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Risk prevention and control strategy for upper limb musculoskeletal disorders.

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INTRODUCTION

Numerous methods are described in the literature to evaluate the risk of musculoskeletal disorders of the upper limbs (ULD). These include checklists, assessment scales, observation techniques or even very sophisticated measurement procedures. Two fundamental criticisms can be formulated concerning these approaches developed and published by experts:

- they usually do not correspond to the expertise and the technical and time possibilities of the people responsible for the working conditions at these workplaces, in the large, and obviously, in the small companies;
- the objective of these people is not to evaluate the risk, as scientists would do in the context of epidemiological studies, but to collect the information needed to improve the working conditions and, if possible, to avoid the problems.

Actually, the participation of the workers usually guarantees that some significant control measures will be easily and readily found. An intervention study requires therefore a procedure allowing the people responsible for risk prevention to gather information progressively, as it becomes necessary to define the adequate control measures.

This paper proposes a procedure in four stages of increasing complexity, to be used successively, if necessary, by people with different expertise levels. Its objective is to help these people to recognise conditions with a risk of ULD and to identify the most adequate corrective or preventive measures.

DESCRIPTION OF THE PROCEDURE

The philosophy of the strategy is not specific to the problems of musculoskeletal disorders. It is recommended in industry for the prevention of any type of risk (Malchaire et al. 1998a; 1998b; 1998c; 1998d; 1999).

- At stage I, *"Screening"* the complaints or disorders presented by the workers are reviewed and the working conditions are rapidly inspected. It is then decided whether to study the problem more in detail and to look for means to avoid this risk and make the work as comfortable as possible.
- If the problem cannot be directly controlled, a stage II: *"Observation"* is then started by the people in the company who are in charge of the organisation of the working conditions and the work places.
- If these persons are not able to define satisfactory solutions, the assistance of specialists is searched and a more detailed stage III: *"Analysis"* is performed.
- Still, if this *"Analysis"* does not make possible to find the necessary solutions, the complementary assistance of experts is required for the stage IV: *"Expertise",* oriented towards a very specific aspect of the working conditions, in order to single out final control solutions.

Table 1 describes the characteristics of the four different stages.

Stage I: "*Screening*"

The method must be very simple to understand and to use, ideally by the workers themselves who know perfectly their working conditions. It must not be time consuming in order to be used systematically as soon as a problem is suspected. Table 2 deals with different items that can be proposed to the workers, the objectives being to discuss the circumstances, the reasons and the simple improvements that can be brought to eliminate the problem.

Stage II: "*Observation*"

The method must remain simple to use in the field by the people responsible for the organisation of the working conditions who usually are not trained concerning the musculoskeletal disorders. The method should again be rapid and little expensive. A checklist (table 3) was developed, based on a proposal by Keyserling et al. (1993). It includes the main aspects of the working conditions (postures, forces, and repetitiveness…) that could contribute to the development of an ULD. No limit is specified at this stage, the optimum situation being simply the one that requires the minimum of rotation, twisting, forces...

Table 4 gives the four questions to ask for each item of the checklist. The participants (workers and the technical services) are invited to estimate whether the unfavourable item occurs "*sometimes*", "*often*" (suggested as about one third of the time) or "*always*", for the body zone concerned (neck, shoulders,

elbows, wrists/hands). Again, rather than searching for a consensus on this frequency, they are invited to consider the reasons for it and to seek together ways to avoid the situation or to reduce its occurrence.

At the end of stage II: "*Observation"*, an overview of the risks before and after implementation of the control measures can be achieved in counting the number of items occurring "*often*" or "*always*". This makes possible to determine the overall efficiency of the proposed measures as well as the acceptability of the anticipated situation. If this situation does not seem acceptable, it is easy to identify the zone of the upper limbs which is the most exposed, the priority with which additional control measures must be found and therefore the priority of a more detailed "*Analysis"*.
The acceptability judgement is based on the perception of the work. There is no reason however to believe that the *"subjective"* evaluations by the workers, who know perfectly their working conditions, are less reliable than the so-called *"objective"* evaluations by experts, who have limited knowledge of these conditions. Nevertheless, it is recommended to adopt a safety factor and it is suggested to have recourse to a stage III: "*Analysis"* as soon as some items occur *"often"* for the same body segment.

Stage III: "*Analysis*"

In most cases, working conditions can be significantly improved and the risk of ULD eliminated based on the *"Observations"* discussed above. In certain cases however, the task requires such combination of postures and efforts that it is not possible to identify right away the operations at risk. A more detailed "*Analysis"* is then required. The method for this stage III: "*Analysis"* must remain rather simple and based essentially on observations. It should give a semi quantitative indication of the risk encountered.
The proposed method is an adaptation of the OWAS method (Karku et al. 1977). A video recording is made of the work during a representative period. It is focused on the body zone of interest.
The recording is later played back and, at regular intervals, 100 instantaneous pictures are observed (Louhevaara and Suurnäkki 1992). The posture of the body segments in the zone of interest is compared to a set of reference postures defined in the literature. These are:

- for the neck (Kilböm et al. 1986):
  - bending, neutral position or extension;
  - left or right lateral bending or neutral position;
  - left or right rotation or neutral position.
- for the shoulders (McAtamney and Corlett 1993):
  - extreme extension, neutral position, light bending, average or extreme bending;

- neutral position, light, average or extreme abduction in the vertical and horizontal plan;
- internal rotation, neutral position or external rotation.

- for the elbows (Grandjean 1988):
  - no flexion, light, average or extreme flexion;
  - extreme pronation, neutral position or extreme supination.
- for the wrists and hands (Armstrong et al. 1982; Punnett and Keyserling 1987):
  - extreme extension, neutral position or extreme flexion;
  - extreme radial deviation, neutral position or extreme ulnar deviation;
  - type of grasp.

This analysis can be conducted globally for the recorded phase or separately for several elementary operations.

This analysis of the video recordings does not make possible to evaluate the forces. It was chosen to base the estimation of the forces on the opinions of the workers, expressed on the Borg scale (Borg 1990), for each elementary operation.

As for the stage II: *"Observation"* method, the main objective is not the encoding of the angles or the forces, but the understanding of the work process, questioning about its adequacy and searching ways to do it more economically. In that regard, the comparison of procedures adopted by different workers performing the same task can lead very rapidly and effectively to the optimisation of the procedure and to recommendation for adaptation of the workplace and education of the workers.

Nevertheless, the analysis of the 100 pictures leads to a summary table making possible to compare the percentage of the time spent in an extreme posture with the threshold values recommended in the literature. The number of digital grips is noted as well as the mean level of force and an index of repetitiveness. All the results are expressed globally and for each operation.

It is clear that this stage III: *"Analysis"* method requires greater knowledge in ergonomics from the users. It will also be more time consuming and more costly. Therefore, it justifies itself only in those cases where solutions cannot be found directly. The assistance and leadership of ergonomists, occupational physicians or occupational hygienists, with a specific training concerning the upper limb disorders, is usually required.

Stage IV: *"Expertise"*

Still, for some working conditions particularly sophisticated, more sophisticated investigating methods can be required in order to determine the adequate solutions. It is the case, for instance, for some assembly lines when work is so fast and complex that the analysis of the video recordings still does not make possible to single out the movements to improve or avoid.

The investigation method is based this time on the direct measurements of the angles, of the electromyographical activity of the muscles, of the repetitiveness and of the speeds of movement. This requires the use of sophisticated and costly transducers and recorders, carried by a sample of workers during representative periods. Experts are required. The results are expressed in terms of mean values of these parameters and/or percentages of the time during which threshold values of angles, forces, repetitiveness, velocities… are exceeded. The main goal again is not to quantitatively evaluate the risk in itself. It is to identify the motions, the postures or the efforts that are the most dangerous and to determine how to modify the organisation in the workplace in order to eliminate these dangerous situations.

CONCLUSIONS

The proposed strategy should make possible to organise the surveillance of the working conditions and the prevention of the musculoskeletal disorders of the upper limbs in a more efficient manner. It has the advantage of situating the different intervening parties in cascade, according to their expertise and the difficulty of the problem. It is based essentially on people from the companies to perform the stage I: *"Screening"* and stage II: *"Observation"* methods and people with a specific training are called upon in special cases when needed.

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Table 1:

	Stage I ***"SCREENING"***	**Stage II** ***"OBSERVATION"***	**Stage III** ***"ANALYSIS"***	**Stage IV** ***"EXPERTISE"***
• When?	All cases	If problem	Difficult cases	Complex cases
• How?	Simple observations	Qualitative observations	Quantitative observations	Specialised Techniques
• Cost?	Very low • 10 minutes	Low • 2 hours	Average • 2 days	High • 2 weeks
• By whom?	Workers and people of the company	Workers and people of the company	Workers and people of the company + Specialists	Workers and people of the company + Specialists + Experts
Expertise				
• work • ergonomics	Very high Low	High average	Average High	Low Very high

Table 2:

		YES	*Comments*
1	Some accidents happened with problems at the neck, shoulders, elbows or wrists		
2	Some workers complained of pain in any of these body regions		
3	The same motions or actions are repeated every minute		
4	The work speed is very high		
5	Some postures are very uncomfortable: twisting, arm raised, flexion/extension of the wrist…		
6	The work requires important and repeated efforts of the arm and/or the wrist		
7	The efforts with the hands are heavy: tightening, grasping, pressing, hitting, gripping with the fingers		

Table 3:

1. The head deviates from a neutral position: in rotation, lateral bending, flexion, extension or twisting.
2. Some specific postures and movements are imposed by a task.
3. During some work phases, the shoulder is reaching down and behind the torso with the elbow stretched.
4. Some movements of the hand and forearm in the horizontal plane lead to important rotations of the shoulder.
5. For some movements, the elbow is at mid-torso level or above.
6. Some operations require torsion of the forearm (ringing, screwing, …)
7. At some moments, the wrist deviates from the neutral position: extreme flexion or extension, radial or ulnar deviation, prosupination.
8.The operator uses grips such as the followings. 
9. Some efforts for lifting, pushing, pulling objects or tools are greater than 2 kg.
10. The operator uses tools or objects weighting more than 1 kg per hand.
11. Some objects or tools are slippery and require a very tight grip.
12. The tip of the fingers is used for operations of pressing, pushing or pulling.
13. The work requires some static efforts: postures maintained during more than 1 minute.
14. The worker has to perform some sudden efforts.
15. The work requires repetition of the same movements.
16. It requires some fast movements.
17. Some direct contacts exist with objects, tools, edges or parts that are sharp or can induce a local compression.
18. The operator uses the palm or the basis of the hand as a hammer.
19. The handle of the tool is too small or too large.
20. The handle of the tool leads to a non-neutral position of the wrist.
21. The operator uses vibrating tools.
22. The worker is exposed to cold, air draughts, or is in contact with cold surface
23. The worker uses gloves
24. The tools lead to chocks in the hand and elbow.

Table 4:

1. Does this happen for any body zone? (neck, shoulders, elbows or wrists/hands)
2. Does it happen? 0: never
1: sometimes
2: often (more than 33% of the time)
3: always
3. What can you do to avoid this or to reduce its occurrence?
4. What would be the frequency if these solutions were implemented?
0: never
1: sometimes
2: often
3: always