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Improving the quality of life through a new approach aimed at controlling musculoskeletal disorders at work

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Abstract

In the past few decades, working systems have continually contributed to increased productivity; many innovations have drastically affected citizens' quality of life. Science has played a dominant role in at least two ways: a) the appearance of new technologies increasing the possibilities for the end-users, and b) changing peoples' working conditions. Changes in working conditions bring new risks. Whereas with wide-spread mechanization and manual work many accidents occur because of techno-mechanical and environmental factors, the more recently introduced work systems have given rise to psycho-somatic problems via sensory-mental load, risk perception, physical fatigue and muscle load. To reduce the undesirable human effects, more functions were allocated to the technical systems (automation/robotics) which resolved a series of evident problems, but that policy also created new risks for operators: alienation in the production process, cognitive load (vigilance, psycho-mental stress), machine paced work, repetitive work for smaller muscle groups and postural load. As long as there was a direct cause-effect relationship, protection strategies (individual as well as collective) were successful in reducing occupational injuries and diseases. But when the causal factors became unreliable and less predictable - as in the case of musculoskeletal disorders (MSD) - the classic preventive measures failed completely. The main reasons for this failure lay in the fact that injuries due to labor accidents are immediate and obvious, whereas for MSD the effects on humans have a cumulate causal impact over longer periods. This fact necessitates a participative and risk-anticipating approach in which subjectively experienced pre-symptoms are corroborated by an objective quantification of the complaints.

Keywords: *quality of life, accident analysis, musculoskeletal disorder (MSD), cumulative trauma disorder (CTD), system analysis*

Introduction

At the present time, it is almost impossible to assess correctly the incidence and seriousness of MSDs in Europe. Some reliable sources estimate that more than 44 million people, or 20% of the total workforce in the European Union, have a long-standing health problem or disability related to MSDs. (Bevan, 2009) This covers not only the muscle tissues but also nerves, joints, tendons, bursa, ligaments and bones. A long list of phenomena has resulted in a terminology that encompasses the injuries/diseases, which are either general such as the work-related upper limb disorder (WRSULD) or more specific like, low back pain (LBP), carpal tunnel syndrome (CTS), thoracic outlet syndrome (TOS) and tension neck syndrome (TNS). This list is not exhaustive and might also include job-related musculo-skeletal issues, e.g., repetitive strain injury (RSI), cumulative trauma disorder (CTD), rheumatoid arthritis (RA) and spondylo-arthropathy (SpA). (Bevan, 2009). General information about incidence and severity are available through numerous publications, but the results are impossible to assess correctly in terms of frequency, as well as the long-term physical, managerial and financial consequences. The difficulties that may lead to confusion are created by the links to different types of causal factors (accidents, cumulative disorders, diseases). Any confusion may also be exacerbated by the interests or intentions of the various authors, which tend to focus on the disease or injury, on the comparison of nations, industries, jobs or even tasks.

However, this paper posits that a broader approach is needed in order to understand the nature of MSD, an increasingly serious global problem.

Indeed, understanding MSDs in reliable and comparable terms would be valuable to all stakeholders involved: the exposed employees, management, social security systems, and politicians. Even if its impact on life and society cannot be assessed with perfect accuracy, the search for scientific information must continue. Ultimately, everyone pays for the days lost in labor: rehabilitation periods, compensation for direct and indirect losses, employment and re-employment, etc., the financial consequences of which indicate staggering numbers. Note: for example the EU, where 100 million people are confronted with chronic musculoskeletal pain; and the US, where an estimated 56 % of all occupational diseases are caused by MSDs. (Melhorn, 1998). The total costs of MSD can represent anywhere from 0.5% to 2% of the known gross national product. (GNP). The amounts at national levels should not be overlooked, either, as some national studies reveal only the tip of the iceberg. In the UK for example, 538,000 MSD cases were reported in 2008-2009, with about 9.3 million work-days lost, an approximate financial price tag of 8.5 billion Euros. (HSE, 2009) Apart from financial considerations, other angles must be considered. These include such outcomes as the quality of life of the MSD-victims, the social aspects of employment, the financial burden for governmental or private compensation funds, and the non-physical side effects of bad processes, reduced productivity, lower quality outcomes, increasing wastage, low efficiency and a deteriorated social climate. It is no wonder that the EU Commission has put a high priority on the issue. In fact, in the last decade initiatives have been launched by the European OSHA (Occupational Health and Safety Agency, Bilbao, Spain) and the European Foundation for the Improvement of Living and Working Conditions, (Dublin, Ireland), both of which are part of a large network aimed at understanding the nature of the MSD.

However, despite the efforts invested (workshops, research projects, developed guidelines, official standards and legislative rules, practical examples and meetings) the fact is that the alarming MSD problem has not improved consistently. It is incumbent upon scientists, practitioners, politicians, authorities, and managers to understand MSD as a cumulative trauma phenomenon. To this end, we must seek answers to the following inter-related questions:

a) Is the current knowledge of and approach to MSD fundamentally correct?
b) What should be the most appropriate risk-assessment technique?
c) What can be done to better address MSD with respect to assessment and analysis and subsequently the ultimate evaluation and implementation of a new approach?

The understandings of MSD

MSD is broadly defined as a damaged human movement system: a disturbed normal functioning of the musculoskeletal system, including the muscles, tendons, ligaments, bursa, joints and bones, due to a number of physical conditions traumatizing the body either instantly or over a period of time.

There are four essential elements to take into account: a) normal functioning, b) external work conditions, c) traumatizing events and conditions and d) the occurrence, explained as:

a) Normal functioning: the human system (biomechanical, physiological, mental and intellectual components) interacts with the working conditions, a process during which balance is sought between the individual capacities and the work-demands. It is assumed that a balanced system fosters a healthy, safe and efficient work situation.
b) External work conditions: workload is determined by the job-demands. They include: tasks (operations), organization (e.g., work-rest schedules, team work, materials supply) and the physical environment such as climate, noise, vibration, lighting, shapes, weights, sizes of goods, materials, tools and environmental space. This large range of combinations establishes what the workload actually is.
c) Traumatizing events and conditions: refers to the specific biomechanical functioning of the physical and physiological body to the type of injuries or diseases which could be caused by overload, infection and other agents
d) Moment of occurrence: the time differentiation between accidental and cumulative is an important element in the risk assessment. In the case of an accident, there is an almost immediate, relatively simple, cause-effect

relation. MSDs have a cumulative character in which the relation between cause and effect is built up over a period of time**.** There may be a combination of many elements building up to a set of causal factors over an indefinite period, simultaneously interacting with para-work situations or conditions (possibly identical, but mostly different). For example: a hernia may occur instantly when handling cement bags on the shop floor (accident) but it can also occur later in the same month when getting up awkwardly from a cozy club chair when watching TV (cumulative disorder).

Assessment and analysis principles

Schematically presented, the accident analysis is carried out by using a classic feed-back principle, illustrated in Figure 1 below.

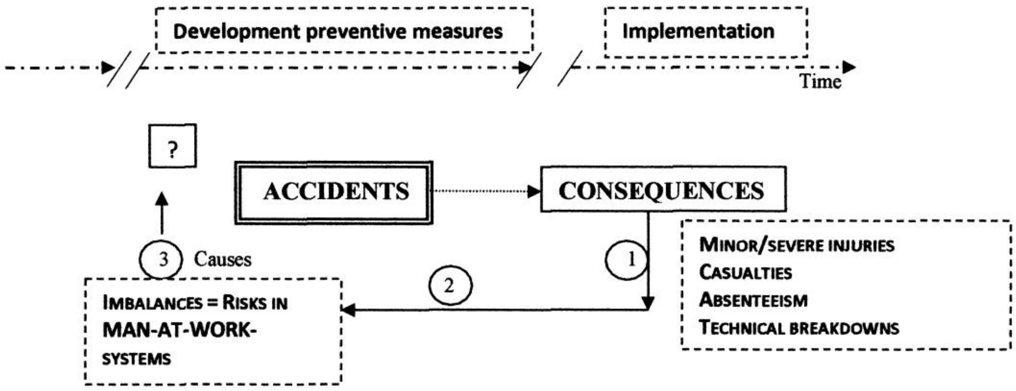

Figure 1 Accident analysis

1) Observed injuries are registered and classified according to frequency and seriousness in different activities. Mostly the accident itself is described as a direct cause to the injury (e.g. fall = broken leg, over-exertion = cardiac failure, contacts with moving objects, etc.) and priorities for analysis can be launched depending on the nature and importance of the injuries.
2) Analysis of the “man-at-work” system – the external factors (task, organization and environment) and the human behavior as the final result in the decision making process. The operational behavior is determined by imbalances between load (working condi- tions) and individual capacity.
3) Determining and selecting the major causal factors: fixing and implementing prevention measures; identifying which measures should be taken in the short term (mostly individual and/or collective protection) to reduce the se riousness of the damage. In the long term: technical or organizational re-designing system; eliminating or minimizing risks at the workplace. Priorities should be judged according to the seriousness of the risk.

MSD - CTD analysis

MSD/CTDs have a different evolution from accidents as illustrated in the following graph, which follows the classic adaptation syndrome pattern (Selye, 1946). In the adaptation phase the muscular system is developed following the “auto-training at work” principle and the apparent problems disappear after the muscle-capacity; an operational behavior is adjusted to the task-demands (Vanwonterghem, 2009a). However, if the cumulative aspects persist without such an adjustment, at a certain moment the trauma can materialize without any discernible warning.

Three samples of evolution are provided, indicating MSD as a cumulative occurrence: cases **A** representing the majority of these cases (about 70 %); cases **B** refer to a minority (+/- 12%), namely those employees who cope with the risks and who can perform the job without detriment over many years; and cases **C**, those which evolve to an MSD-injury in a relatively short time (+/- 18%).

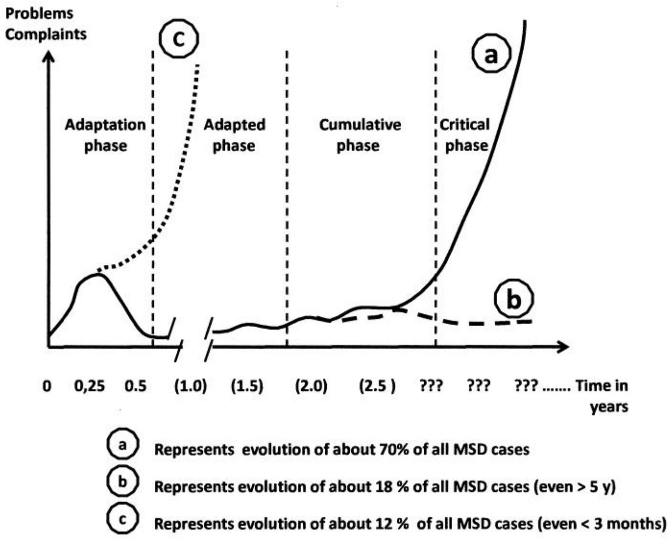

Figure 2 Evolution in MSD/CTD

Evolution MSD-CTD

This evolution of the cumulative effects depends on the individual's risk-coping process. In cases **C** for example, people experience some problems during the adaptation phase but deny any of the signals such as forearm pain, loss of power, excessive fatigue because of what might be termed over-motivation for any variety of social, financial or personality reasons. Cases **A** include some muscle-recovery periods (formal and informal work-breaks, week-ends, informal or formal days off, etc.) but after a certain time the recovery is not 100% and then they enter into a cumulative strain. However they can perform the work over longer periods. Cases **B** demonstrate the optimal coping strategy, those who can complete a normal professional career. In reality each evolution has an individual pattern, but they fall, broadly, into one of these three categories for varying periods of time (asymptotic phases can slide left or right). Individuals who have been afflicted by a CTD who return to the same job will face the risk of recurrence, but probably within a shorter time period.

Practical reduction of MSD–CTD

Recognizing and assessing risks in man- at-work systems present certain difficulties, since the worker and the employer often have different goals in mind. While it is true that both must collaborate in an active system with a common goal (work efficiency, health and safety issues), it is equally true that management is primarily concerned with economic values (productivity, economic growth) while employees have personal objectives (financial, socio-economic). Both have specific system-related characteristics: on one side sequential, rigid technical and organizational factors in which human operators are conceived as formal parts; work-related concerns often emphasize technical interrelations (e.g. Rohmert and Landau, 1979; Institute of Medicine, 2001). On the other side exist individuals with psychological, intellectual, cognitive, emotional and physical capacities. These are in permanent exchange with the technical environment and produce the ultimate operational behavior (Vanwonterghem, 2010).

Factors in risk assessment

It is expected that when the workload and the individual work capacity are in balance, no specific problems will occur. Imbalance (overload and under-load) (Figure 3) will result in acknow-ledged negative outcomes: e.g., management: loss of production, absenteeism, loss of quality, technical breakdowns, increased insurance costs, social conflicts. For the employee: discomfort, human integrity (injuries, diseases), unemployment and loss of income (Vanwonterghem, 2010).

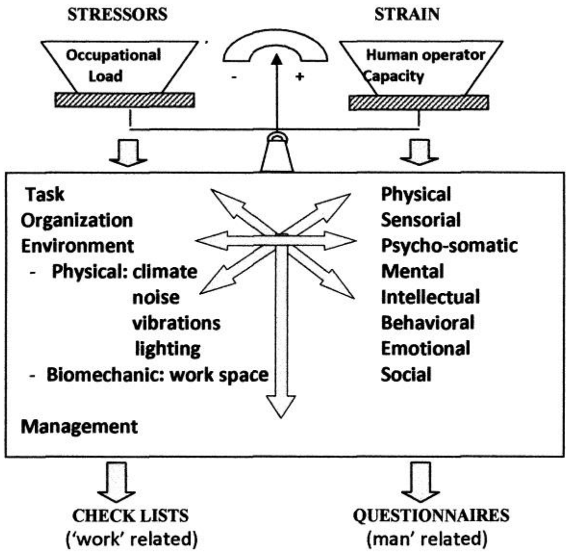

Figure 3 Factors in risk assessment

Analysis of verifiable facts

In a typical work-related risk assessment concept, the management team covers the external working conditions, which can be checked following objective and standardized methods and procedures --usually in the form of check-lists**.** From the operators' side, some objective failures are known (registered accidents, absenteeism, etc.) but less obvious symptoms have a more subjective character, that is, complaints of fatigue and all individually experienced discomfort, all of which must be assessed by means of questionnaires.

Both elements must be considered: work-related check-lists of facts (task, organization, environment) and man-related opinions (question- naires) on the experiences of, and what happened to, exposed individuals.

Check-lists

Check-lists focus on working conditions wherein a number of objective criteria (direct, indirect causes) can be detected by using a systematic screening of the external load factors in the observable tasks, organization and environment. Tasks include the type of operations, materials and load characteristics as weight, sizes, equipment, tools, and intensity; organizational factors represent work-rest schemes, duration, paced work, shift work, team work; physical environmental elements, e.g. temperature, humidity, noise, vibrations, lighting, air quality; and finally workplace design factors, e.g., working space, reaching distances, working heights. All these job factors are categorized in the check-lists and may be measured and evaluated in comparison to the acceptable limits and thresholds from previous research observations. There are numerous analyses that can be undertaken for MSDs. A brief list includes: NIOSH Risk Factors for material handling and lifting (Waters et al., 1993); the AET, a German scientific analysis of occupational load check-list (Rohmert & Landau, 1979); the Rapid Upper Limb Assessment, RULA (McAtamney & Corlett, 1993);the Key Indicator Method, KIM (Steinberg, Behrendt, & Caffier, 2008); and the Manual Handling Chart, MAC (Mital, Nicholson, & Ayoub, 1993). KIM and MAC are promoted by the European OSH Agency, OCRA (Colombini, Occipinti, & Grieco, 2002) for repetitive work, and many other organizations (Steinberg et al., 2008). Objective work related factors can be measured and evaluated based on quantity, quality and their impact on the individual such as: lifting weights and acceptable loads, exposure time and work-rest schedules, climate and heat stress, noise and temporary threshold shift in hearing. The evaluation of loads and their biomechanical effects on the body, particularly in relation to posture, are based on a long history of scientific research in laboratory as well as in field conditions. Many of the results are used in work-related guidelines, standards and legislative rules.

Questionnaires

Similarly to check-lists, questionnaires include items that give information of problems perceived by individuals that have led to a MSD (i.e., search of causes after treatment). The difference from checklists is that questionnaires refer to the effects of work conditions on the affected body areas (neck, shoulders, elbows, wrists/hands, upper back, lower back, hips/thighs, knees, and ankles/feet) in relation to tasks, organization and environment. The information is useful because it can give risk factors which are complementary to the data of the check-lists. Examples of such check-lists are the Nordic Musculoskeletal Questionnaire (MSQ) (Kuorinka et al., 1987), which is widely used to assess the nature and severity of self-rated musculoskeletal symptoms. Other methods of this type refer to specific body parts e.g. neck and upper limb (Armstrong et al., 1993); to particular jobs as for example in computer work (Ming, Narhi, & Siivola, 2004) in the form of the Computer Aided Design (Karlqvist et al., 1996), in which the victims report on their experienced body problems as a result of their job. As these questionnaires also start from objective post-injury facts, they meet the same difficulties as the check-lists**.** Although the operator's body is the related target (checklists are work-related) questionnaires are focused on the human being. In other words, the victim is not seen as an integrating causal factor. This approach is also reflected in the used problem terminology such RSI – repetitive strain injuries (e.g., carpal tunnel syndrome, thoracic outlet syndrome, tennis elbow, bricklayers knees etc.), and it is logical that the injuries should match the subjective feelings such as pain, discomfort and incapacity. Although appearing in a weakened and less intensive form, similar complaints occurring during the cumulative phase are important as they are integrated signs of an installing problem. The stronger the feelings, the faster the critical point of escalation to an MSD will be reached. Essential in prevention is *risk anticipation*, a principle which should be implemented (by preference, even with some priority) at the moment when imbalances between capacities and workload appear, that is to say, before objective symptoms occur.

Considerations about check-lists and questionnaires

Check-list**s**, or the observation of working conditions in the injury analysis, refer to proven facts --the results of a damaging combination -- but ignore and/or neglect the essential i*ntegrating* human reactions. External observations of the technical and organizational work system are essential in the very design of work systems. Even questionnaires about post-factual symptoms are, despite the added value of offering a view on the consequences for the operators, not representative of the integrated aspects of the working individual. When in this type of analysis as in the checklist approach the symptoms are present, it is much too late to act preventively. Nonetheless, despite the incompleteness many risky working conditions can be corrected with appropriate design and work organization and therefore should be maintained and further developed.

Questionnaires reflect the integrative aspects necessary in anticipating an MSD and CTD prevention strategy (as learned from the specific pattern of CTD-evolution). When the complaints occur, an anticipative intervention can be launched. Questionnaires do however miss the hard or objective evidence that is usually necessary to convince management of potential victims.

In conclusion it can be stated that both screening methods may contribute to solving the CTD-problem but – in practice – they will never be successful when implemented separately. The statistical evidence, as noted in the introduction, supports this statement because almost no progress has been achieved in the reduction of MSD/ CTD cases. In order to increase the efficiency of the actions against CTDs, a combined systems-approach is needed in which both objective and subjective criteria are equally involved and complementary of each other. This requires an active participation of management and employees; it will be from such cooperation that an efficient improvement in the MSD occurrence can be expected.

Ergonomics risk assessment – integrated analysis

Ergonomics, as the science of working people, aims to protect human integrity as well as to respect the economic and socio-economic issues associated with human activities. One of the main objectives of ergonomics is to solve problems where there is an imbalance between workload and capacity in human activity. These can be expressed in terms of health, safety and discomfort, but also as outcomes of failing processes, such as errors, mistakes, poor productivity, poor quality and quantity, drop-outs, wastage, high absenteeism rates, increasing turnover, social conflicts and the interrelations between man and work.

Risk assessment

Management prefers to make decisions based on hard evidence (e.g. supporting statistics, return-on-investment) and operators are more prepared to accept guidelines and proposals for adjusting their behavior (e.g., changing work patterns, use of safety equipment) based on subjective arguments. Consequently, irrespective of the nature of the problem solutions that have to be found either technical-economic from management or socio-behavioral from the operators both objective and justified subjective arguments will contribute to a better acceptance.

In this context, many activity-checklists and questionnaires are also used in ergonomics, but despite attempting to follow technical evolutions, they ultimately fail to handle the MSD problems. This opens up opportunities for new innovative methods, which should be focused on a broader systems approach. This integrated method should include all job related workload and capacity issues, with the active participation of the exposed individuals. The operator, regarded as an integrating instrument which combines the individual psychosomatic reactions with the work-related load factors, differentiates between safe or risky operational behavior (Vanwonterghem, 2009). Such participatory ergonomics – concentrated on complaints or other perceived risks – could become much more valuable in the future when operators have received the appropriate training (Wilson & Haynes, 1997).

In practice, the participating individual serves in the first stage as a messenger of the existing imbalances or balances in working conditions by reporting problems through subjective complaints, and secondly, as a measurable subject who reflects the external workload on the body (physiologic, psycho-mental, biomechanical reactions) to confirm the subjective findings. This view is quite different from the scientific standardized and controlled set-ups in laboratory conditions, but the systems approach does not deny that reality. The variations in subjects' assignments -- the inter- and intra-individual reactions, differences in subjects and colleagues, the permanent changing working and environmental conditions, and the evolutionary technical and organizational progress -- cannot be standardized. The operators strive to perform the job and try, cognitively and subconsciously, to keep the balance between the individual capacities and work-demands. By expressing their experiences about problems, their commitment will be enhanced and appreciated.

Combining subjective and objective data is very important for a thorough analysis. A sound decision-making process should therefore incorporate both elements.

Ergonomic assessment of CTDs

From the evolution of a CTD (Figure 2) it can be concluded that the prevention of CTD-cases should be based on an anticipatory strategy, i.e., acting when complaints appear in the cumulative phase. The innovative participatory ergonomic approach of such an anticipating analysis should be based on subjective criteria, justified in a second phase by objective arguments. Such a method has been used successfully in a series of studies (Vanwonterghem, 2009; Vanwonterghem, 2010; Yoopat et al., 2010), which used the SWI (Subjective Workload Index) as an interviewing tool which comprises two parts. One is a general score reflecting the actual problems experienced and includes a rating on an 11-point scale (between 0 – no problems at all to 10 (unbearable) for 6 load factors (LF): fatigue, physical risks, concentration, complexity, work-rhythm and responsibility). Two compensating factors (CF) are introduced to attenuate the load and concern interest in the job and degree of autonomy (0 = no interest at all and no freedom, 10 = highest appreciation). The SWI is then calculated as follows: SWI = [(∑ LF)-(∑CF)]/'n' (n =8). Results below 2 are estimated as at low hindrance level and values of up to 5 will reflect a gradual increase of hindrance up to 5 which is unbearable. When SWI exceeds the score of 2.5 a detailed analysis is advised.

The detailed SWI-analysis introduces a list of operations (maximal number of operations = 10) and includes resting periods as representative of specific tasks. Their relative duration (minutes calculated as % of total working time) is included as a load-enhancing or -attenuating factor (high intensity over short time versus low intensity after longer periods). For each of the factors, found in the general analysis as critical, (usually for fatigue), a detailed matrix table with two entries gives specific problem indicators. One table-entry concerns the operations and time distribution; the second table-entry refers to the physical aspects (movements, postures, environmental factors as temperature heat/cold, noise, vibrations, lighting, air quality, dust and work organization). The importance of the risks is expressed in values between 0 -- no risks, up to 5-- high risks. Examining the matrix table allows one to detect the most crucial combinations, which may steer further actions. For example, a link between the subjective fatigue in the general analysis could receive a high score for some operations, which may be combined with heart rate (HR) measurements (average HR for the operation), and in the matrix analysis the load factors could be, for example, heat, poor postures, certain movements and work organization. Eventually poor posture can be objectively tested (e.g. electromyography) and climatic conditions can be measured (humidity, radiation and/or internal body temperature).

Body-related subjective strain symptoms such as tingling arms, prickling fingers, numbness, pain in some areas (neck, wrist, knees, etc.) swelling in tendons, heat of the local areas, loss of power in hands,(e.g. white fingers) can be visualized in the detailed analysis in accordance with earlier performed work (Vanwonterghem, 2010).

Conclusion

Recognizing early symptoms or subjective pre-signals is of fundamental importance in the prevention of MSD/CTDs and investments should be made in a sustaining an anticipatory prevention program. The approach should concentrate on workers and be based on the stringent medical advice: “listen to the body.” The earlier the problems can be anticipated**,** the more efficient the preventive action.

Management, medical staff, human resource managers, prevention experts and concerned scientists are advised to take complaints seriously. Depending on the seriousness of the CTD problem, an ergonomics screening or research evaluation can be advised in conjunction with scientists and experts in applied research: there are already rational and efficient methods to assess the risks correctly. However, because of the fast evolving world and the increasing complexity of man-at-work systems, further research on a regular basis is strongly advised. Their mission could be, for example, to refine measurement equipment and methods so as to elaborate more reliable and usable thresholds in the subjectively expressed complaints. This should lead to a better understanding of MSD/CTD problems by both management and employees. Although some applied research methods may seem to be lengthy and tedious (and, therefore, expensive), there is proof that in reducing the frequency of MSD cases, there is an associated reduction of up to 35% in lost days in a research participating SME (representing about 0.62 million Euros annually). This is a good return on investment that largely compensates for the cost of research and redesign of the working systems. (Vanwonterghem, 2010b).

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