Risk prevention and control strategy for upper limb musculoskeletal disorders

J.B. Malchaire, Ph.D. and N.A. Cock*

Introduction

A trawl of the literature reveals many methods for assessing the risk of upper limb musculoskeletal disorders (ULD). They include checklists, assessment scales, observation techniques and even highly sophisticated measurement procedures. But these approaches developed and published by experts are open to two fundamental criticisms:

- they rarely take account of the expertise, technical possibilities and time available to those responsible for working conditions in workplaces of large, and especially small, companies;
- the aim of such people is not to evaluate risks, as scientists would, in the context of epidemiological studies, but to collect the information needed to improve working conditions and, if possible, avoid problems.

Employee participation usually ensures that significant control measures will be easily and readily found. An intervention study, therefore, requires a procedure through which for risk prevention practitioners to gather information progressively, as it becomes necessary to define appropriate 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 (Malchaire and Indesteege, 1997). It aims to help them recognise ULD risk conditions and identify the most appropriate corrective or preventive measures.

Description of the procedure

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

- In stage I, "*Screening*", workers' complaints or disorders are reviewed and the working conditions rapidly inspected. A decision is then made whether to study the problem more in detail and look for ways of avoiding the risk and improving uncomfortable work postures.
- If this does not solve the problem, a stage II - "*Observation*" - is initiated by the company officials responsible for working conditions and workplace organization.
- If they cannot devise satisfactory solutions, specialist expertise is enlisted and a more detailed "Analysis" is carried out (stage III).
- If the "Analysis" still fails to turn up the necessary solutions, further expert assistance is enlisted for stage IV, "Expertise", targeted on a very specific aspect of the working conditions to single out final control solutions. (See table 1 p. 28: Characteristics of the four different stages).

Phase I: *"Screening"*

The method must be very easy to understand and use, preferably by the workers themselves who are thoroughly familiar with their working conditions. It must not be time-consuming, so that it can be used each time a problem is suspected. Table 2 (p. 28) shows different items that may be suggested to employees as a basis for discussing the circumstances, causes and simple improvements that can be made to eliminate the problem.

Phase II: *"Observation"*

The method must be easy to use in the field by those responsible for work organisation who usually lack training in musculoskeletal disorders. Again, the method needs to be rapid and low-cost. A checklist (table 3 p. 29) was developed, based on a proposal by Keyserling et al. (1993). It includes the main aspects of working conditions (postures, forces, and repetitiveness...) that might 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 rotation, twisting, forces...

Table 4 (p. 29) gives the four questions to ask for each item in 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 frequency, they are invited to consider the reasons for it and to look together for ways to avoid the situation or reduce its occurrence.

* Occupational Hygiene and Physiology Unit, Catholic University of Louvain, Belgium

At the end of the "*Observation*" stage, an overview of the risks before and after implementing the control measures can be had by counting the number of items occurring "*often*" or "*always*". This makes it possible to determine the overall efficiency of the proposed measures and the acceptability of the anticipated outcome. If the outcome is not acceptable, it is easy to identify the most exposed zone of the upper limbs, prioritise additional control measures, and determine the priority of a more detailed "*Analysis*".

Acceptability is a value judgement based on perception of the work. There is, however, no reason to believe that "*subjective*" evaluations by workers thoroughly familiar with their working conditions are less reliable than so-called "*objective*" evaluations by experts with limited knowledge of those conditions.

Table 1 • Characteristics of the different stages

	Phase I *"SCREENING"*	Phase II *"OBSERVATION"*	Phase III *"ANALYSIS"*	Phase 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 company personnel	Workers and company personnel	Workers and company personnel + Specialists	Workers and company personnel + Specialists + Experts
Expertise				
• work	Very high	High	Average	Low
• ergonomics	Low	Average	High	Very high

Table 2 • Checklist for stage I: *"Screening"*

		YES	Comments
1	Some accidents involving neck, shoulder, elbow or wrist problems.		
2	Some workers complain of pain in any of these body regions.		
3	The same motions or actions are repeated every minute.		
4	Very high work pace.		
5	Some postures are very uncomfortable: twisting, arm raised, wrist flexion/extension…		
6	The work involves important, repeated arm and/or wrist effort.		
7	Hand efforts are heavy: tightening, grasping, pressing, hitting, gripping with the fingers.		

Table 3 • Checklist for stage II: *"Observation"*

1	The head deviates from a neutral position: in rotation, lateral bending, flexion, extension or twisting.
2	Specific postures and movements are imposed by a task.
3	In some work phases, the shoulder reaches down and behind the torso with the elbow stretched.
4	Some movements of the hand and forearm in the horizontal plane lead to significant shoulder rotations.
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 times, 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 weighing 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 involves some static efforts: postures maintained for more than 1 minute.
14	The worker has to exert sudden efforts.
15	The work involves repetition of the same movements.
16	It involves rapid movements.
17	There is direct contact with objects, tools, edges or parts that are sharp or can induce local compression.
18	The operator uses the palm or base of the hand as a hammer.
19	The tool handle is too small or too large.
20	The tool handle 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 surfaces.
23	The worker uses gloves.
24	The tools produce impacts in the hand and elbow.

Table 4 • Questions to consider for each item of table 3

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

Even so, it would be wiser to adopt a safety factor, and it is that a stage III "*Analysis*" be initiated immediately some items occur "*often*" for the same body segment.

Phase III: *"Analysis"*

In most cases, working conditions can be significantly improved and the risk of ULD eliminated through the "*Observations*" described above. In some cases however, the task involves a combination of postures and efforts, making it impossible to identify the risk operations immediately. A more detailed "*Analysis*" is then required. The method for this stage III "*Analysis*" again has to be fairly 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, 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;
• adduction, neutral position, light, average or extreme abduction in the vertical and horizontal plane;
• 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 made globally for the recorded phase or separately for several elementary operations. This analysis of the video recordings cannot be used to evaluate forces. Instead, the estimation of forces was based on the opinions of the workers, expressed on the Borg scale (Borg, 1990), for each elementary operation.

The main aim for stage II - "*Observation*" - is not to encode angles or forces, but to understand the work process, to question its appropriateness and look for ways to improve economy of movement. Here, comparing procedures adopted by different workers performing the same task can lead very rapidly and effectively to the development of an optimum procedure and recommendations for adapting the workplace and educating the workers.

Nevertheless, from the analysis of the 100 pictures, a summary table can be devised to compare the percentage of time spent in an extreme posture with the threshold values recommended in the literature. The number of digital grips is recorded, along with 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 more knowledge of ergonomics from the users. It will also be more time-consuming and more costly. So, it is justified only in cases where no immediate solutions can be found. Assistance and leadership from ergonomists, occupational physicians or occupational hygienists with specific training in upper limb disorders is usually required.

Phase IV: *"Expertise"*

For some particularly complex working conditions, more sophisticated investigating methods may be needed to identify appropriate solutions. This is so, for instance, for some assembly lines where work is so fast and complex that even analysis of the video recordings cannot single out the movements to be improved or avoided.

In this stage, the investigation method is based on direct measurements of angles, muscle electromyographic testing, repetitiveness and speeds of movement. This requires sophisticated and costly transducers and recorders, used by a sample of workers during representative periods. Expertise is 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. Again, the main aim is not to quantify the risk itself, but to identify the most dangerous motions, postures and efforts, so as to determine how workplace organisation can be changed to eliminate the risk situations.

Conclusions

The proposed strategy should promote better organized surveillance of working conditions and more efficient prevention of upper limb musculoskeletal disorders. It has the advantage of establishing multi-level intervention by the different parties (workers, ergonomists and experts) according to their expertise and the difficulty of the problem. Essentially, stage I: "*Screening*" and stage II: "*Observation*" are carried out in-house, while specific expertise is enlisted in special cases when needed. ■

References

• Armstrong, T.J., Foulke, A.J., Joseph, S.B., *et coll.* (1982), Investigation of cumulative trauma disorders in a poultry processing plant, *American Industrial Hygiene Association Journal*, 43, 103-116.

• Borg, G. (1990), Psychophysical scaling with applications in physical work and the perception of exertion, *Scand J Work Environ Health*, 16, 55-58.

• Grandjean, E. (1988), *Fitting the task to the man*, Taylor & Francis.

• Karku, O., Kansi, P., Kuorinka, I. (1977), Correcting working postures in industry: a practical method for analysis, *Applied Ergonomics*, 8, 199-201.

• Keyserling, W.M., Stetson, D.S., Silverstein, B.A., *et coll.* (1993), A checklist for evaluating ergonomic risk factors associated with upper extremity cumulative trauma disorders, *Ergonomics*, 36, 807-831.

• Kilböm, A., Persson, I., Jonsson, B.G. (1986), Risk factors for work related disorders of the neck and shoulder with special emphasis on working postures and movements, in Corlett E.M., Wilson J.R., Manenica J. (Eds.), *The ergonomics of working posture*, Taylor and Francis.

• Louhevaara, V., Suurnäkki, T. (1992), OWAS: *a method for the evaluation of postural load during work*, Helsinki, Institute of Occupational Health.

• Malchaire, J., Indesteege, B. (1997), *Troubles musculo-squelettiques. Analyse du risque*, Institut National de Recherche sur les Conditions de Travail, 122.

• Malchaire, J., Piette, A., Cock, N. (1998a.), *Stratégie d'évaluation et de prévention des risques liés aux vibrations mains-bras*, Commissariat général à la Promotion du Travail, ministère de l'Emploi et du travail.

• Malchaire, J., Piette, A., Cock, N. (1998b), *Stratégie d'évaluation et de prévention des risques liés aux vibrations corps total*, Commissariat général à la Promotion du Travail, ministère de l'Emploi et du travail.

• Malchaire, J., Piette, A., Cock N. (1998c), *Stratégie d'évaluation et de prévention des liés au bruit*, Commissariat général à la Promotion du Travail, ministère de l'Emploi et du travail.

• Malchaire. J., Piette, A., Cock, N. (1998d), *Stratégie d'évaluation et de prévention des risques liés à l'éclairage*, Commissariat général à la Promotion du Travail, ministère de l'Emploi et du travail.

• Malchaire, J., Gebhardt, H.J., Piette, A. (1999), Strategy for evaluation and prevention of risk due to work in thermal environment, *The Annals of Occupational Hygiene*, (to be published).

• McAtamney, L., Corlett, E.N. (1993), RULA: A survey method for the investigation of work-related upper limb disorders, *Applied Ergonomics*, 24, 91-99.

• Punnett. L., Keyserling, W.M. (1987), Exposure to ergonomic stressors in the garment industry: application and critique of job-site work analysis methods, *Ergonomics*, 30, 1099-1116.