many clinicians and researchers and a small step in addressing these issues by discussing various aspects of musculoskeletal disorders from different professions, researchers and countries.

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InTech Europe

University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China

Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

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