# Musculoskeletal disorders and psychosocial factors at work

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# 1. Introduction

Almost 40 million workers in Europe suffer from musculoskeletal disorders (MSDs) of the limbs and the back; according to Eurostat (2010), these disorders account for almost 60% of work-related health problems, and are therefore the most common occupational disease in the European Union (EU). They are a corollary of the intensification of working conditions which is becoming ever more widespread in both the industrial and service sectors (Gauthy 2007). Their impacts, which include not only suffering and employment disruption on the part of victims but also economic costs, have secured their position as an occupational health priority for the EU, and in 2007 the European Commission carried out a consultation on potential countermeasures (including EU-wide legislation). Yet even though MSDs have been recognised as a priority by the EU Member States and the European social partners, proposals for directives on the prevention of MSDs have been on the back burner since 2014 (EU-OSHA 2017).

If we wish to understand the reasons behind the current 'epidemic' of MSDs, we must first investigate the ways in which production and work are organised and the most popular management practices. The onset of the MSD epidemic occurred during a period of time which saw the introduction (from the 1980s and 1990s onwards) of new work organisation methods and management practices aimed at making production and employment processes in Europe's industrial and service sectors more streamlined and flexible. The intensification of work, which was the outcome not only of these new methods but also of the significant social and financial upheaval which characterised this period, has been amply documented in regular surveys on working conditions in Europe (Eurofound 2016). It is associated with a mounting burden of physical, psychosocial and organisational constraints caused by the various risks (chemical, noise, etc.) to which a growing number of workers or employees in the industrial sector and, more recently, the service sector are exposed (Westgaard and Winkel 2011; Arnaudo *et al.* 2012); in the EU, the latter has in fact been identified as posing the highest risk of MSDs.

The organisation of work, management practices and psychosocial factors at work are pivotal elements in understanding and preventing MSDs. They influence the conditions under which work is carried out and the environmental, psychosocial and biomechanical characteristics of the working situations which workers encounter. Rigid constraints in terms of work rates and working procedures, combined with a high level of responsiveness to the demands of clients (both inside and outside the company), often make it necessary to work to tight deadlines and leave little leeway to handle

unforeseen incidents. Management practices and HR strategies dictate the quality of working relations and work appraisal arrangements. Management practices have a two-fold impact, since they determine not only the severity of the constraints under which work is carried out but also the individual or collective resources available to workers to tackle these constraints. One way of reducing MSD risk is to increase workers' individual or collective freedom to utilise their professional skills and know-how in order to carry out freely the movements required to produce high-quality work.

Research carried out in a range of disciplinary fields has revealed an interrelationship between MSDs and organisational and psychosocial factors at work. MSDs and psychosocial risks at work can therefore be regarded as the pathological effects of dysfunctional work organisation and the resulting intensification of work, and expressions of physical suffering (MSDs) or mental suffering (psychosocial risks) at work. Preventing MSDs in workers in the industrial and service sectors necessitates a better understanding of the interrelationship between MSDs and psychosocial risk factors at work. Effective MSD prevention programmes must be based on psychosocial and organisational considerations as well as biomechanical and medical components in order to pave the way for holistic and integrated interventions.

In spite of significant efforts in the field of prevention at European level, MSDs remain a major occupational health problem, and it is vitally important for European workers, particularly those in the industrial sector, that more is done to prevent them. Workers suffering from MSDs not only experience pain and a reduced quality of life at work, but are also among those most likely to be absent from work for long periods or to be recognised with a workplace disability. The resulting drop in productivity and quality means that MSDs jeopardise the very survival of certain production-based sectors or companies, for example because of loss of know-how, high staff turnover and recruitment problems linked to reputational damage. Leaving the human costs to one side, the economic and societal costs associated with MSDs are significant, and perhaps as high as 2% of the European Union's GDP (EU-OSHA 2014).

In recent years, efforts to prevent MSDs have been largely restricted to workplace interventions aimed at 'reducing the biomechanical load' and introducing technical or organisational measures to lessen workers' exposure to intense and/or repetitive physical strain (Driessen *et al.* 2010; Kennedy *et al.* 2010; Van Eerd *et al.* 2016). The problems faced by those seeking to implement long-term MSD prevention measures can be overcome only by asking questions firstly about prevention strategies, and secondly about the underlying conceptual models of MSDs, with a view to identifying relevant levers for prevention (Daniellou 2008). The first such models developed were directly inspired by the biomechanics of soft tissues and remain relevant in biomedical terms, but they fall short when it comes to explaining MSD risk in a wide range of working situations, particularly those associated with a moderate physical workload (Hagberg *et al.* 1995, 1996; National Research Council 2001). Later models built upon these earlier ones by gradually incorporating organisational, social and psychological characteristics of

working situations into a general biopsychosocial model of health. More recently, MSD modelling techniques have been expanded to include a strong organisational dimension, based on findings in the scientific literature and practical knowledge from previous prevention interventions.

These conceptual developments call into question the nature of current prevention efforts, and suggest that they should be expanded beyond technocentric approaches and instead examine from an ergonomic perspective the managerial, organisational and productive models which hold sway within companies. This requires a broader and deeper base of knowledge on the interrelationship between psychosocial and organisational factors at work and the onset or development of MSDs, viewed from a two-fold analytical perspective, i.e. both individual and collective.

**At individual level**, important points for consideration include individuals' unique experience of pain at work (physical suffering at work or psychosocial stress at work) and the influence of psychological distress on the genesis or aggravation of MSDs;

**At collective level**, it is important to analyse ideas about psychosocial factors (or risks) which apply at work, or in other words the organisational, social and psychological dimensions of the objective and subjective conditions under which work is carried out, and their impact on the onset or development of MSDs. The collective approach is of pivotal importance for MSD prevention in the industrial and service sectors; what is more, since many of the determinants of MSDs are identical to those of certain work-related mental health problems, it is likely that advances in the field of MSD prevention will also prove useful in tackling these latter.

**The purpose of this document** is to present the current state of scientific knowledge on the way in which psychosocial factors influence the genesis of MSDs, their development and their impact on work capacity and the quality of life at work.

An interdisciplinary methodological approach has been chosen in order to synthesise the main scientific findings on MSDs and psychosocial factors at work in the scientific literature from various disciplines (biomechanics, neurobiology, psychology, work psychodynamics, epidemiology, sociology and ergonomics). The paucity of literature on prevention interventions made it necessary to incorporate evidence from the grey literature in order to build on key experiential findings gathered by leading international institutions responsible for occupational risk prevention. In view of the sheer quantity of literature available, the choice was made to focus on workers in industry.

The ultimate aim of this document is to provide an impetus for future prevention efforts based on an integrated and multidimensional model of MSDs, and to set out scientifically well-founded recommendations intended to improve the occupational health of Europe's workers.

# 2. Definitions, basic concepts and contextual epidemiological data

Although one potential definition of a musculoskeletal disorder (MSD) is 'a disease triggered by biomechanical overstrain', the scientific literature makes it clear that MSDs have a multifactorial genesis which goes well beyond biomechanical factors (physical demands, repetitive work, awkward positions, vibrations) and individual factors (age, height, weight, medical history) and includes psychosocial factors at work (Bourgeois 2006; Hauke *et al.* 2011; Roquelaure *et al.* 2014). A better understanding of the interrelationship between MSDs and psychosocial factors at work would pave the way for improved MSD prevention strategies targeted at workers (Roquelaure 2016).

## 2.1 Musculoskeletal disorders

After reviewing the definitions and clinical characteristics of musculoskeletal disorders (MSDs), the main risk factors for MSDs of the limbs and spine will be presented together with contextual epidemiological data.

### 2.1.1 Definition

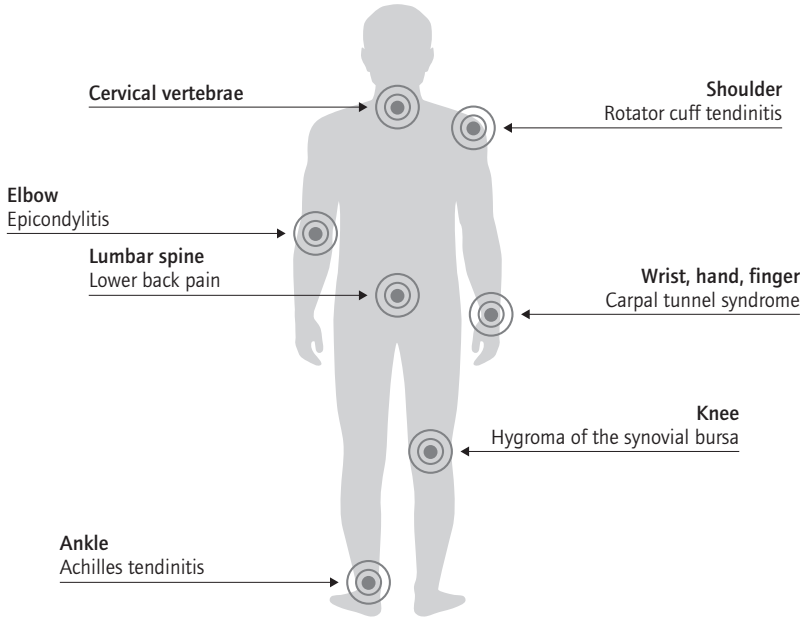
MSDs of the limbs and/or spine are painful diseases of the periarticular soft tissues (muscles, tendons, vessels, etc.) and peripheral nerves which are caused by occupational overstrain (Hagberg *et al.* 1995). They make it uncomfortable for sufferers to carry out their work and worsen the quality of their life at work; in their most severe manifestations, sufferers find it difficult to keep their jobs and are at risk of long-term occupational disability. The term 'MSD' is used as an umbrella heading for medically established periarticular diseases of the limbs and spine, and for multiple or localised pain syndromes (National Research Council 2001; Van Eerd *et al.* 2003; Huisstede *et al.* 2007). These diseases are associated with musculoskeletal overstrain and are, by definition, unrelated to infectious, tumoral or general medical causes of inflammation which might otherwise explain the tissue lesions (International Classification of Diseases, ICD-10) (Ministry of Social Affairs and Health, 2015).

The main conditions which have been clinically described are as follows (Figure 1):

— **in the wrist**, carpal tunnel syndrome, or in other words compression of the median nerve at the carpal tunnel, which is involved in gripping and dexterity; tendinopathies of the extensor/flexor muscles of the fingers;

— **in the elbow**, diseases of the tendons of the external aspect of the elbow (tendinopathies of the lateral epicondyle muscles) which carry out gripping under load; ulnar nerve compression syndrome at the elbow;
— **in the shoulder**, diseases of the shoulder rotator cuff tendons (shoulder rotator cuff tendinopathies), caused in particular by movements and positions in which the arm is stretched out from the body;
— **in the lower back**, lumbar radicular pain (lower back pain which radiates into the lower limbs or predominantly radicular pain) caused by a herniated disc.

Figure 1 **Musculoskeletal disorders**




Source: based on INRS

The symptomatic forms of 'non-specific' MSDs (i.e. MSDs which are less well characterised in clinical terms) are generally syndromes involving pain localised in an anatomical area such as the neck (cervical pain), the shoulder (scapular pain), the elbow (epicondylar pain) or the lower back (lumbar pain) (Van Eerd *et al.* 2003; Huisstede *et al.* 2007; Boocock *et al.* 2009). In complex cases, several anatomical areas may be affected (regional pain syndromes, multiple pain syndromes). These cases are more severe and typically have a significant impact on functional capacity; in serious chronic cases, they can result in motor dysfunction which leaves the sufferer unable to carry out even the simplest of gestural movements required in the course of his or her daily or working life (Hagberg *et al.* 1995; Roquelaure *et al.* 2014).

Table 1 **Classification of the main MSDs in the limbs and spine**

| Types of disease | Location | ICD-10* |
|---|---|---|
| 1. Tendinopathies | Shoulder rotator cuff | M75.1-M75.2 |
| | Lateral epicondyles | M77.1 |
| | Medial epicondyles | M77.0 |
| | Flexors and extensors of the hands/fingers | M70.0-M70.8 |
| | De Quervain syndrome | M65.4 |
| | Quadriceps and patellar tendons | M76.5 |
| | Achilles tendon | M76.6 |
| 2. Tunnel (or outlet) syndromes and nerve compressions | Median (carpal tunnel) | G56.0 |
| | Ulnar (Guyon's canal) | G56.2 |
| | Ulnar at elbow | G56.2 |
| | Radial at elbow (radial tunnel) | G56.3 |
| | Shoulder: suprascapular, serratus anterior, musculocutaneous, circumflex nerves | G56.9 |
| | Cervical thoracic outlet syndrome | G56.9 |
| | Sciatic popliteal nerve (leg) | G57.3 |
| | Lumbar radicular pain caused by a herniated disc | M51.1 |
| 3. Hygromas | Elbow hygroma | M70.2-M70.3 |
| | Hygroma of the back of the phalanges | M70.1 |
| | Knee hygroma | M70.4-M70.5 |
| 4. Bone syndromes | Microtraumatic arthrosis | |
| | – elbow | M.19.9 |
| | – wrist | M19.9 |
| | – base of the thumb | M18.3-M18.9 |
| | Osteonecrosis caused by vibrations (Köhler and Kienböck) | M92.6-M93.1 |
| 5. Vascular syndromes | Angioneurotic disorders | I73.0 |
| | Hypothenar hammer syndrome | I73.8 |
| | Compartment syndrome | T79.6 |
| 6. Meniscus lesions | Menisci | M22.9 |
| 7. Non-specific disorders | Cervicobrachial syndrome (muscular tension in the neck) | M53.1 |
| | Non-specific pain in the upper limbs | M70.9-M79.6 |
| | Cervical pain | M54 |
| | Dorsal pain | M54 |
| | Non-specific lower back pain and lumbagos | M54.5 |

* ICD 10: International Classification of Diseases, 10th Revision (WHO) (Ministry of Social Affairs and Health, 2015).
Source: EU-OSHA (1999)

## 2.1.2 Contextual epidemiological data

MSDs represent a major occupational health issue and are a key focus of occupational risk prevention. Surveys on working conditions in Europe reveal that they rank joint top of the list of occupational health problems faced by European workers, together with psychosocial risks at work (Eurostat 2010; Eurogip 2016). In 2010, 45.9% of workers in the European Union (EU 27 + 7) reported suffering from back pain, 44.5% reported suffering from muscular pains in the shoulders, neck and upper limbs and 33.8% reported suffering from muscular pains in the lower limbs (Eurofound 2012).

— Upper-limb MSDs (UL-MSDs) are the leading cause of occupational diseases in several European countries (France, Spain, Italy, etc.).
— Lower back pain is one of the main outcomes of work-related accidents in the majority of EU Member States.
— UL-MSDs and lower back pain account for a significant proportion of prolonged absences from work or occupational disabilities among workers in industrial sectors.
— According to the ESENER survey carried out in 2014 by the European Agency for Safety and Health at Work, MSDs are the second most pressing occupational health concern for European companies after work-related accidents, and almost 80% of companies believe that MSDs represent a major challenge (EU-OSHA 2014).

The number of occupational diseases is significant among the 217 millions of the European Union's workers, but fail to reflect the true magnitude of the problem because of the different criteria for recognition applied in the various countries (differences in terms of presumption of imputability, diagnostic and exposure criteria, disability criteria, etc.) (Eurogip 2016: 7):

— tendinopathies of the shoulder rotator cuff: eligible for recognition in Belgium, Spain, France and Sweden but not in Germany or Finland;
— lateral epycondylitis (elbow): eligible for recognition in Germany, Belgium, Denmark, Spain and France but not in Finland or Sweden;
— carpal tunnel syndrome: eligible for recognition in Germany, Belgium, Denmark, Spain, Finland and France but not in Sweden.

A 2016 Eurogip report reveals that recognition rates are higher in countries where the national register of occupational diseases operates on the basis of a presumption of occupational origin (France, where the figure is 322 out of 100,000 insured parties, Spain (94), Belgium (82) and Italy (64)) and lower in countries where this is not the case (Austria (1), Germany (3), Switzerland (6) and Sweden (7)). Carpal tunnel syndrome is a representative example of this phenomenon, with around 20,000 cases recognised each year in France compared to between 2,000 and 3,000 in Spain and Italy and only around 50 in Germany (Eurogip 2016: 7).

Table 2 **Recognition of MSDs in the European Union**

| Country | Ratio of MSDs recognised in the MS (/100,000 insured parties) | Proportion (%) / occupational diseases |
|---|---|---|
| Germany | 3 | < 20 |
| Belgium | 82 | 69 |
| Denmark | 257 | < 20 |
| Spain | 94 | 75 |
| Finland | | < 20 |
| France | 322 | 88 |
| Italy | 64 | 69 |

Source: Eurogip (2016)

There is also a strong tendency to under-report MSDs, which can be attributed to a number of factors, such as lack of awareness, the overwhelming nature of complex administrative procedure or a fear of losing one's job (Rivière *et al.* 2014). Surveys on working conditions in Europe reveal that the scale of the epidemic is much larger, with around one in two of the workers surveyed reporting pain in the neck, shoulders or lower back (Eurofound 2016). Differences can be observed between the Member States (EU 27 + 7), but on a much smaller scale than those seen in terms of the recognition of occupational disease. Almost one worker in four reports feeling work-related stress for the majority or all of their time at work. A French study carried out in the Pays de la Loire region resulted in the finding that 13% of workers were suffering from an MSD diagnosed by an occupational physician (Brière *et al.* 2015), or in other words over 100,000 of the 1.5 million workers in this region.

The workers at highest risk of suffering from MSDs are those who perform repetitive tasks under time pressure and with little leeway. They include firstly workers in the agri-food and manufacturing sectors as well as the agricultural and construction sectors, and secondly low-skilled workers in service sectors, most of whom are female (housekeeping staff, care assistants, home helps, cashiers, etc.) (National Research Council 2001; Silverstein *et al.* 2002; Brière *et al.* 2015).

Older workers are particularly at risk owing to premature tissue ageing and the delayed effects of biomechanical constraints accumulated over the course of their careers (the 'legacy of a working life'). Occupational constraints typically remain high even when people are close to retirement age, frequently resulting in situational disabilities which are difficult for the individual to overcome in spite of know-how gained from many years of experience and the application of strategies aimed at reducing the constraints (Côté *et al.* 2008; Daniellou 2008; Brière *et al.* 2015). These individuals are often forced to carry on working to an advanced age even though it causes them severe pain on a daily basis, for example because they have not accrued enough pension rights. Age inequality combines with gender inequality in such cases, because it is women who are most often subject to financial pressures of this kind. The rising average age of workers in certain industrial sectors also increases the risk of UL-MSDs in the absence of prevention initiatives, firstly because of the degenerative phenomena associated with the ageing process itself and secondly because of residual biomechanical constraints accumulated over ever-longer careers. A new development is the increasingly frequent diagnosis by occupational physicians of MSDs in young workers who are not only in precarious employment, but also forced to work under arduous conditions.

### 2.1.3 General modelling of MSD risk

The scientific community has agreed on the multifactorial nature of MSDs ever since the 1990s (Armstrong *et al.* 1993; van Rijn *et al.* 2009; Lang *et al.* 2012). MSDs do not fit the traditional mono-causal model of occupational diseases such as lead poisoning, and are instead more suited to the multi-causal model

of work-related diseases in which occupational exposure represents one factor, but other factors such as individual characteristics or state of health also play a role. Work-related diseases have been defined by the WHO as diseases with a multifactorial aetiology in which the work environment and the performance of work play a significant but not exclusive role (WHO 1985).

There is ample evidence that certain personal characteristics (age, genetic predisposition, etc.) and medical characteristics (obesity, diabetes, inflammatory rheumatism, etc.) increase the risk of MSDs (Hagberg *et al.* 1995; National Research Council 2001; Roquelaure *et al.* 2014), but their role should not be overestimated. Women are more at risk of certain MSDs such as carpal tunnel syndrome and less at risk of other MSDs such as lower back pain, yet it is impossible to determine whether the MSDs from which female workers tend to suffer can be attributed to potential physiological predispositions (anthropometric, hormonal, etc.) or to greater exposure to occupational risk factors owing to the gender-based division of labour (Hooftman *et al.* 2009; Messing *et al.* 2009; Heilskov-Hansen *et al.* 2016). It is important to note that prevention efforts in the workplace have little or no effect on most individual characteristics. The significance of physical activity outside work (leisure pursuits, housework) should also not be overestimated. Although excessive pursuit of activities of this kind can result in cumulative overstrain when combined with occupational overstrain, if pursued on a more moderate basis they are more likely to help prevent MSDs thanks to activation and conditioning of the musculoskeletal tissues.

A broad base of epidemiological research has made it possible to identify the role of occupational factors in the onset and development of MSDs, despite the problems involved in carrying out longitudinal epidemiological studies in the workplace owing to corporate restructuring measures and the increasing flexibility of employment (Roquelaure *et al.* 2012).[1] This research has confirmed the accuracy of the initial models of MSDs based on clinical and biomechanical approaches in the workplace (National Research Council 2001), and has led to three major findings:

1. Epidemiological data converge in showing that prolonged exposure to biomechanical constraints in working situations is a major determinant in the onset of MSDs of the limbs and spine. The main factors which have been identified are as follows (van Rijn *et al.* 2009, 2010; da Costa and Vieira 2010; Kozak *et al.* 2015):

— repetitiveness of movements;
— intensity of movements used when gripping and manipulating objects/apparatus or handling loads;

**1.** Most of the data presented in this report have been taken from longitudinal studies or recent systematic literature reviews.

— repetitiveness or length of time spent adopting uncomfortable postures of the limbs and torso;
— exposure to vibrations transmitted to the hands or spine.

The risk models are consistent for all MSDs, whether specific or non-specific, and differ according to location only in terms of the relative importance of biomechanical factors and the type of posture which places workers at greatest risk based on the joints involved. The body of evidence proving a causal link between exposure to work-related biomechanical constraints and the onset of MSDs justifies the stepping up of workplace interventions, and prevention efforts must focus on reducing forced movements, uncomfortable positions, mechanical vibrations, low temperatures and the handling of heavy loads, as well as avoiding excessive repetition of movements and intense efforts. Further research must be carried out to clarify the 'dose-effect' relationship between occupational exposure and the onset or persistence of musculoskeletal symptoms.

2. More recently, epidemiological studies have demonstrated the impact of psychosocial factors at work on the onset or persistence of non-specific MSDs and, to a lesser extent, specific MSDs of the limbs and spine (Bongers *et al.* 2006; Hauke *et al.* 2011; Lang *et al.* 2012). This confirms that symbolic and psychological dimensions are just as important for MSDs as they are for all chronic pain phenomena, and these areas will be investigated in greater depth in the following chapters. Broadly speaking, it is well known that stress of psychosocial origin disrupts muscle activation and makes work-related movements less efficient, as well as stimulating pain and inflammation mechanisms, reducing tissue repair capacities and promoting the chronicity of pain. Psychosocial factors at work such as the heavy mental load associated with low levels of autonomy give rise to situations of 'work-related tension' which increase the risk of MSDs, particularly if line managers fail to provide their workers with the necessary support or recognition. More recently, a link has been established between MSDs and organisational justice, and between MSDs and the meaning ascribed by workers to their work and the quality of this work, potentially providing new areas for intervention (Elovainio *et al.* 2002; Davezies 2013; Clot 2015). Current research focuses on similarities between the psychological determinants of pain of musculoskeletal and mental origin and their neurobiological mechanisms (Hasenbring *et al.* 2012). As with the biomechanical component, further research needs to be done to identify the impact of 'psychosocial' factors on the onset of various types of MSDs and the resulting occupational disabilities.

3. It is clear from ergonomic studies and prevention interventions that the organisation of work and management practices are of pivotal importance in understanding MSDs and their prevention in industrial and services sectors (National Research Council 2001; Bourgeois 2006; St-Vincent *et al.* 2011). By way of contrast, few epidemiological studies focus specifically on the impact of exposure to these factors (Bao *et al.* 2015; Leider *et al.* 2015; Petit *et al.* 2015). Work organisation characteristics have a domino effect on the conditions under which work is carried out and the biomechanical, psychosocial and

environmental features of the working situations which workers encounter. Management practices and HR strategies dictate the quality of working relations and work appraisal arrangements. Like the organisation of work, they influence not only the constraints associated with particular working situations but also the individual and/or collective resources available to tackle these constraints. Multidisciplinary research is needed to improve prevention interventions targeting the organisational factors which give rise to MSDs.

Table 3 lists the main risk factors for MSDs which have emerged from ergonomic, epidemiological and clinical research carried out in the workplace (Roquelaure *et al.* 2014).

Table 3 **Main risk factors for MSDs**

| Extra-occupational factors | Occupational factors |
|---|---|
| **Individual susceptibility factors** | **Biomechanical** |
| Age<br>Female gender (carpal tunnel syndrome)<br>Genetic predispositions<br>Obesity<br>Pregnancy (carpal tunnel syndrome) | Highly repetitive movements (frequency, speed)<br>Intense efforts (force applied, weight carried or moved, general physical arduousness of working at the workstation)<br>Adoption of uncomfortable postures for long periods (shoulder abduction, flexion/extension of elbow or wrist, flexion/torsion of torso)<br>Large range of movement<br>Using the heel of the palm or the elbow for support, or localised pressure on these areas<br>Exposure to vibrations transmitted to the hand<br>Exposure to vibrations transmitted to the entire body<br>Working in cold conditions<br>Length of exposure to physical constraints<br>Combination of biomechanical factors (+++) |
| **Medical and surgical history** | |
| History of tendinopathies/tunnel syndromes/lower back pain<br>Diabetes<br>Inflammatory rheumatism<br>Severe hypothyroidism (carpal tunnel syndrome) | |
| **Extra-occupational overstrain** | **Organisational** |
| Heavy/prolonged exercise which places strain on the limbs or spine<br>Heavy/prolonged DIY activities<br>Heavy/prolonged gardening | Working under time pressure<br>Very short cycle times<br>Lack of time to recover<br>Inflexibility of procedures and checks<br>Lack of individual/collective leeway<br>Lack of resources to carry out high-quality work<br>Monotonous tasks<br>Gender-based division of work |
| | **Psychosocial** |
| | Job-related stress<br>Heavy mental load<br>Lack of decision-making autonomy<br>Lack of support from line managers<br>Lack of support from colleagues<br>Lack of recognition for work done |

Source: based on Roquelaure *et al.* (2014)

Table 4 is based on a report on MSDs by the Bilbao-based European Agency for Safety and Health at Work (EU-OSHA) and summarises the estimated attributable fractions of risk for the main work-related MSD risk factors. It highlights the importance of work-related factors and reveals the proportion of MSDs which could theoretically be avoided by means of workplace interventions. According to the WHO, work-related factors account for 37% of

the global burden of disease for lower back pain (Concha-Barrientos *et al.* 2004; WHO 2004).

Table 4 **MSDs of the back and limbs; fraction of risk attributable to the main work-related risk factors, based on the Bilbao-based European Agency for Safety and Health at Work (EU-OSHA 2008)**

| Risk factors | Study number | Range of attributable risk fractions in different studies (%) |
|---|---|---|
| **Lower back pain** | | |
| Manual material handling | 17 | 11-66 |
| Frequent bending and twisting | 8 | 19-57 |
| Heavy physical load | 5 | 31-58 |
| Static working posture | 3 | 14-32 |
| Whole-body vibration | 1 | 41 |
| High job demands | 11 | 21-48 |
| Low stimulus from work (monotony) | 1 | 23 |
| Low social support at work | | |
| High perceived stress | | |
| **MSDs of upper limbs** | | |
| Manual material handling | 17 | 11-66 |
| Repetition | 3 | 53-71 |
| Force | 1 | 78 |
| Repetition and force | 2 | 88-93 |
| Repetition and cold | 1 | 89 |
| Vibration | 15 | 44-95 |

Source: National Research Council (2001)

In general terms, the proportion of lower back pain attributable to work is higher among men than among women (41% compared to 32%); this can be explained by the fact that more men are exposed to the types of work associated with the highest level of risk. Research carried out in France has shown that the proportion of carpal tunnel syndrome attributable to work-related factors varies in the employed population (averaging 25% after adjustment on personal factors), but may be as high as 90% in certain populations of workers with high levels of exposure, such as abattoir workers (Roquelaure *et al.* 2009; Brière *et al.* 2015).

## 2.2 Psychosocial factors at work

Since the 1980s/1990s, the introduction of new management practices and methods for streamlining production in Europe's industrial and service sectors has resulted in a sharp increase in MSDs. Since the 1990s/2000s, an 'MSD epidemic' affecting tens of millions of European workers who suffer from pain at work on a regular basis (including several hundred thousand suffering from clinically diagnosed MSDs) has gone hand-in-hand with another 'epidemic' –

work-related mental health problems, which had previously been an unusual occurrence (Dejours 2008), but which can be serious enough to result in workplace suicides, the spread of work-related stress throughout all occupational groups and the widespread exposure of workers not only to 'biomechanical' risks but also to psychosocial risks at work (Inserm 2011).

According to Eurostat, the proportion of workers in Europe (EU-27) who are exposed to at least one factor likely to have a detrimental impact on their mental well-being stands at 56 million or 28% (Eurostat 2009). In the same vein, a report on psychosocial risks in Europe published in 2014 states that one quarter of workers are subject to stress during all or most of their time at work, with a similar percentage of workers claiming that their job has a negative impact on their health (Eurofound and EU-OSHA 2014). According to the Sixth European Working Conditions Survey, hostile social behaviour (physical violence, sexual harassment and intimidation/bullying) has been encountered by almost one in six workers, with significant variation between countries and sectors of activity (EWCS 2015).

In the absence of internationally agreed definitions of work-related psychosocial factors or risks, however, the meaning of these terms remains vague. Within the European Union, the Framework Directive on Safety and Health at Work (Directive 89/391/EEC) does not explicitly refer to 'work-related stress' or 'psychosocial risks', but states that employers have a duty to ensure the safety and health of workers in every aspect related to the work. The Machinery Directive (Directive 2006/42/EC) states that the discomfort, fatigue and psychological stress faced by the operator must be reduced to the minimum possible taking ergonomic principles into account. Since the 2000s, the burgeoning importance of psychosocial risks at work has attracted the attention of companies and European institutions responsible for occupational risk prevention, as reflected in framework agreements signed by the social partners in 2004 (on work-related stress) and 2007 (on bullying and violence at work). The term 'psychosocial factors at work' will be used in the remainder of this document in preference to terms such as stress, psychosocial risks or psychosocial hazards, which are sometimes used elsewhere in the literature. Similarly, work-related organisational factors will implicitly be included under the heading of 'psychosocial factors at work'.

### 2.2.1 Work-related stress

According to the International Labour Organization (ILO), 'stress is the harmful physical and emotional response caused by an imbalance between the perceived demands and the perceived resources and abilities of a person to cope with those demands'. The ILO further states that 'Work-related stress is determined by work organisation, work design and labour relations and occurs when the demands of the job do not match or exceed the capabilities, resources, or needs of the worker, or when the knowledge or abilities of an individual worker or group to cope are not matched with the expectations of the organisational culture of an enterprise' (ILO 2016: 2). The main two models

used as a basis for research into work-related stress (see below) are the 'job demand-control-support' (DCS) model developed by Karasek and Theorell and the 'effort-reward imbalance' model (ERI) developed by Siegrist (Chouanière *et al.* 2011).

The European Agency for Safety and Health at Work (EU-OSHA) has proposed the following definition of stress: 'the psychological state that occurs when there is a mismatch between perceptions of the significance of a demand, and beliefs about one's ability to cope with it' (Cox *et al.* 2000). A report published by this Agency in 2002 emphasises the organisational dimension of work-related stress and defines it as 'a pattern of emotional, cognitive, behavioural and physiological reactions to adverse and noxious aspects of work content, work organisation and work environment… Stress is caused by poor match between us and our work, by conflicts between our roles at work and outside it, and by not having a reasonable degree of control over our own work and our own life' (EU-OSHA 2002). According to the authors of the report, 'stress can be said to be experienced when the demands of the work environment exceed the employees' ability to cope with (or control) them. Defining stress in this way focuses attention on the work-related causes and the control measures required' (EU-OSHA, 2002).

The European Framework Agreement of 8 October 2004 on work-related stress states that 'stress is a state, which is accompanied by physical, psychological or social complaints or dysfunctions and which results from individuals feeling unable to bridge a gap with the requirements or expectations placed on them'.

### 2.2.2 Psychosocial factors at work

The ILO has defined psychosocial factors at work in keeping with its definition of work-related stress, i.e. in the context of their interactions with the content of work, the organisation of work and management practices on the one hand, and workers' skills and expectations on the other hand. 'Psychosocial factors at work refer to interactions between and among work environment, job content, organisational conditions and workers' capacities, needs, culture, personal extra-job considerations that may […] influence health, work performance and job satisfaction' (ILO 1984). According to the Joint ILO/WHO Committee, the 'stressful psychosocial factors in the working environment are many and varied. They include physical aspects, some aspects of the organisation and system of work, and the quality of human relations in the enterprise. All these factors interact and affect the psychological climate in the enterprise and the physical and mental health of workers' (ILO/WHO 1984).

A report on work-related stress published by the European Agency for Safety and Health at Work in 2000 (Cox *et al.* 2000) identifies 10 types of characteristics which give rise to work-related stress; these characteristics are assigned to the headings 'content of work' or 'context of work' (Table 5), with some of the characteristics also relating to the organisation of work.

Table 5 **Work-related stress and psychosocial factors at work**

| Content of work | |
|---|---|
| **Environment and equipment** | Inadequate reliability, availability, suitability, maintenance or repairs of equipment and installations |
| **Job content** | Lack of variety or short work cycles, fragmented or meaningless work, exploitation |
| **Work load and work pace** | Work overload or under load, machine pacing, continually subject to deadlines |
| **Management of working time** | Management of working time |
| **Culture and purpose of the organisation** | Poor communication, lack of support for problem-solving and development |
| **Role in the organisation** | Role ambiguity, role conflict and responsibility for people |
| **Career development** | Career stagnation and uncertainty, under promotion or over promotion, poor pay |
| **Decision-making autonomy/control** | Low participation in decision-making, lack of control over work (control, particularly in the form of involvement, is also a problem in terms of context and organisation) |
| **Interpersonal relationships at work** | Social or physical isolation, poor relationships with superiors, interpersonal conflicts, lack of social support |
| **Home-work interface** | Conflicting demands of work and home, low support at home, dual career problems |

Source: based on Cox *et al.* (2000)

According to the National Institute of Health and Medical Research [Institut National de la Santé et de la Recherche Médicale, Inserm], psychosocial factors 'are psychological, social and relational constraints resulting from the organisation of work, and include all occupational exposures not involving physical and chemical agents' (Inserm 2011).

In France, a board of experts on the monitoring of psychosocial risks at work, chaired by Michel Gollac, has defined psychosocial risks as 'risks to mental, physical and social health, resulting from employment conditions and organisational and relational factors likely to interact with mental functioning' (Ministry of Labour, Employment and Health 2011). According to this definition, an occupational health risk should be considered psychosocial in nature on the basis of its origin rather than its manifestation. The board of international experts proposes that these risks should be grouped into six categories (Table 6):

Table 6 **Psychosocial factors at work according to a board of experts on the monitoring of psychosocial risks at work**

| Categories | Examples of psychosocial factors at work |
|---|---|
| **Intensity and duration of work** | – Constraints relating to work pace<br>– Unrealistic or vague objectives<br>– Excessive demands for versatility<br>– Contradictory instructions<br>– Long working days, atypical work schedules, unpredictable working hours, etc. |
| **Emotional demands** | – Expectation that emotions will be controlled and suppressed<br>– Obligation to smile or pretend to be in a good mood<br>– Conflict with members of the public, exposure to suffering or human distress<br>– Full self-control in all circumstances and a 'positive attitude' at all times |
| **Lack of autonomy** | – Lack of agency over one's own work<br>– Lack of decision-making freedom and room for manoeuvre (ability to organise one's own work)<br>– Lack of employee involvement in decisions directly affecting their activities and the utilisation and development of their skills |
| **Poor social relations at work** | – Relations with colleagues and line managers<br>– Career prospects<br>– Suitability of the task for the individual<br>– Work appraisal procedures<br>– Value placed on employees' well being<br>– 'Pathologies' of social relations such as bullying |
| **Conflicts of values** | – Intrapsychological conflicts resulting from an imbalance between what is demanded at work and professional, social or personal values of employees |
| **Job insecurity** | – Socio economic insecurity (fear of losing one's job, drop in wages, precarious contract)<br>– Risk of not being able to cope with changes to tasks and working conditions (restructuring, uncertainty about the future of one's job, etc.) |

Source: Ministry of Labour, Employment and Health (2011)

## 2.2.3 Epidemiological models of psychosocial factors at work

The significance of psychosocial factors at work is made clear by the epidemiology of occupational risks, and the conceptual models of psychosocial factors at work which have been developed on the basis of studies and for which validated questionnaires are available can be categorised under three main headings (Chouanière and Niedhammer 2011; Thébaud-Mony *et al.* 2015).

1. **The 'job demand-control-support' (DCS) model** developed by Karasek and Theorell (1990) (Karasek and Theorell 1992) drew its inspiration from work previously done on the psychophysiology of stress in the late 1970s and the theory of alienation (Thébaud-Mony *et al.* 2015). It defines decision-making freedom as the worker's ability to exercise control over his or her work, either by utilising existing skills and competencies or by taking decisions at work (Karasek *et al.* 1998).

The DCS model proposes that the combination of high mental demands and low decision-making control at work (a situation referred to as 'job strain') engenders in workers a state of strain which exceeds their capacity to adapt, and which manifests itself in physical and mental health problems. Workers subject to job strain experience alienation (Thébaud-Mony *et al.* 2015).

The DCS model suggests that other demand-control combinations give rise to little or no stress:

— a combination of low mental demands and high decision-making control is referred to as 'low strain';
— a combination of high mental demands and high decision-making control is deemed to promote the acquisition of new skills and what is termed 'active' work;
— a combination of low mental demands and low decision-making control, on the other hand, is referred to as 'passive' work.

In the late 1980s, a third dimension – social support at work – was added to the DCS model in order to take account of the harmful impact of social isolation or poor social support on individuals suffering from job strain. The term 'social support' refers to all utilitarian social interactions at work, either with colleagues or line managers, and covers both socio-emotional support (level of social and emotional integration and trust between colleagues and line managers) and instrumental support (level of help and assistance given by others). The model suggests that the psychosocial situation of workers encountering weak social support (iso-) together with high mental demands and low decision-making control (job strain), referred to as 'job iso-strain', is most harmful to health.

The DCS model is one of the most popular among researchers investigating the links between psychosocial factors at work and MSDs, but certain authors have highlighted the vagueness of concepts such as decision-making control, mental demands or social support and the lack of consensus in this respect, and criticised the heterogeneous nature of evaluations of DCS dimensions in epidemiological studies (Stock *et al.* 2013).

2. **The effort-reward imbalance (ERI) model** developed in the 1990s by Siegrist (1996) postulates that work-related stress originates from an imbalance between the efforts made by workers and the rewards they obtain from their employer as a result in the form of wages, recognition, job security and career opportunities. This model makes a distinction between 'extrinsic' effort, which is determined by the nature of the tasks or the working environment, and 'intrinsic' effort, which is determined by the motivations and expectations of the individual worker.

The DCS model centres around the concept of decision-making autonomy (control), but the ERI model centres on that of 'social reciprocity', i.e. how easy it is for a worker to have access to the benefits which he or she is legitimately entitled to expect. An imbalance between effort on the part of a worker and the

recognition gained for this effort results in the worker feeling exploited (Thébaud-Mony *et al.* 2015). Unlike the DCS model, the ERI model introduces the concepts of worker motivation and individual personality as elements which may have an impact on occupational health. As highlighted by Stock *et al.* (Stock *et al.* 2013), it is important to ensure that this emphasis on the personality of individual workers does not encourage health and safety bodies to attribute a psychogenetic origin to these health problems, thus shifting the focus of prevention interventions away from alterable aspects of the working environment. Like the DCS model, the ERI model furthermore prioritises certain psychosocial elements while ignoring other variables which may be relevant; for example, certain psychosocial factors at work which tend to affect women or their jobs have not been included (conditions which have an impact on work/life balance, the emotional demands of jobs, gender-based discrimination, etc.) (Stock *et al.* 2013; Thébaud-Mony *et al.* 2015).

3. **The organisational justice (OJ) model** which has been applied to occupational health in recent years (Thébaud-Mony *et al.* 2015) is based on the idea of equity in relationships, procedures and resource distribution at work (Elovainio *et al.* 2002). Organisational justice can be evaluated in several different dimensions, including that of distributive justice (i.e. the perceived equity of the outcomes of a decision), procedural justice (i.e. the perceived equity of the decision-making processes which reflect the company's decision-making systems) and interactional justice (the equity of interpersonal relations during decision-making procedures, such as the level of politeness, dignity and respect accorded to workers by their line managers), which is sometimes divided into interpersonal justice (i.e. the extent to which workers perceive that they are treated with respect and dignity during decision-making procedures) and informational justice (i.e. the extent to which workers perceive that the explanations provided by senior managers are satisfactory and of a high quality).

Unlike the DCS and ERI models, which are based on workers' individual perceptions, the OJ model makes it possible to measure situations of injustice which occur in the workplace even if the worker has not experienced the injustice himself or herself (Thébaud-Mony *et al.* 2015). The only meta-analysis available (synthesising 83 studies published between 1991 and 2009) on the relationship between organisational justice and occupational health (Robbins *et al.* (2012)) concentrates on studies investigating mental health at work, none of which cover MSDs. The perception of justice changes over time, and these changes correlate with changes in health or well-being variables. There is therefore an association between organisational justice, burn-out and perceived stress, although it is impossible to determine whether this association is direct or indirect.

Very few studies focusing exclusively on MSDs have been published in recent years. Pekkarinen *et al.* (2013) demonstrated that distributive justice was associated with a lower frequency of MSDs and helped to reduce the negative impact of mental workload on MSDs. Heponiemi *et al.* (2013) confirmed these findings through a more holistic evaluation of organisational justice

(procedural and relational justice), by comparing employees with permanent or precarious contracts. More recently, Manville *et al.* (2016) found that organisational justice (in all of its dimensions) was negatively linked to the prevalence of MSDs, and that this relationship could be explained by a reduction in sleep disorders and emotional exhaustion. The mechanisms which form the link between organisational justice and MSDs remain poorly understood, and there are potentially multiple direct and indirect mechanisms. Organisational injustice may constitute a stress factor which exists separately to the factors identified in the DCS and ERI models, and which influences the perception of musculoskeletal symptoms through the lens of negative emotional states. Organisational justice may also modulate the relationship between mental demands and musculoskeletal symptoms and serve as a resource which can be drawn upon to cope with these latter, as suggested in the studies by Pekkarinen *et al.* (2013) and Heponiemi *et al.* (2013). The relationship between organisational justice and MSDs has not yet been firmly established, but this appears to be a promising area of research with a view to broadening the understanding of psychosocial factors at work and their links with MSDs.

Many different tools are available for evaluating psychosocial factors at work, with the most commonly used including the 'Job Content Questionnaire' (JCQ) by Karasek and Theorell and the 'Effort-Reward Imbalance Questionnaire' (ERIQ) by Siegrist (Chouanière *et al.* 2011). More recently, the Danish National Research Centre for the Working Environment identified a number of different categories of psychosocial factors at work as a basis for developing the Copenhagen Psychosocial Questionnaire (COPSOQ I and II).

This long version of the questionnaire, which is one of the most comprehensive of its kind and has been validated in several languages, includes the following dimensions (Kristensen *et al.* 2005; Pejtersen *et al.* 2010):

— five dimensions relating to *work requirements* (quantitative demands, work pace, cognitive demands, emotional demands, demands for hiding emotions);
— five dimensions relating to *work organisation and job content* (influence at work, use of skills/possibilities for development, variation, meaning of work, commitment to the workplace);
— eight dimensions relating to *interpersonal relations and leadership* (predictability, recognition, role clarity, quality of leadership, social support from colleagues, social support from supervisors, sense of community);
— four dimensions relating to *work-individual interface* (insecurity at work, job satisfaction, work/life conflicts, life/work conflicts);
— four dimensions relating to *values in the workplace* (mutual trust between employees, trust in the management, justice, social inclusion);
— seven dimensions relating to *harmful behaviours* (sexual harassment, threat of violence, physical violence, bullying, malicious teasing, conflicts and disputes, gossip and slander);

— eight dimensions relating to *health and well-being* (general health, burn-out, emotional distress, symptoms of depression, somatic symptoms, cognitive symptoms, mental health, energy, vitality).

# 3. Interrelationship between psychosocial factors at work and musculoskeletal disorders

The data available in the literature on the interrelationship between MSDs and psychosocial factors draw on a number of different models of health, namely the biomedical model, the biopsychosocial model and the ergonomic model.

## 3.1 Biomedical modelling of MSD risk

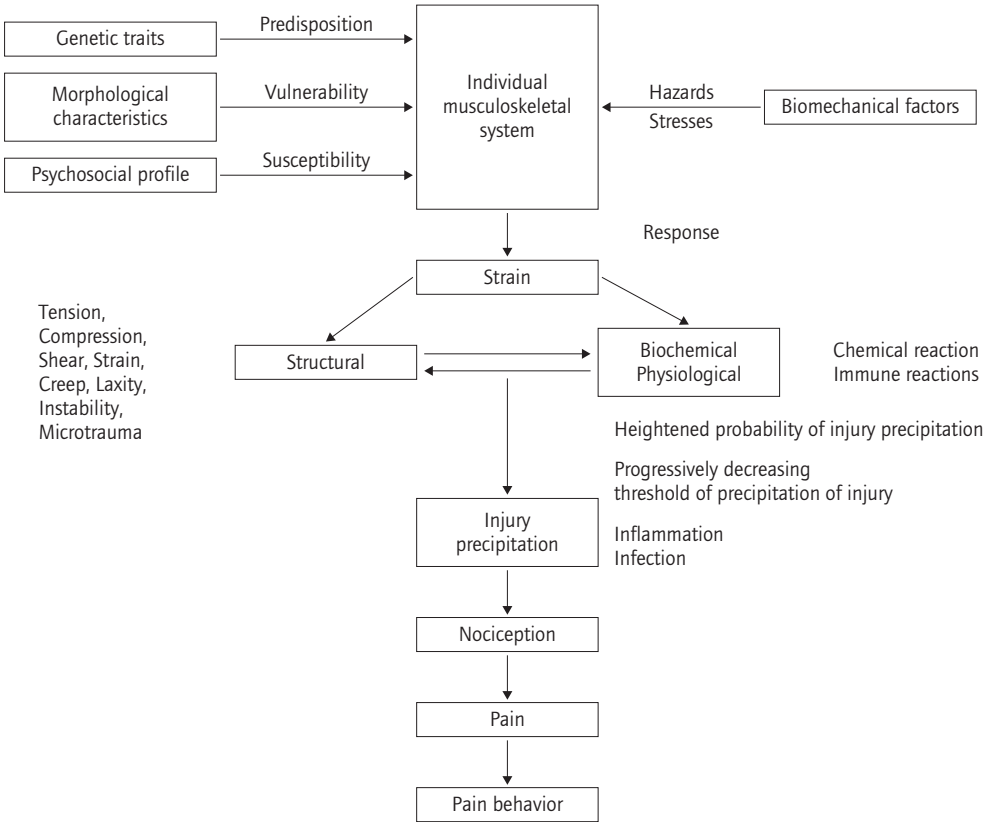
Biomedical modelling of MSDs is based mainly on research in the fields of soft tissue biomechanics and neurobiology (Armstrong *et al.* 1993; National Research Council 2001; Freivalds 2011). One of the most significant considerations is the mechanical load applied to the musculoskeletal tissues (constraint), which brings about tissue effects (strains) which may in turn give rise to the physiopathological mechanisms which cause MSDs (tissue lesions). The viscoelastic properties of the periarticular soft tissues mean that tissue deformations (strains), and accordingly tissue lesions, depend both on the intensity and time (or repetition) of constraint application (McGill 1997; Kumar 2001, 2007; Freivalds 2011). The model proposed by Kumar (Kumar 2007) illustrates the chain of biomechanical, structural and biochemical factors which may result in the onset of MSDs, as well as the influence of predisposition, vulnerability and susceptibility as factors linked to individual characteristics (Figure 2).

Biomechanical musculoskeletal load is determined primarily by the constraints of the working situation, i.e. the real-life conditions under which work is carried out, the intensity of gripping efforts, the frequency and/or duration of these efforts, and the positions in which work is carried out, which determine the geometric characteristics of the joints when effort is applied. The extent of the response to musculoskeletal load (strain) is modulated by individual characteristics (e.g. previous musculoskeletal lesions) and individual responses to exertion (e.g. the application of know-how about precautions which can be taken). Periarticular tissue microtraumas caused by painful stimulations occur when constraints exceed the capacity of a worker's tissues to adapt, i.e. in the event of a mismatch between the exertion and the individual's functional capacities (Kumar 2007; Aptel *et al.* 2011).

In practice, however, it is extremely challenging to evaluate workers' functional capacities in an industrial setting, since they depend on many different factors (National Research Council 2001; Freivalds 2011; Hasenbring *et al.* 2012):

— individual susceptibility factors: age, personal characteristics, etc.;
— state of health: previous MSDs, diabetes, inflammatory rheumatism, etc.;
— job history: intensity and duration of past exposure to organisational, psychosocial and biomechanical constraints, residual biomechanical effects (the 'legacy of a working life'), etc.;
— professional experience and development: on-the-job learning and acquisition of know-how so that constraints inherent to working situations can be overcome by utilising competencies and taking precautions; opportunities for workers to help each other, etc.

Figure 2 **Kumar's biomechanical model based on the domino effect**




Source: based on Kumar (2007)

Given the vast number of different parameters which modulate workers' functional capacities and the extremely high level of inter-individual and intra-individual variability, it would be unrealistic to attempt to evaluate the functional capacities of a group of workers in a scientifically valid and accurate manner. Primary MSD prevention efforts within companies must therefore focus on reducing exertion for all workers rather than trying to achieve a precise match between the demands of a particular task and an individual's functional capacities (National Research Council 2001; Aptel *et al.* 2011; Freivalds 2011).

The physiopathological models refer to the same risk factors for all MSDs (Table 3, p. 15), but the tissue mechanisms differ depending on whether the lesions in question are muscle lesions, tendon lesions (tendinopathies, Figure 3a) or nerve lesions (canal syndromes, Figure 3b).

In the case of *tendinopathies* (for example rotator cuff tendinopathy), multiple mechanisms are involved: mechanical and structural mechanisms linked to the anatomical conflict between the tendons and the bone structures, degenerative mechanisms linked to premature tissue ageing, microtraumatic mechanisms linked to cumulative tissue lesions resulting from tendon overstrain (musculoskeletal load), vascular mechanisms linked to an increase in intramuscular pressure which weakens the tendon vessels, and regenerative mechanisms linked to changes in the physiological mechanisms of tissue repair (Hopman *et al.* 2013). Exposure to psychosocial stress can interfere with microtraumatic, vascular and regenerative mechanisms (see below).

In the case of *tunnel syndromes* (e.g. carpal tunnel syndrome), the mechanisms are both mechanical (compression and elongation of the nerve) and vascular (increase in intra-tunnel pressure weakening the microcirculation of the nerve and promoting nerve lesions) in response to musculoskeletal strains on the wrist and hand (Viikari-Juntura and Silverstein 1999). Motor control faults may also occur (Maeda *et al.* 2016). Psychosocial stress may interfere with microtraumatic and microcirculatory mechanisms (see below).

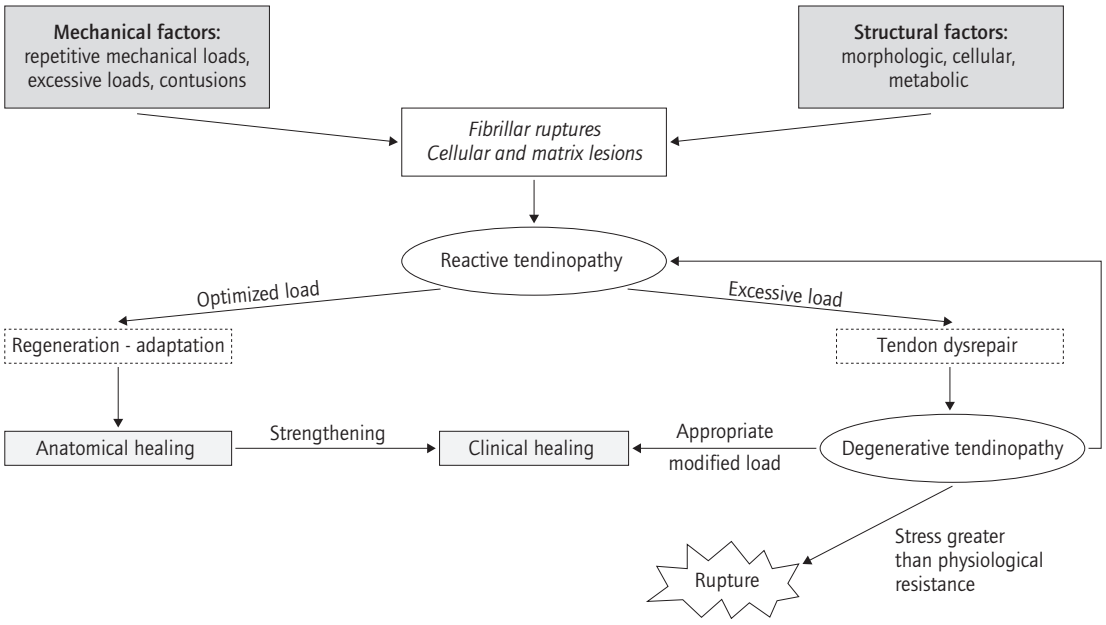
Certain types of *muscle pain (myalgia)* are responses to existing mechanisms in workers carrying out physically demanding and repetitive tasks (Kumar 2007; Aptel *et al.* 2011; Freivalds 2011). By way of contrast, the concept of tissue overexertion does not provide an explanation for muscular problems in the region of the neck, shoulders or back in workers carrying out tasks which require them to remain immobile (static work). Tasks of this kind – for example those carried out by office workers using computer systems or binocular microscope operators in the bio or electronics sectors – require little force but very precise movements. The unvarying nature of these tasks, which are associated with a low level of repetitiveness but which are carried out over long periods of time, results in physiological and psychological monotony, which is significant in that it mirrors the repetitiveness of physically demanding tasks. The lack of any breaks or variation in muscle activity is a proven source of fatigue in the neck and shoulder muscles even if the amount of effort involved is small, owing to the prolonged recruitment of slow motor units which have a low activation threshold (Hagberg *et al.* 1995; Johansson *et al.* 2003; Aptel *et al.* 2011).

**In summary**, the biomedical model of MSDs is a 'mechanistic' model which hypothesises that any symptom manifests the onset of accidental 'tissue lesions' caused by a severe trauma (e.g. a workplace accident which occurs during the manual handling of heavy loads) or cumulative and progressive trauma (e.g. an occupational disease linked to the habitual and repetitive handling of moderate loads under time pressure) (McGill 1997). This model is relevant when assessing the risk of acute MSDs (for example muscle tears), but

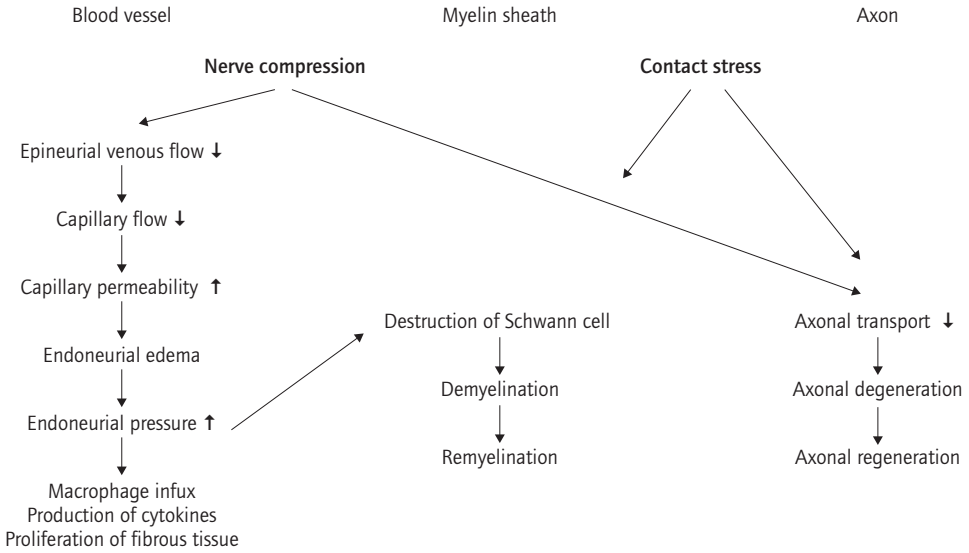
less relevant when predicting chronic MSDs and MSD-related disability (van Oostrom *et al.* 2009; Hasenbring *et al.* 2012; Loisel and Anema 2013).

Figure 3 **Physiopathological models of tendinopathies and tunnel syndromes**

**a. Tendinopathies**




**b. Tunnel syndrome**




Source: based on Viikari-Juntura and Silverstein (1999)

## 3.2 Biopsychosocial approach to MSDs

### 3.2.1 The experience of bodily pain at work: a biopsychosocial phenomenon

Workers suffering from MSDs experience pain at work (and/or outside work) when carrying out certain tasks, and find it uncomfortable to carry out certain work-related (and/or domestic) activities. Pain at work is always an individual, multidimensional and subjective experience (Hasenbring *et al.* 2012; Vlaeyen and Linton 2012), as demonstrated by the definition of pain proposed by the International Association for the Study of Pain (IASP): 'an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage'. Musculoskeletal pain is therefore a global neurobiological, psychological and social phenomenon.

**a. Neurobiology of musculoskeletal pain:** musculoskeletal pain is a complex phenomenon (Fouquet 2003; Roquelaure *et al.* 2014), since the nociceptive stimulus may originate from the musculotendinous structures (tendons, tendon sheaths, muscles) and/or the nerve structures.

Pain can be assigned to one of two broad categories – nociceptive and neuropathic – depending on the nature of the pain process:

— **Nociceptive pain** (linked to an organ lesion): the nociceptive influx originates from tendon, muscle, capsular or ligament structures or tendon sheaths. If the biomechanical tolerance threshold of a structure (physical tolerance threshold) is exceeded, this may result in a nociceptive influx, either via the mechanoreceptors, or via the chemoreceptors or the polymodal receptors in the event of local inflammatory reactions. After being relayed to the posterior ganglion, the nociceptive stimuli result locally in a state of segmental hypersensitivity of all the receptors located in the same territory. An interneuron which inhibits the nociceptive transmission exists at this level and plays a role in moderating pain. It is stimulated by sensory afferents conveyed at rapid conduction speed through myelinated fibres which are activated by physical exercise.

— **Neuropathic pain** (linked to lesions of the nervous system): pain of this kind is associated with focal or sequential lesions (rarely immediate lesions) of the nerve trunk. In the case of carpal tunnel syndrome, local hyperpressure phenomena give rise to nerve lesions (in particular of the myelinated fibres), resulting in permanent short-circuits of the interneuron which inhibits the posterior horn and leading to secondary hypersensitivity. The threshold for triggering of the neuropathic stimulus can be lowered by general factors (fatigue, diabetes, etc.) or local factors which alter the vascularisation of the nerve (focal ischemia). These lesions, which are theoretically reversible, may be accompanied by prolonged medullary hypersensitivity linked to reorganisation of the

reflex, segmental and then locoregional motor system, oedematous neurovegetative modifications, vasomotor disorders, and enlargement of the sensory reception areas (through the activation of sensory neurons which are generally silenced). The resulting mechanism may amplify sensory disorders and, through disorganisation of the motor system, gestural activity.

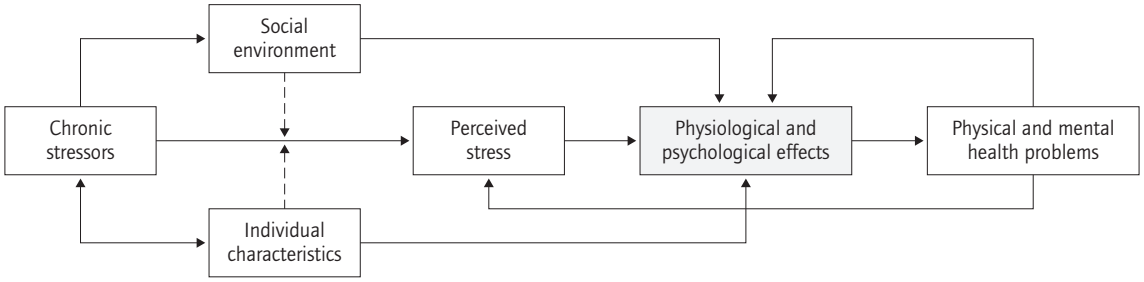
— **Mixed pain**: localised MSDs, particularly in the case of a nociceptive stimulus at a tendon starting point, reorganise the motor control of work-related movements by modifying the motor synergies. This reduces the output of the gestural activity and leads to the recruitment of muscle groups which were not initially involved in the work-related movement. For example, it is this phenomenon which explains the 'over-use' of muscles in the scapular belt leading to hypertrophy of the muscles in the thoracobrachial outlet and compression of the adjacent nerve trunks, resulting in neuropathic pain (Laulan *et al.* 2011). If the output of the secondary gestural activity is modified into pain and motor reorganisation, the same workload costs more effort.

**b. Pain, MSDs and psychosocial stress**: neurobiological arguments shed light on the mechanisms which explain the interrelationship between psychosocial stress and MSDs. Stress is an overarching emotional, psychological and biological concept. In 1936, Hans Selye provided a biological definition of stress as 'the non-specific [biological] response of the body to any demand for change'. In the intervening decades, the neurobiology of stress has revealed an interrelationship between the mechanisms of psychosocial stress, pain and inflammation of the periarticular soft tissues.

Stress is an integrative concept, which explains why a holistic approach must be taken to the balance of subject/environment interactions and no distinction made between 'social, emotional, mental and cognitive' balance on the one hand, and 'somatic, biological and brain' balance on the other (Moisan and Le Moal 2012). Stress is 'a fundamentally psychobiological concept, since stressors act through cognitive and emotional processes, and any mental phenomenon is by definition reflected in the brain and on a biological level' (Inserm 2011; Moisan and Le Moal 2012).

The afore-cited definitions of work-related stress draw on a transactional concept of stress (Inserm 2011), according to which 'stress is the harmful physical and emotional response caused by an imbalance between the perceived demands and the perceived resources and abilities of individuals to cope with those demands'. Although acute (i.e. occasional) stress is adaptive ('fight or flight'), chronic stress is a maladaptation and a source of physical or somatic pathologies if the permanent presence of the stressors prevents recovery and the restoration of balance. The pathological effects emerge over the days, weeks or even years following the stressful events through dysregulation of the stress systems (Figure 4) (Inserm 2011; Moisan and Le Moal 2012).

Figure 4 **Links between chronic stressors and health**




Source: based on Inserm (2011)

Responses to stress involve four systems which may interact with the musculoskeletal system: 1. Arousal of the central nervous system; 2. Activation of the catecholaminergic pathway (vegetative nervous system); 3. Activation of the adrenal cortex (endocrine system); 4. Activation of the secretion of cytokines (immune system) (Figure 5) (Aptel *et al.* 2011; Hasenbring *et al.* 2012; Moisan and Le Moal 2012):

**1. Arousal of the central nervous system:** stress-related arousal of the central nervous system increases the level of activity of the reticular formation, which in turn increases muscle tone. The increase in muscle tone is the key mechanism, since by increasing muscle stiffness, it also increases the musculoskeletal load of the muscles and tendons and thus increases the risk of MSDs (Schleifer *et al.* 2008; Eijckelhof *et al.* 2013; Taib *et al.* 2016). This mechanism is particularly important at the level of the scapular belt and the spine in view of the significance of diffuse reticulospinal projections on the motor neurons of the muscles of the scapular belt and the dorsolumbar muscles (Kumar 2007). It has been established experimentally that activity of the shoulder musculature increases upon exposure to psychosocial stress, with a greater static scapular load (Schleifer *et al.* 2008; Eijckelhof *et al.* 2013; Taib *et al.* 2016). A specific feature of the muscular arousal associated with psychosocial stress compared to that associated with physical activity is its long duration. Since workers are not always allowed to relax in order to release their muscles (as referred to above), this means that stress results in extremely prolonged but low-intensity muscular arousal which can lead to myalgia (pain in the trapezius, upper back or lower back) (Johansson *et al.* 2003; Aptel *et al.* 2011; Heneghan and Rushton 2016). The latter can in turn also influence the perception of stress (Bonzini *et al.* 2015).

**2. Activation of the catecholaminergic pathway:** stress activates the vegetative nervous system, which triggers the secretion of catecholamines (adrenaline and noradrenaline) which, through a variety of mechanisms, reduce microcirculation in the muscles and in the muscular tendons, which naturally have a low level of vascularisation. The resulting effects on the musculoskeletal tissues are twofold: (i) a reduction in the supply of nutrients to the tendons, impeding the self-repair of microlesions in the tendon fibres following excessive biomechanical constraints; and (ii) the earlier onset of

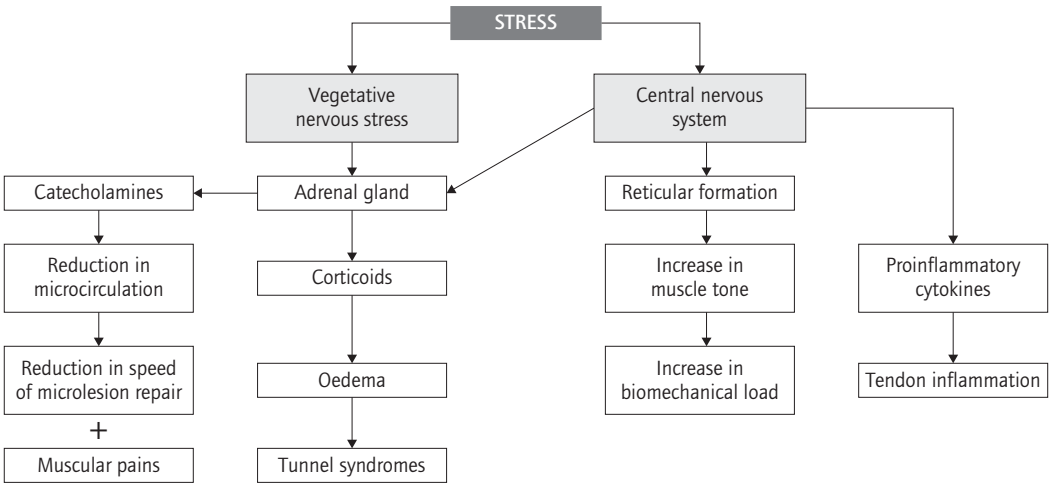
muscle fatigue and chronic myalgia (Kumar 2007; Hasenbring *et al.* 2012; Davezies 2013).

**3. Activation of the adrenal cortex:** acute stress arouses the central nervous system which, through the hypothalamus, in turn activates the pituitary gland, which (among other things) triggers the release of corticoids by the cortico-adrenal gland; this may disturb the hydromineral balance of the body and result in increased sodium and fluid retention, promoting the onset of 'tunnel syndromes' through local compression of the nerves by oedomatous adjacent tissues (tendons, etc.) (Aptel *et al.* 2011; Palmer 2011; Aboonq 2015). In the event of chronic occupational stress, on the other hand, the production of cortisol may drop or the cellular receptors may become less sensitive to cortisol, which lowers the pain threshold and promotes the expression of musculoskeletal disorders (Hasenbring *et al.* 2012; Davezies 2013).

**4. Activation of the secretion of cytokines:** stress activates the central nervous system, which in turn activates the production/release of proinflammatory cytokines (tumour necrosis factor alpha (TNF-α), interleukins 1 (IL-1) and 6 (IL-6), etc.) which participate in chain reactions that promote the onset or increase the severity of neuropathic tunnel pain and inflammatory tendon lesions. These cytokines also appear to interfere with the mechanisms for tendon tissue repair (Hasenbring *et al.* 2012; Burger *et al.* 2015; Millar *et al.* 2017).

Physiopathological mechanisms which respond to chronic stress (modification of the cortisol response, secretion of proinflammatory cytokines) also act on the hippocampus and the loci for serotonin secretion (Inserm 2011). They can therefore promote the onset of mental health problems (depression) or sleep disorders.

Figure 5 **Relationship between stress and MSDs, based on INRS**




Source: based on Aptel *et al.* (2011)

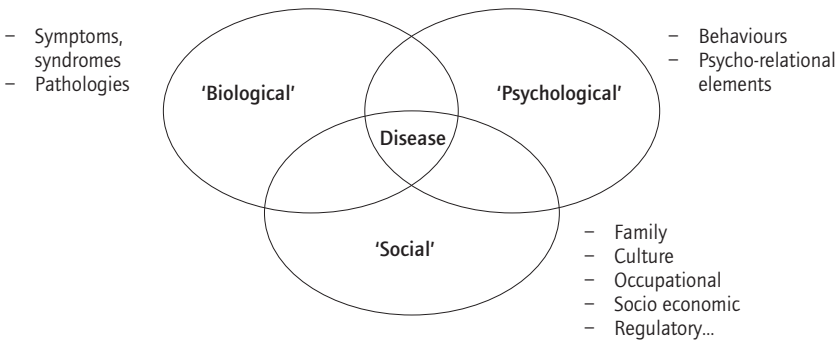
**In summary**, there are many neurobiological arguments supporting the idea of an interrelationship between psychosocial stress and MSDs. In view of the multidimensional and subjective nature of the pain experience, MSDs must be understood as multifactorial entities which incorporate neurobiological, biomechanical, psychological and sociological factors. This justifies a biopsychosocial approach to the aetiological and prognostic factors for MSDs (both individual susceptibility factors and work-related factors).

## 3.2.2 Biopsychosocial model of MSDs

The current approach to MSDs is based on several general models of health, in particular Engel's biopsychosocial model and the work done to adapt this model to MSDs, as well as organisational models based on research in the fields of ergonomics, management and the sociology of work.

**a. Biopsychosocial model of health:** Engel's biopsychosocial model of health (Engel 1997) is based on a holistic and integrated approach to the human being in which 'biological, psychological and social factors are regarded as being simultaneously involved in the maintenance of health or the development of disease' (Figure 6).

Figure 6 **Biopsychosocial model of health and disease**




Source: based on Engel (1982)

**b. Biopsychosocial model of MSDs:** given the limits of the biomedical and biomechanical models, the biopsychosocial model of health has been applied to MSDs to explain the fraction of cases (5%-10%) which become chronic even when they occur in working situations which do not involve a high physical workload (e.g. office work on computer systems).

The 'biopsychosocial' model of MSDs is now widely accepted by the scientific community and the major institutions involved in prevention efforts (National Research Council 2001; Huang *et al.* 2003; George *et al.* 2015). It takes account not only of the physical or microlesion component of MSDs (*biological*) but also of their *psychological* and *social* components. From this perspective,

MSDs are regarded as a consequence not only of tissue microlesions but also of neurophysiological dysfunctions and pain management, and of sensory-motor coordination anomalies. This explains the importance of the *psychological dimension of pain* (not only its affective and psychosocial component but also its cognitive component) in the onset and, in particular, the development of MSDs (Waddell and Burton 2001; Vlaeyen and Linton 2012; Besen *et al.* 2015). For example, it has been demonstrated that workers' representations of their pain, and their social and occupational consequences, are highly significant prognostic factors when they result in dysfunctional behaviour (fear of movement, catastrophic thinking, overdramatisation) or inappropriate behaviour (avoiding work and social contacts, etc.) (Waddell and Burton 2001; Vlaeyen and Linton 2012).

Truchon *et al.* (Truchon 2001) propose that the factors underlying the biopsychosocial model should be divided into four main categories: medical factors, ergonomic and psychosocial factors at work, psychosocial factors outside work and sociodemographic variables (Table 7).

Table 7 **Factors underlying the biopsychosocial model of MSDs**

| | |
|---|---|
| **Sociodemographic factors** | – age, sex, ethnicity<br>– level of education<br>– financial rewards |
| **Medical factors** | – severity of diagnosis by a doctor<br>– results of clinical tests<br>– medical history |
| **Ergonomic and psychosocial factors at work** | – physical demands of the work<br>– subjective evaluation of the work's difficulty<br>– job satisfaction<br>– perceived stress |
| **Psychosocial factors outside work** | – pain (perceived intensity and behavioural expression)<br>– personality (type of personality and locus of control)<br>– emotional distress<br>– cognitive evaluation<br>– adaptive strategies |

Source: based on Truchon *et al.* (Truchon 2001)

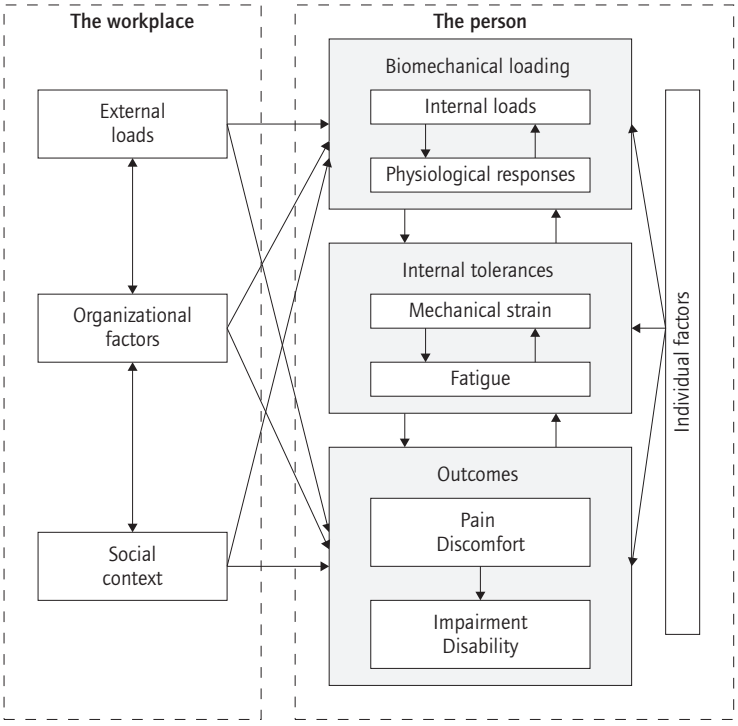
The traditional model of MSDs proposed by a panel of experts set up by the National Research Council (NRC) ('*IOM/NRC model*') draws inspiration from the biopsychosocial model of work-related MSDs and also incorporates the interrelationship between workplace-related and person-related dimensions (Figure 7) (National Research Council 2001):

— organisational factors interact with external loads (constraints) and the social context;
— these three elements directly affect biomechanical loading (strain) and outcomes at 'individual' level (pain, disability);

— at 'individual' level, biomechanical loading, tissue characteristics (internal tolerances such as mechanical strain and fatigue) and outcomes (pain and disability) interact and are also influenced by individual factors.

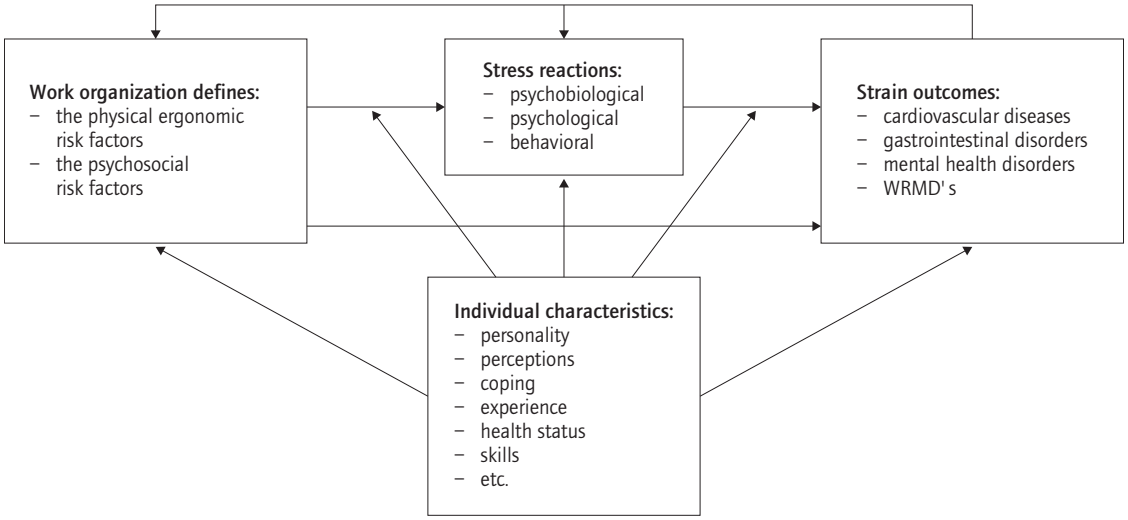
This model was one of the first to take into consideration organisational factors while remaining focused on the individual, but does not take account of individual psychological factors which are likely to promote the chronicity of MSDs (Loisel and Anema 2013). By way of contrast, Carayon *et al.* (Figure 8) (Carayon *et al.* 1999) believe that individual characteristics influence the interrelationship between psychosocial and organisational factors and MSDs (or other health disorders). Stress responses play a key role in this respect, since they mediate the relationship between occupational factors and MSDs. In the opinion of Carayon *et al.* (Carayon *et al.* 1999), exposure to physical (or biomechanical) factors and psychosocial factors is determined by the organisation of work, and psychosocial factors can give rise to stress reactions which, if they are present for long periods, can result in MSDs. This model also posits that physical factors have a direct effect on health events irrespective of stress reactions. Finally, feedback loops demonstrate that MSDs can influence the organisation of work and stress reactions.

Figure 7 **Model by the National Research Council, 2001**



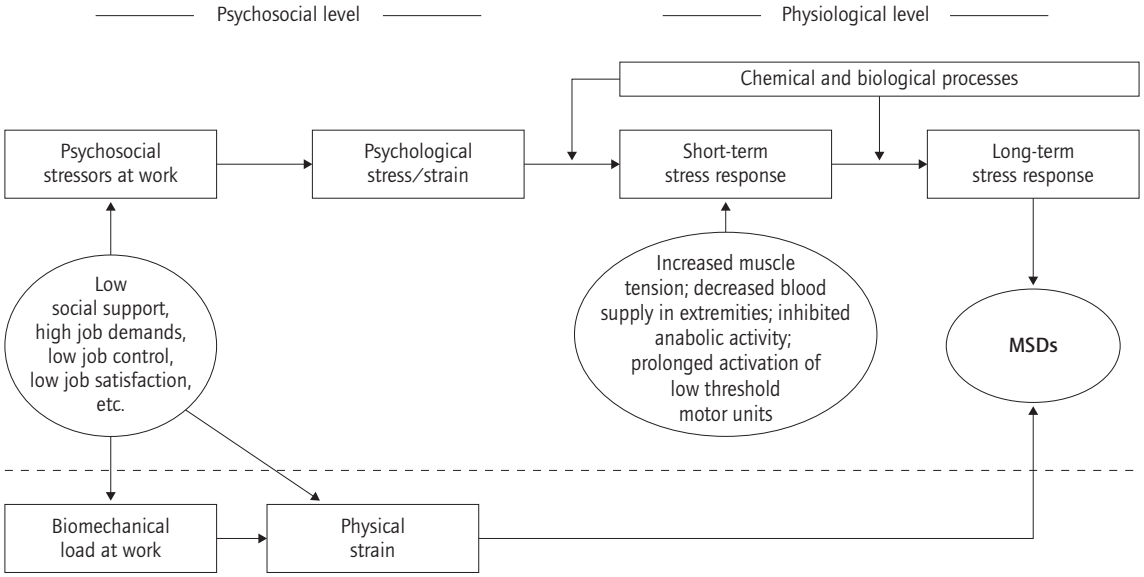

Source: based on National Research Council (2001)

Figure 8 **Model by Carayon *et al.* (1999)**




Source: based on Carayon *et al.* (1999)

Figure 9 **Model by Hauke *et al.* (2011)**




Note: below the dotted line: psychosocial stressors may increase risk of MSD via increased biomechanical load or physical strain.
Source: based on Hauke *et al.* (2011)

Hauke *et al.* (Hauke *et al.* 2011) propose a model which explains the relationship between psychosocial stress and MSDs by combining the biomedical and biopsychosocial models of stress (Bongers *et al.* 1993; 1996; Carayon *et al.* 1999) (Figure 9). A plethora of psychosocial factors at work (e.g. heavy mental load, low social support) trigger psychosocial stress and chain reactions modulated by individuals' resources for coping with the stress.

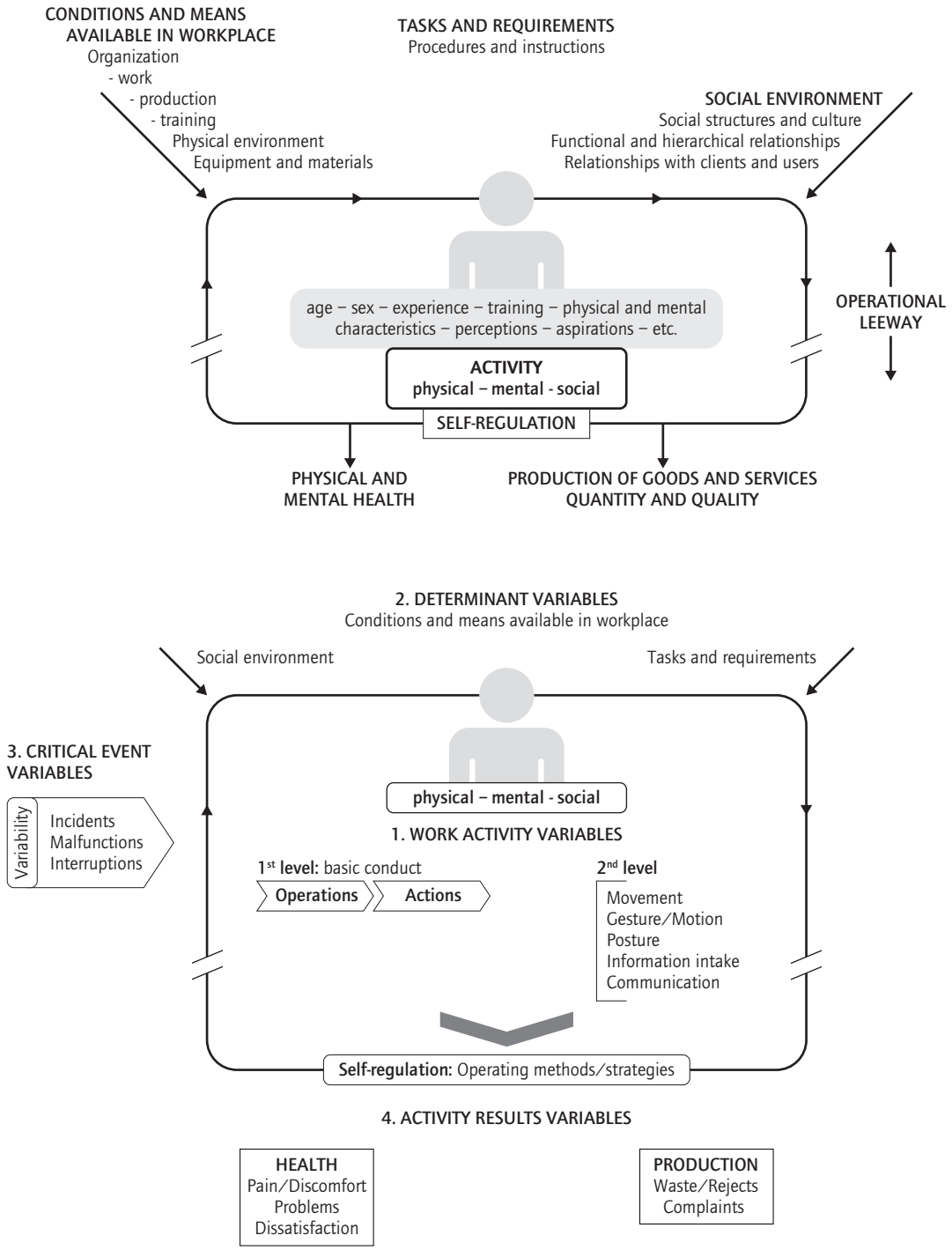
The stress then appears to trigger a chain of physiological reactions, including biochemical reactions, which may in the short term increase muscle tension and in the long term heighten the risk of MSDs. Furthermore, certain psychosocial factors such as high workload or lack of control over working situations may also heighten the risk of MSDs by increasing musculoskeletal load and tissue strain of mechanical origin.

**c. Ergonomic or organisational models of MSDs.** Certain biopsychosocial models of MSDs (Huang *et al.* 2003; Stock *et al.* 2013; Roquelaure 2016) highlight the role played by organisational factors, alongside psychosocial factors, in triggering stress and the chain reactions which lead to the onset of MSDs. This applies to the prevention-focused 'organisational' models of MSDs which were developed in the 2000s.

The model of MSDs developed by Vézina in 2001, which focuses on the activities carried out by workers, can be applied to the working situations which give rise to MSDs or to post-MSD return-to-work procedures (Coutarel *et al.* 2009; Durand *et al.* 2009, 2011; St-Vincent *et al.* 2011). It incorporates key ergonomic concepts such as variability of working situations, individual and collective regulation of activities and leeway.

The concept of 'leeway' refers to the options available to (and utilised by) a worker to develop different ways of working in order to meet productivity-related objectives without suffering any detrimental effects (Daniellou 2008; Roquelaure *et al.* 2012). Various forms of leeway may exist within the same company, i.e. organisational, spatial, temporal or collective. Their preventive nature depends not only on their actual existence (objective, observable) but also on workers' ability to make use of them at the right point in their activities. It is for this reason that the concept of leeway serves as a key foundation for developing workers' capacities, i.e. their knowledge of the occupational context and their ability to perceive variations in working situations in order to make regular adjustments at an operational level. The concept of leeway has certain similarities with the idea of decision-making autonomy (control) in work-related stress models, although they stem from different theoretical stances. Nevertheless, the organisational approach to MSDs focuses more rigorously on the unique nature of working situations, i.e. on the involvement of the operator's body and his or her subjectivity towards the activity, taking into account the physical, mental and social components of the situation and variability in the working environment and in the worker himself or herself.

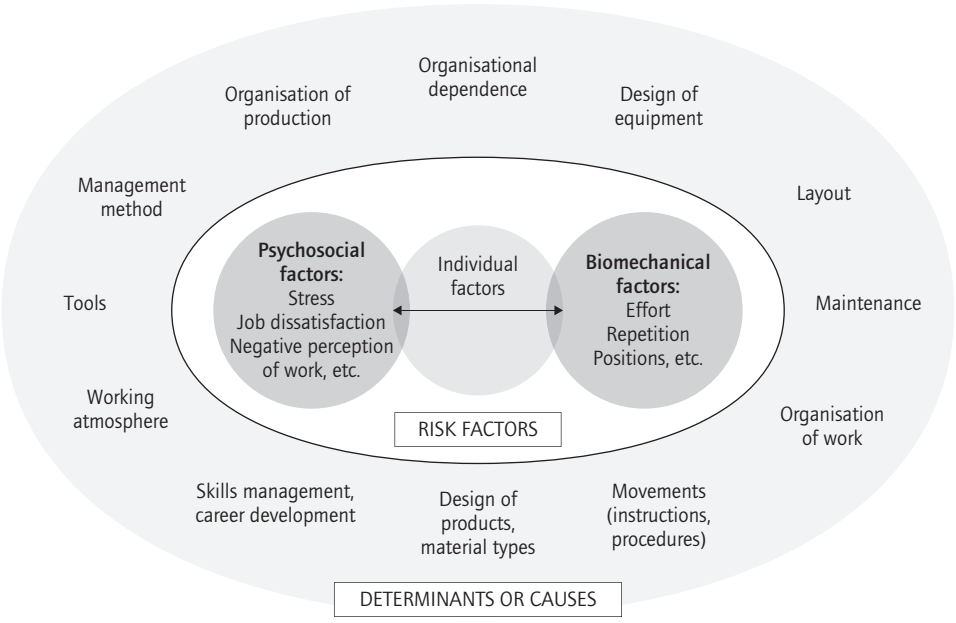
Figure 10 **Explanatory model of MSDs focusing on the activities performed by workers**




Source: based on St-Vincent *et al.* (2011)

The organisational approach to MSDs makes it possible to grasp the complexity of the cluster of causes at their origin, by shifting the level of analysis from the working situation to the factory, the company and the company's socio-economic environment (Daniellou 2008). As illustrated in Figure 11, the biomechanical constraints (e.g. forceful or repetitive movements) which workers must overcome in order to carry out a task are determined by the material and organisational conditions of the task; these depend on a cluster of organisational constraints within the company, which in turn form part of the socio-economic situation of the company and the geographical location (NORA Organization of Work Team Members 2002; Bourgeois 2006; St-Vincent *et al.* 2011). The organisational approach to MSDs presumes that an analysis of work must not focus solely on workstation(s), but must instead explore the company systematically by broadening the scope of analysis to include the 'network of demands and constraints' within which it is located (e.g. clients, suppliers, worker population, regulations, local involvement, etc. ('determinants of determinants').

Figure 11 **Organisational model of situations giving rise to MSDs**



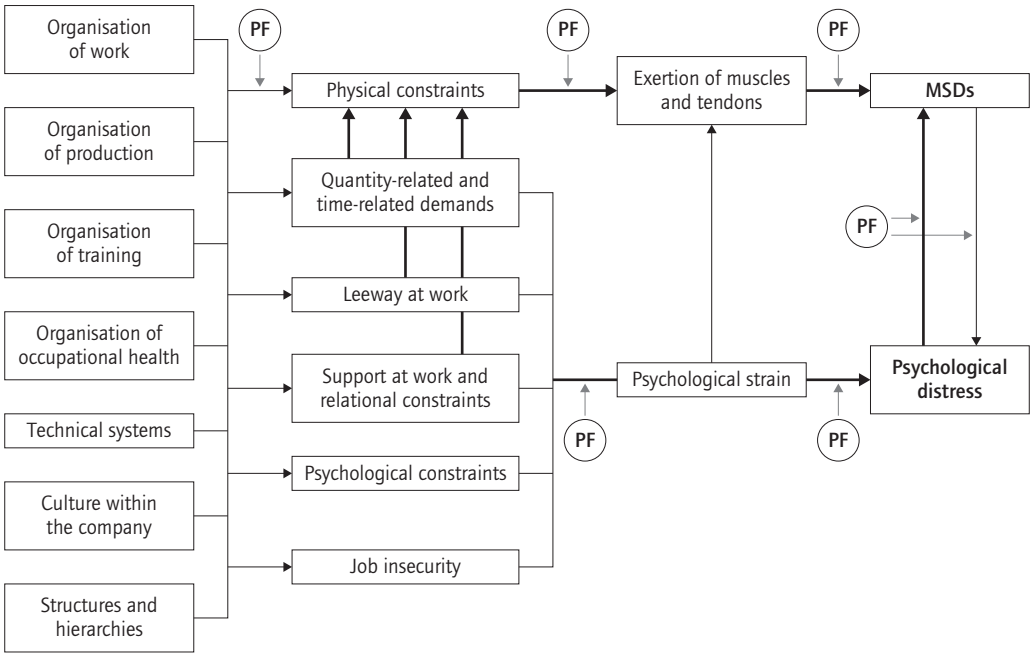

Source: based on ANACT (Bourgeois 2006)

Identifying the chain of determinants for MSDs is a vital precursor to prevention interventions, since these determinants serve as levers of action to reduce exposure to the risk factors pinpointed by epidemiology (Bourgeois 2006; St-Vincent *et al.* 2011). Whereas the majority of tools for assessing MSD risk focus on the biomechanical dimension of the work, the SOBANE strategy for assessing MSD risk is based on the principles enshrined in the organisational model of MSDs (Malchaire *et al.* 2011; Petit and Roquelaure 2014) and incorporates not only manual tasks (or more specifically handling

tasks), but all dimensions of the working situation and working activities, adopting a holistic and hierarchical approach.

The model developed more recently by Stock *et al.* (Stock *et al.* 2013) (Figure 12) is an organisational model which builds on the findings of epidemiological and ergonomic research into MSDs (St-Vincent *et al.* 2011). It differs from other models in that it examines in greater detail the organisational environment (organisation of work, organisation of production, etc.) and the interrelationships between the organisation of production and the organisation of work on the one hand, and physical constraints and psychosocial factors at work on the other hand. Organisational characteristics directly influence physical constraints and psychosocial factors at work. For example, an employee who is given an unsuitable workstation is forced to adopt awkward postures; an employee who works on a production line to a machine-imposed pace is unable to take breaks when he or she wants, which has a negative impact on the experience of physical constraints. Organisational constraints may also interact with psychosocial exposures and indirectly influence physical constraints as a result of the quantity-related or time-related demands of the activity, a low level of control over work-related demands or relational constraints. For example, a high throughput of work may reduce employees' leeway and mutual social support. According to this model, psychosocial factors influence psychological strain, which in turn influences the psychological distress which plays a mediating role in the relationship between psychosocial factors and MSDs. The relationship between MSDs and psychological distress is presumed to be bidirectional, since the presence of pain may also promote

Figure 12 **Model by Stock *et al.* (2013)**

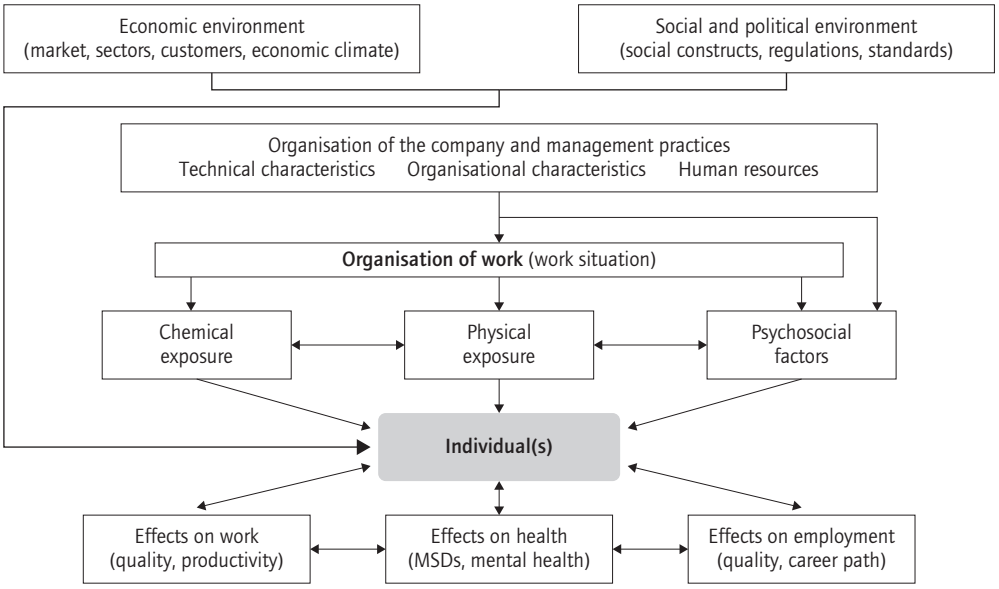



PF: personal factors
Source: based on Stock *et al.* (2013)

psychological distress (Inserm 2011; Stock *et al.* 2013; Bonzini *et al.* 2015). Finally, the model incorporates personal factors which may constitute both susceptibility factors and resources for tackling psychosocial or physical constraints (St-Vincent *et al.* 2011).

The model proposed by Roquelaure (Roquelaure 2017) can be generalised to the majority of countries and industries (Figure 13). It incorporates the various levels of organisation of work defined by NIOSH, as well as concepts from the fields of workplace ergonomics (Bourgeois 2006; Daniellou 2008; St-Vincent *et al.* 2011; Coutarel *et al.* 2013) and quantitative sociology (Lorenz and Valeyre 2005; Valeyre *et al.* 2009; Amossé *et al.* 2014); these include the external context (economic environment and social and political environments), the organisational context (organisation and management practices) and the working context (work organisation). It also takes into account personal factors which can represent susceptibility factors or resources (individual or collective) for tackling the constraints of working situations in a way that ensures high-quality and high-quantity production without adversely affecting health or job security (Coutarel *et al.* 2013; Roquelaure 2016). According to this model, the organisation of work and management practices determine the conditions under which work is carried out, and therefore also determine the biomechanical and psychosocial exposures to which workers must adapt. Individual resources are not only influenced by these exposures, but also exercise a codetermining influence on their impacts in terms of health, the quantity and quality of work and job security. Stress (i) promotes the onset of MSDs by interfering with muscle activation, the mechanisms of inflammation and pain and tissue repair and (ii) promotes the chronicity of pain and disability.

Figure 13 **Multidimensional model of occupational health**




Source: based on Roquelaure (2017)

The organisational model of MSDs also emphasises the importance of the chain of determinants at different levels (micro, meso and macro) of companies in all industries. In particular, it focuses on the economic dimensions (market conditions, organisation of the economic sector, etc.), the social dimensions, the regulatory dimensions and the political dimensions of the determinants of working conditions within companies, which ultimately determine the risk of UL-MSDs. It highlights the fact that company-based interventions, no matter how effective, can only ever form one part of a multi-pronged preventive approach to MSDs, since an adverse political and societal context necessarily limits the effectiveness of ergonomic interventions within companies. This model helps to broaden the spectrum of MSD preventive efforts, which must focus not only on reducing exposure to their physical and psychosocial determinants (primary prevention) but also on establishing modes of production and management at societal level which are more durable and socially responsible (primordial prevention).

### 3.2.3 Epidemiological data on the interrelationship between psychosocial factors at work and MSDs

Epidemiological research and several recent systematic reviews of the scientific literature back up the findings on the interrelationships between psychosocial factors at work and MSDs which have emerged from previous syntheses of basic clinical and psychological research. An international consensus has been reached on the multifactorial nature of MSDs and the involvement of individual susceptibility factors and work-related factors, and the literature converges on the importance of work-related biomechanical factors (physical effort, repetitive movements, awkward positions, vibrations) in the onset of MSDs. Despite the smaller volume of research, the same is true for work-related psychosocial factors (da Costa and Vieira 2010; Hauke *et al.* 2011; Kozak *et al.* 2015) (Table 8). The nature of the complex interrelationships between physical constraints, psychosocial factors at work and organisational factors in the context of MSDs is not yet fully understood, however.

#### Psychosocial factors at work and MSDs

Given the high volume and variable quality of the available epidemiological research, we will concentrate on recent systematic reviews and meta-analyses focusing on the links between psychosocial factors and MSDs.

The three dimensions of the demand-control-support (DCS) model are the variables which appear most frequently in the literature:

— A systematic review (Macfarlane *et al.* 2009) exploring the links between psychosocial constraints at work and MSDs lists several studies which identify an association between MSDs of the upper limbs and spine and heavy mental load; the association is weaker for decision-making control or poor social support at work.

— A systematic review and meta-analysis of 40 longitudinal studies on the links between job strain and MSDs (Hauke *et al.* 2011) concludes that there is a significant relationship for MSDs of the neck and shoulders (13 studies) and lower back pain (four studies), but not for other MSDs of the upper limbs (five studies).
— A systematic review and meta-analysis of 45 longitudinal studies on the links between psychosocial factors and MSDs of the limbs and spine in industrial workplaces (Lang *et al.* 2012) identifies a significant but modest effect of psychosocial factors (job strain, poor social support, monotonous tasks) on the development of MSDs. This is backed up by the systematic review carried out by Vargas-Prada and Coggon (Vargas-Prada and Coggon 2015).
— A systematic review of 18 longitudinal studies on the links between psychosocial factors and MSDs of the neck and shoulders, carried out by Kraatz *et al.* (Kraatz *et al.* 2013), demonstrates that the majority of these studies use the DCS model. They conclude that there is a high level of evidence for an association between MSDs of the neck and shoulders and heavy mental load (nine studies), decision-making control (three studies), social support (six studies) and job strain (four studies).

An analysis of data relating solely to MSDs of the shoulder (Table 8, p. 44) reveals that although the three dimensions of the DCS model appear to be moderately to strongly associated with MSS/MSDs of the back of the neck and the shoulder, the findings relating to job satisfaction, monotony and job security do not provide enough evidence to draw any conclusions.

The number of longitudinal studies that have analysed the link between effort-reward imbalance (ERI) and MSDs is limited (Stock *et al.* 2013). The longitudinal study by Rugulies and Krause (Rugulies and Krause 2008) based on compensation data for lower back pain and cervical pain reveals that ERI is associated with lower back pain and cervical trauma irrespective of factors such as individual worker characteristics, physical load, ergonomic constraints and job strain. The systematic review by Koch *et al.* (Koch *et al.* 2014) of 19 studies (including three longitudinal studies) on the link between ERI and MSDs proves that a significant relationship exists between ERI and musculoskeletal pain in the limbs or spine (13 studies). The poor methodological quality of the studies means that only limited conclusions can be drawn, however.

The significant lack of epidemiological data makes it difficult to confirm the influence of organisational justice on the onset of MSDs in the same way that it has been proven to have an influence on mental health problems (Thébaud-Mony *et al.* 2015). Nevertheless, the study by Pekkarinen *et al.* (2013) (Pekkarinen *et al.* 2013) shows that both distributive justice and social support are associated with a lower MSD risk for nurses working in geriatrics. Furthermore, Heponiemi *et al.* (2013) demonstrate that organisational justice, measured by a combination of items relating to procedural justice and relational justice, is also associated with a lower prevalence of MSDs among workers in permanent (rather than temporary) employment. Nevertheless, the

Table 8 **Summary of work-related psychosocial risk factors associated with MSDs of the shoulder**

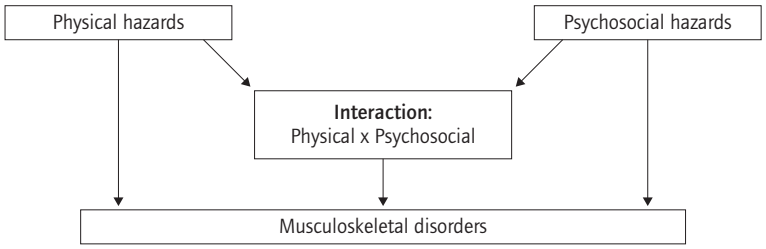
| Author (year) | Studies | MSD | High quantitative demand | Overload at work | High job demand | Low job control | Low decision authority | Low skill discretion | Low social support | Lack of support from colleagues | Lack of support from superiors | High job strain | Low job satisfaction | Job security |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Van Der Windt *et al.* (2000) | R T, CT S | Shoulder pain | | | +/0 | +/0 | | | +/0 | | | | +/0 | |
| Malchaire *et al.* (2001) | R T, L S | Neck/shoulder problems | | | | +/0 | | | +/0 | +/0 | +/0 | | +/0 | +/0 |
| Bongers *et al.* (2002) | R T, L, CT S | Upper arm/ shoulder symptoms/ signs | ++ | | | ++ | | | ++ | | | | +/0 | |
| Kuijpers *et al.* (2004) | R L S | Shoulder disorders | | +/0 | +/0 | | | | | | | | | |
| Larsson *et al.* (2007) | R S | Neck/shoulder pain | + | | | +/0 | | | | +/0 | +/0 | | | |
| MacFarlane *et al.* (2009) | R T, L S | Neck/shoulder pain | | | ++ | +/0 | | | +/0 | | | | +/0 | |
| Van Rijn *et al.* (2010) | R T, L S | Specific disorders of the shoulder | | | ++ | +/0 | | | +/0 | | | | +/0 | ++ |
| Hauke *et al.* (2011) | M L A | Neck/shoulder | | | NS | + | + | NS | + | | | + | NS | |
| Lang *et al.* (2012) | M L A | Neck/shoulder problems | | | + | + | | | + | NS | + | + | | |
| Kraatz *et al.* (2013) | R L S | Neck/shoulder disorders | | +/0 | ++ | ++ | +/0 | +/0 | ++ | | | ++ | +/0 | |

++: 'Consistent' associations, 'strong evidence', significant associations (50% or above); +: 'Reasonable evidence'; +/0: 'Insufficient evidence' or significant associations (below 50%).
If no symbol is shown, the association was not examined.

methodological limitations of these transverse studies make it impossible to establish a causal link between organisational justice and MSDs.

As demonstrated by the various conceptual models of MSDs, biomechanical and psychosocial factors can influence the genesis of MSDs both separately and through their interactions (Figure 14). Many different research studies in the fields of biology, psychology and ergonomics (Bongers *et al.* 1993; Hauke *et al.* 2011; Inserm 2011; Eijckelhof *et al.* 2013; Bao *et al.* 2015) support the hypothesis of synergistic effects between biomechanical and psychosocial factors, and the same hypothesis has been posited by recent epidemiological studies (Kraatz *et al.* 2013; Stock *et al.* 2013; Harris-Adamson *et al.* 2016).

Figure 14 **Links between physical and psychosocial factors and MSDs**




Source: based on Leka and Jain, WHO report (2010)

### Organisational factors and MSDs

The amount of epidemiological data on the following characteristics of work organisation which are regularly cited in the ergonomic literature is limited (Bourgeois 2006; Daniellou 2008; St-Vincent et al. 2011):

- periods of physiological rest or recovery;
- organisation of production (lean production, just-in-time, tight workflow, work on a production line or conveyor, interdependency of workstations);
- distribution of tasks between workstations;
- time constraints associated with standards, customers, machines or colleagues;
- operators' autonomy (ability to decide on operating procedures and movements, or to interrupt work at will);
- scheduling of workload and unpredictability of operations (urgent or unexpected);
- concentration and mental exertion;
- arrangements for managing job rotations and operator versatility;
- HR systems (skills management, frequent use of inexperienced workers or workers in precarious employment, recognition of work done, training);

— working time (working hours, working time accounts, management of breaks);
— level of pay and pay conditions (payment by results, bonuses).

Three literature reviews (Landsbergis *et al.* 1999; Brännmark and Håkansson 2012; Koukoulaki 2014) have examined the associations between lean production on the one hand and risk factors for MSDs and MSDs themselves on the other hand. The studies by Landsbergis *et al.* and Koukoulaki show similar findings. The review by Landsbergis *et al.* (Landsbergis *et al.* 1999) concludes that lean production in the automotive industry intensifies the pace of work and mental load without increasing employees' decision-making control, and that this intensification of work furthermore increases the rate of MSDs. In the other sectors studied (manufacturing other than automotive, telecommunications and health), the results are not consistent enough to conclude that lean production has health impacts.

The most recent review by Koukoulaki (Koukoulaki 2014) proves that lean production, particularly in the automotive industry, has a detrimental effect on musculoskeletal and mental health and on the risk factors for these latter. The 1990s saw the introduction of just-in-time work environments with an increasing pace of work and a decreasing amount of time available for recovery, and studies from this period report the most adverse effects; this suggests that the principles of lean production were implemented most rigidly at this time, which appears to have a detrimental impact on health because it reduces or even eliminates employees' leeway while intensifying their workload. Studies in other manufacturing industries reveal an increase in risk factors for MSDs, but no increase in the frequency of MSDs.

The studies included in the literature review by Brännmark and Håkansson (2012) on manufacturing industries which had adopted lean production principles (Brännmark and Håkansson 2012) were highly variable in quality and design, and did not describe the implementation of lean production principles in sufficient detail for conclusions to be drawn regarding an association between lean production and MSDs. The authors, however, note that there is a tendency for the risk of MSDs to increase if lean production systems are not accompanied by ergonomic interventions, and that the introduction of lean production principles into a company means that work intensifies and work pace, workload and stress increase. In Swedish companies, these tendencies were strongest for MSD risk factors.

Westgaard and Winkel studied the effects of streamlining as it relates to the production of goods and services and various organisational measures (workforce reduction, corporate restructuring, implementation of lean production principles, high-performance work systems (HPWS), parallel production versus series production, level of mechanisation) on musculoskeletal and mental health (Westgaard and Winkel 2011). The majority of the studies (93 out 162, 57%) showed negative effects on health and risk factors, 30 showed positive associations (19%) and 39 showed mitigated or non-significant associations (24%). Negative effects were observed most

frequently in the health sector (73%). High-performance work systems (HPWS) appeared to have more positive results (six out of 10 studies) than the other organisational measures studied.

The systematic review by Leider *et al.* highlights the contradictory conclusions of research into the effects of job rotation on MSDs of the limbs and spine (Leider *et al.* 2015). The older literature review by Malchaire *et al.* documented several organisational factors associated with MSDs of the shoulder (Malchaire *et al.* 2001). The evidence base is weak (fewer than 50% of the studies included demonstrated a significant association) for all of the organisational factors studied. According to the study by Sluiter *et al.*, there is a strong evidence base for lack of recovery time (Sluiter *et al.* 2001).

### 3.2.4 MSDs and the psychopathology of work

The organisation of work plays a pivotal role in the onset of MSDs, since it determines not only the conditions of exposure to biomechanical and psychosocial factors at work but also collective and individual capacities for coping with these factors (Davezies 2013; Thébaud-Mony *et al.* 2015; Roquelaure 2017).

The psychodynamics of work approach to MSDs, which centres around a dynamic analysis of the psychological processes triggered when the subject encounters the organisation of work (Dejours 2008), emphasises the idea of movement pathology (Davezies 2013). According to Christophe Dejours, 'Movements cannot be reduced to joint biomechanics, because they are a technique of the body', or in other words a way of forcing the body to perform activities which are supremely unnatural. An understanding of these techniques is an essential prerequisite for conceptualising work-related movements of the kind involved in activities such as handling, production of manufactured goods or typing on a keyboard. According to Dejours, this touches on the key problem of ensuring that we are all recognised by others – and recognise ourselves – as members of cultural, social or professional communities. MSDs cannot therefore be reduced to an imbalance between biomechanical constraints at work and the capacity of soft tissues to resist these constraints, and instead operate at the level of workers' subjective perceptions. This approach supports the conclusions of the biopsychosocial model of MSDs, despite being based on different theoretical foundations (Davezies 2013).

A key step towards understanding and preventing MSDs is allowing for workers' subjectivity, or in other words their uniqueness. Philippe Davezies stresses that, at work, 'we never encounter the abstract systems which appear in biomechanical research, the statistical beings who appear in epidemiological research or the average Joes who appear in research into the organisation of work. We encounter men and women who draw on their unique life trajectories in order to imbue work-related movements with relational content, to differentiate their contribution and to "flesh out" the organisation of work' (Davezies 2013). Since this subjectivity runs counter to efforts to standardise

procedures, however, it is excluded by certain types of work organisation which expose workers to repetitive movements under time pressure (Davezies 2013). This is why the psychodynamic approach to MSDs, taking its inspiration from the tradition of the Paris Psychosomatic School, likens these movements to pathologies which are associated with a mental silence and which are expressed not only at the level of mental pathology but also at the level of somatic weakness (Pezé 2002; Dejours 2008; Davezies 2013).

The Clinic of Activity established by Yves Clot is also rooted in the concept of a fundamental psychological function of movement which mobilises resources (ingenuity, creativity, etc.) allowing the worker to overcome the constraints of the task (or not, as the case may be) (Clot 2011; Clot and Lhuilier 2013; Clot 2015). Yves Clot believes that suffering occurs when it is impossible to recognise oneself 'in the mirror of one's activities'. Being unable to 'do a good job' is therefore a pivotal factor in suffering and a significant obstacle in improving occupational health (Clot 2011; Clot and Lhuilier 2013; Clot 2015).

According to the approach endorsed by the Clinic of Activity, preventing MSDs involves asking questions about the meaning of work and the meaning of the movements relating to a particular job or trade; the scope of these questions must not be limited merely to biomechanical overexertion, however. MSDs occur when workers carrying out a particular trade can no longer perform the movements they have developed for themselves, and must instead carry out movements which have been imposed externally and which cannot be modified. Yves Clot refers to 'blocked' movements, which can be likened to an 'underexertion' of workers' skills and competencies. Seen from this perspective, the organisation of work can be regarded as a resource or a constraint, depending on whether or not it allows competencies to be utilised and movements relating to a particular trade to be carried out freely (Clot 2011; Clot and Lhuilier 2013; Clot 2015). According to Philippe Davezies, the main 'psychosocial risk' factor is therefore repetitive work with no prospect of personal expression or development (Davezies 2013). Viewed in this way, strengthening employees' capacities for self-expression at work is a key prevention task, particularly when it comes to psychosocial risks. Damien Cru highlights the fact that effective prevention measures, regardless of their intrinsic value, cannot be applied from the outside; instead, they must represent the outcome of engagement with those affected most – workers – and of debates on topics such as health, arduousness and work in companies, in factories and on construction sites (Cru 2014).

In summary, the biopsychosocial model and the models of MSDs developed on its basis draw on solid neurobiological, psychological, epidemiological and ergonomic data which demonstrate the existence of interrelationships between psychosocial factors at work and MSDs. Nevertheless, an accurate characterisation of these interrelationships requires a distinction to be made between acute MSDs and chronic MSDs, in order to avoid confounding the determinants of MSDs and prognostic factors for chronicity or long-term disability.

## 3.2.5 Psychosocial factors and prognostic factors for MSDs

**MSD-related chronicity and disability**

The concept of chronic pain relates to the persistent nature of symptoms, whereas the concept of disability relates to limitations/restrictions on activity and an inability to work which prevents workers from fulfilling their social and economic roles. Clinical experience reveals the importance of distinguishing between acute or sub-acute disorders on the one hand and chronic disorders on the other, or in other words between transitory or (potentially) reversible disorders and disorders which are established and rarely reversible (Inserm 2000; Waddell and Burton 2001; Burton *et al.* 2006). Traditionally, a distinction is made between several clinical courses of MSDs based on the duration of pain*:*

— **acute MSDs** with a clinical course of four weeks or less;
— **sub-acute MSDs** with a clinical course of 4-12 weeks;
— **chronic MSDs** with a duration of longer than three months;
— **recurrent MSDs**, i.e. the onset of at least two acute episodes within an interval of less than one year. They differ from chronic MSDs in that they feature periods of remission from the symptoms of pain.

The clinical course of MSDs is a vital consideration when designing workplace-based prevention interventions, since it allows a distinction to be made between aetiological and prognostic factors for MSDs:

— **aetiological factors** (or predictive or strongly determining factors) are factors which influence the onset of an episode of pain or significant functional impairment. These determinants of MSDs can serve as levers of action for primary prevention;
— **prognostic factors** are those which influence MSD-related consequences (e.g. the length of absence from work after an episode of pain) (Inserm 2000; Waddell and Burton 2001; Burton *et al.* 2006). These prognostic factors for chronicity or long-term disability can serve as levers of action for secondary/tertiary prevention.

One of the key features of MSDs – alongside pain – is the risk of long-term occupational disability, and it is this risk which renders them such a serious problem in medical, social and occupational terms. Long-term occupational disability is traditionally understood to mean absence from work for a period of over three months, although the Guidelines for the Management of Low Back Pain in Europe (COST B13) (Burton *et al.* 2006) recommends intervening after a six-week period of absence.

According to the World Health Organization (WHO):

— disability is defined as any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being. It reflects a restriction on activity;

— it results from an impairment which corresponds to a loss of substance or alteration to a function or a psychological, physiological or anatomical structure;
— 'handicap' is a disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfilment of a role that is normal (depending on age, sex, and social and cultural factors) for that individual.

Based on an examination of the clinical course of MSDs, a distinction can be made between two categories of workers who are affected by them: those for whom the disease rapidly abates, and a smaller group (5-10%) for whom there is a risk that the symptoms will become chronic and they will suffer from long-term occupational disability (absence from work lasting longer than three months), potentially resulting (in the most severe cases) in occupational marginalisation (Hasenbring *et al.* 2012; Loisel and Anema 2013). These categories of workers coexist on an ever-shifting basis within companies, because pain and functional limitations do not follow a linear path towards chronicity, but instead a complex one incorporating both improvements and deteriorations (Aublet-Cuvelier *et al.* 2006). Parties responsible for designing prevention interventions must take into account the sub-groups of 'non-affected' workers, workers who are suffering from an MSD at various stages of its clinical course (acute, sub-acute, chronic, with or without disability, etc.) and workers suffering from an MSD in varying degrees of severity at different points in time, since their existence justifies a holistic and integrated approach with the aim of avoiding the onset of UL-MSDs in 'non-affected' workers and the shift to chronicity of a certain percentage of cases. Such an approach also makes it more likely that people suffering from severe and incapacitating MSDs will be able to remain in employment.

### Prognostic factors for chronic MSDs and MSD-related disability

The development of chronic MSDs cannot be explained solely by biomedical characteristics such as the intensity of pain or the severity of tissue lesions or musculoskeletal load, since individual and collective work-related psychosocial factors play a key role in the transition between acute and chronic pain (Waddell and Burton 2001; Hasenbring *et al.* 2012; Loisel and Anema 2013). There is abundant literature on the prognostic factors for MSDs (Hasenbring *et al.* 2012; Loisel and Anema 2013). The majority of this research draws on the clinical, medical, psychological or rehabilitative treatment of workers suffering from chronic MSDs, and emphasises the individual psychosocial dimension as it relates to personal history, social and family environment and state of health. More recent research based on ergonomic or epidemiological approaches in the workplace demonstrates the importance of the collective psychosocial dimension (Hasenbring *et al.* 2012; Loisel and Anema 2013; Petit and Roquelaure 2014).

### Individual approach to prognostic factors for MSDs

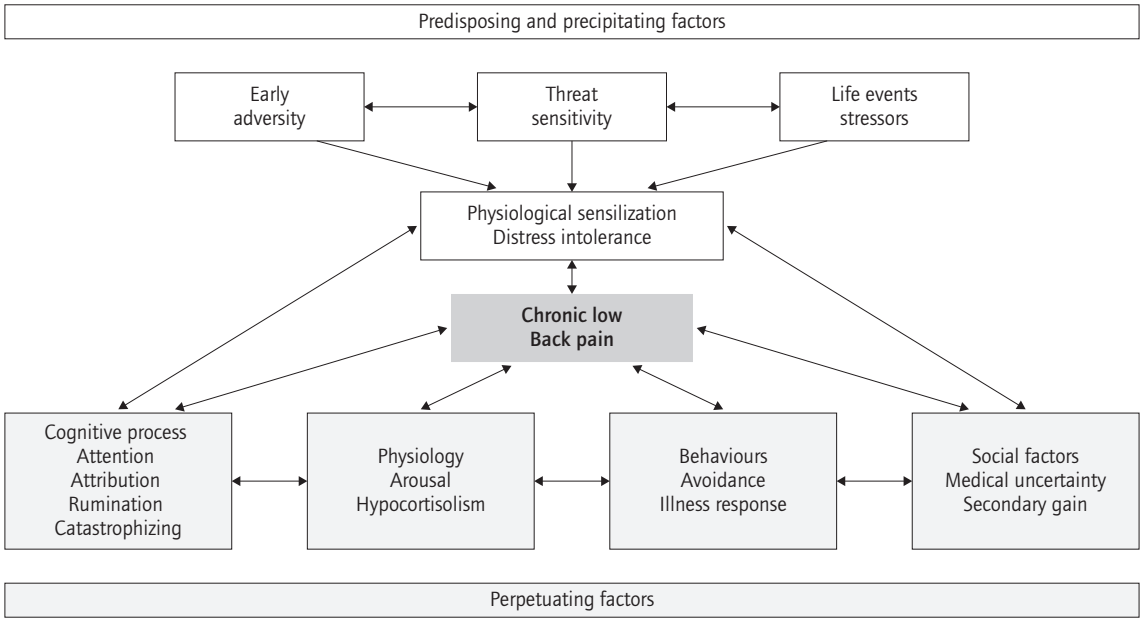
The biopsychosocial approach to MSDs explains why chronic musculoskeletal pain can lead to physical inactivity, a reduction in physical capabilities (collectively known as 'physical deconditioning') and job loss, and may ultimately lead to changes in the worker's quality of life both at work and at home (Waddell and Burton 2001; Loisel *et al.* 2003; Loisel and Anema 2013). This approach underpins the recent programmes which focus on effort retraining and the prevention of occupational marginalisation among workers suffering from chronic MSDs (Durand *et al.* 2007; Hasenbring *et al.* 2012; Loisel and Anema 2013). In particular, the biopsychosocial model takes account of phenomena which perpetuate musculoskeletal pain, especially in the lower back (Hasenbring *et al.* 2012). Drawing inspiration from the model developed by Deary *et al.* (Deary *et al.* 2007) for medically unexplained diseases, McBeth and Power have proposed a multidimensional biopsychosocial model of chronic lower back pain referred to as 'autopoietic' (from autopoiesis, or a system capable of reproducing itself). According to this model, the chronicity of pain is associated with a number of predisposing and precipitating psychosocial factors (early pain experiences, sensitivity to threat, stressful life events) interacting with perpetuating factors (cognitive, physiological, behavioural, social and professional[2]) in an autopoietic cycle of self-perpetuation. Approaches of this kind to the chronicity of MSDs explain why pain and functional impairment can remain even when pathological biomechanical processes are no longer present, and why they can develop independently even if the worker changes job (Figure 15).

According to the 'diathesis-stress' model (Turk and Flor 1984), chronic MSDs are perpetuated as a result of the interaction between stressful personal events and an MSD-predisposing psychological or physiological context. If an individual's coping strategies are ineffective, chronic stress amplifies physiological phenomena (muscle tension, etc.), psychological phenomena (anticipatory anxiety about pain) and behavioural phenomena (immobility, pain behaviour) in response to musculoskeletal pain. This creates a vicious circle in which stress perpetuates pain and pain perpetuates stress.

The 'diathesis-stress' model explains certain clinical and epidemiological findings which show that the chronicity of disorders and the intensity of responses to pain are more accurately predicted by psychological variables (anxiety, feeling of isolation and powerlessness) than by physiological variables (severity of tissue lesions) (Hasenbring *et al.* 2012; Loisel and Anema 2013).

**2.** Added by the author.

Figure 15 **Autopoietic cycle of musculoskeletal pain chronicity**



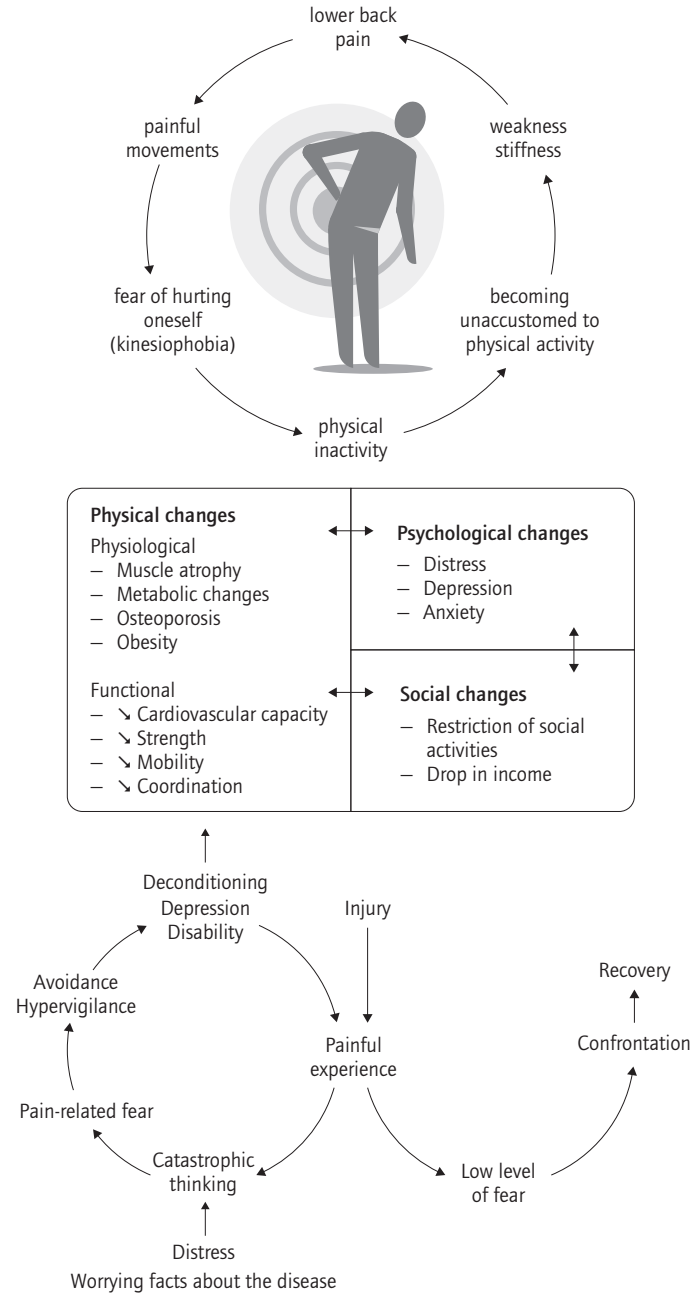

Source: based on McBeth and Power in Hasenbring *et al.* (2012)

Certain individual psychosocial factors promote the perpetuation of pain and disability irrespective of psychosocial stress, for example anxiety and depression (Leino and Magni 1993; Inserm 2011; Linton *et al.* 2011), or even cognitive processes such as 'catastrophic thinking' and avoidant behaviours for activities which give rise to pain (Hasenbring *et al.* 2012; Vlaeyen and Linton 2012; Loisel and Anema 2013).

The cognitive-behavioural model known as the 'fear-avoidance model' (Figure 16) (Vlaeyen *et al.* 1995) explains why certain cases of MSDs become chronic and result in disability. It hypothesises that, if pain is interpreted as threatening (catastrophic thinking about pain), pain-related fear increases; this leads to the avoidance of situations which give rise to pain and depressive elements, and promotes the persistence of pain experiences based on a vicious circle of increasing fear and avoidance resulting in biopsychosocial deconditioning. Workers who do not fall prey to catastrophic thinking do not suffer from pain-related fear, and are able to return to their daily activities within a short space of time; this helps them to recover rapidly. One of the central components of the fear-avoidance model is catastrophic thinking, which is a cognitive antecedent of pain-related fear and recognised today as one of the most significant psychological factors in the prognosis of pain experiences (Sullivan *et al.* 2005). The term 'kinesiophobia' has been coined to refer to the condition in which a patient experiences 'an excessive, irrational and debilitating fear of physical movement and activity resulting from a feeling of vulnerability due to painful injury or reinjury' (Vlaeyen and Linton 2012).

This model is widely used as a basis for return-to-work programmes for workers suffering from chronic pain, and focuses on individual psychosocial factors rather than the perpetuating effects associated with collective psychosocial factors at work.

Figure 16 **'Fear-avoidance' model and 'biological deconditioning' model**




Source: based on Vlaeyen *et al.* (1995)

### Collective approach to prognostic factors for MSDs

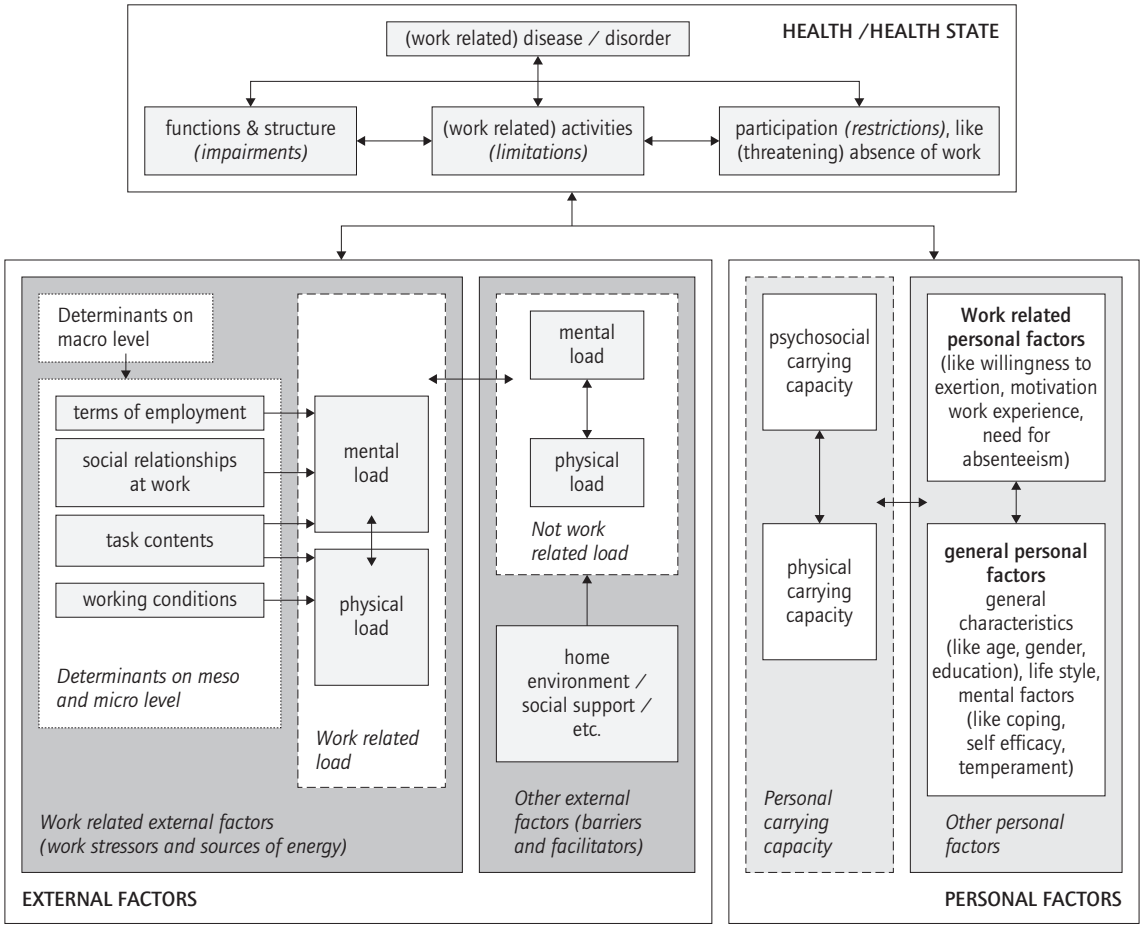
Individual factors cannot by themselves explain chronic and severe forms of MSDs which make it difficult for sufferers to remain in work, since work-related factors (in particular work-related psychosocial factors) play a role in the perpetuation of MSDs and occupational disability (Loisel and Anema 2013).

A worker's negative representations of his or her disease and his or her 'fears and beliefs' regarding its consequences in terms of future employment are key determinants of occupational disability; the same is true for the representations espoused by healthcare professionals and other parties within the company (Hasenbring *et al.* 2012; Loisel and Anema 2013; Besen *et al.* 2015). Other MSD-perpetuating factors, however, include characteristics of working situations such as significant biomechanical constraints (high workload, manual handling, postural constraints, vibrations) or work-related psychosocial and organisational factors (time pressure, job dissatisfaction, lack of social support or recognition, etc.) (Shaw *et al.* 2009; Hasenbring *et al.* 2012; Petit and Roquelaure 2014). It is therefore important to avoid stigmatising the 'false beliefs' of workers exposed to repetitive tasks in industrial workplaces, since these workers are also exposed to an accumulation of physical, social and psychological constraints which are just as likely to be determining factors in the perpetuation of disorders as simple misrepresentations of the benign nature of lower back pain.

The model developed by Heerkens *et al.* (2004) takes account of this fact by incorporating collective and individual psychosocial determinants which influence the development of chronic MSDs and occupational disability. It synthesises several biopsychosocial models of MSDs and adapts the International Classification of Functioning, Disability and Health (WHO-ICF) (WHO, 2001) to work-related diseases (MSDs) (Heerkens *et al.* 2004; Loisel and Anema 2013) (Figure 17), highlighting the interrelationship between individual and collective personal and psychosocial determinants:

— **'collective psychosocial' determinants** are linked to the job, the working environment, social relations in the workplace and working conditions. They are analysed at different levels (macro, meso and micro), as is their influence on physical and mental strain;
— **'individual psychosocial' determinants** are linked to the family and social environment. They interact with 'external' collective factors, and in so doing affect physical and mental strain;
— **personal factors** are linked to an individual's physical and psychological resources and influence his or her capacity to handle workload. Workers' resources are an important piece in the puzzle because they provide a developmental perspective on occupational disability, following the example of certain 'activity-based' ergonomic models aimed at developing workers' skills and capacity for action (Coutarel *et al.* 2013; Loisel and Anema 2013; Falzon 2014).

Figure 17 **Version of the WHO-ICF adapted for work-related diseases**




Source: based on Heerkens *et al.* (2004) in Heerkens *et al.* (2004); Loisel and Anema (2013)

A review of the ergonomic and epidemiological literature on occupational disability factors (Shaw *et al.* 2009; Loisel and Anema 2013) demonstrates the need to take into account the physical and psychosocial demands of the work activity, the organisation of work and the level of support at work, as well as workers' representations ('beliefs') about their work and related behaviours. With this in mind, a number of risk criteria for chronic MSDs or MSD-related disability – referred to as flags in keeping with the term 'red flags', which is used to denote medical severity factors for MSDs – have been developed on the basis of the biopsychosocial model of MSDs (Shaw *et al.* 2009; Loisel and Anema 2013) (Table 9, p. 56):

— 'psychosocial' risk factors for the development or perpetuation of disability ('yellow flags');
— predictive factors for occupational disability and the risk of social and occupational marginalisation ('blue flags' and 'black flags').

The number of workers in the European Union who are unfit for work (whether because of MSDs or other health events) has been on the rise since the 1990s/2000s. Psychosocial factors (both individual and collective) play a pivotal role in the development of occupational disability (Waddell and Burton 2001; Hasenbring *et al*. 2012; Loisel and Anema 2013). Nevertheless, the neurophysiological dysregulations giving rise to musculoskeletal pain which are hypothesised by the biopsychosocial model do not exist independently of the biomechanical exertions which may promote or sustain them. It is likely that the recurrence or chronicity of MSDs is explained not solely by psychological and social factors, but also by greater exposure to biomechanical constraints and arduous work (Marras 2004).

Table 9 **Summary of 'red', 'yellow', 'blue' and 'black' flags in workers with lower back pain**

| | Prognostic factors for the development of chronic MSDs |
|---|---|
| **Individual psychosocial (yellow flags)** | – emotional problems such as depression, anxiety, stress, tendency to depressive moods and withdrawal from social activities<br>– inappropriate attitudes towards and representations of back pain, such as the idea that the pain represents a threat or that it might become a serious handicap, passive behaviour with the expectation that treatment will provide a solution rather than requiring active personal involvement<br>– inappropriate fear-related pain behaviour, in particular avoiding or reducing activity<br>– work-related problems (job dissatisfaction or a working environment perceived as hostile) or money-related problems (disability pension) |
| **Representations of work and the environment (blue flags)** | – high physical workload<br>– high volume of work and low level of control<br>– few options for modifying work<br>– lack of social support<br>– perceived time pressure<br>– job dissatisfaction<br>– work-related stress<br>– hope of returning to work<br>– fear of recurrence |
| **Policies of the company, the healthcare system and the insurance provider (black flags)** | – employer-enforced policy which prevents gradual reintegration or job changes<br>– financial insecurity<br>– criteria for receiving compensation<br>– financial incentives<br>– lack of contact with workplace<br>– length of sick leave |

Source: based on Shaw *et al.* (2009); Loisel and Anema (2013)

Workers' representations of the organisation of work and work-related chronicity factors reflect the subjectivity of these workers, but are also based on their perception of objective aspects of working situations which have been amply documented in epidemiological and ergonomic surveys. If working conditions are intensified, ever more workers suffering from MSDs or disabilities of various origins are excluded as a result of increasing demands and streamlining of productive systems (Westgaard and Winkel 2011; Davezies

2013; Thébaud-Mony *et al.* 2015; Roquelaure 2017). The rise in MSD-related disability can therefore be explained firstly by factors associated with working situations, but secondly and more generally by the transformation of economic and productive models in the European Union over the past few decades.

**In summary**:

— The biopsychosocial model of MSDs is significant because it allows improved conceptualisation of the phenomena of chronicity and occupational disability, neither of which are adequately theorised by the lesional biomechanical model of MSDs.
— Establishing an artificial opposition between the biomechanical and psychosocial models is, however, unnecessary when operating from a prevention perspective; instead, these models must be interpreted on a complementary basis within the framework of an integrated prevention approach. The biomechanical model focuses on risk factors for the incidence of MSDs (or determinants) which can be influenced by primary prevention measures, whereas the biopsychosocial model concentrates mainly on chronicity factors for MSDs, or in other words prognostic factors from the perspective of tertiary prevention.
— Many studies point to the benefits of a disability prevention paradigm in terms of preventing MSD-related occupational marginalisation and improving return-to-work programmes for sufferers of musculoskeletal lesions (Loisel and Anema 2013).

# 4. Interrelationship between psychosocial factors at work and MSDs: prevention pointers

Preventing MSDs is a human, economic and social necessity in the European Union.[3] MSDs continue to pose a significant prevention challenge because of their prevalence, which remains high despite campaigning efforts at European and national level over the past decade. Tens of millions of European workers suffer at work on a daily basis, and some of them struggle to achieve their production targets and risk losing their jobs in industrial or service sectors. MSDs represent a major social challenge for millions of European workers because of the huge impact they have in terms of careers and the risk of occupational marginalisation, and preventing them also means combating social health inequalities, since it is the workers and employees working in arduous conditions and under time pressure who are most affected, in particular ageing workers and workers in precarious employment.

Leaving the human costs to one side, the economic and societal costs are also significant, since MSDs are a major cause of absenteeism from work and high compensation claims. The indirect costs incurred by companies (drop in productivity and quality of work, absenteeism, recruitment problems, job changes for victims, damage to the company's reputation, etc.) and by Member States exceed the direct costs; according to the European Agency for Safety and Health at Work, the overall cost is somewhere in the region of 1.5% of the EU's GDP (EU-OSHA 2014).

In regulatory terms, employers in the European Union are obliged to prevent MSDs as part of their occupational health and safety obligations pursuant to the European Framework Directive on Safety and Health at Work (Directive 89/391/EEC) and specific directives concerning the handling of loads (Directive 90/269/EC) and work with display screen equipment (Directive 90/270/EC). MSDs are characterised by a cluster of causes rather than a single cause, which makes it necessary to evaluate risks on a holistic basis and adopt an occupational health prevention strategy which combines the 'primary', 'secondary' and 'tertiary' levels:

— primary prevention is aimed at reducing the incidence of MSDs of occupational origin by evaluating, restricting and substituting high-risk situations;

**3.** Cf. European Commission (2014). EU Strategic Framework on Occupational Safety and Health (2014-2020); European Commission (2017). Safer and Healthier Work for All – Modernisation of the EU Occupational Safety and Health Legislation and Policy.

— secondary prevention is aimed at limiting MSD-related disability and chronic MSDs through early detection and tailored monitoring of sufferers, incorporating prognostic factors for MSDs;
— tertiary prevention is aimed at helping workers suffering from chronic MSDs and long-term disability to return to work and stay at work using coordinated medical and socioprofessional treatment strategies.

In practice, the high prevalence of MSDs and the problems involved in distinguishing between primary and secondary prevention efforts for workers carrying out activities mean that it is legitimate to group these two aspects of prevention under the term 'early prevention of MSDs' (Inserm 2000).

## 4.1 Prevention of MSDs: importance of reducing the constraints inherent to working situations

### 4.1.1 Early prevention of MSDs

The European Union must continue to prioritise primary MSD prevention efforts with a view to limiting the onset of MSDs in workers. In keeping with the general principles of prevention and the regulatory provisions, these efforts must be rooted in complementary approaches which focus mainly on design-led reduction of exposure to risk factors in working situations or, if this is not possible, corrective measures which draw on risk assessment data. Risks should ideally be assessed within the framework of a participatory ergonomic process, and a hierarchised strategy should be adopted in order to promote a holistic approach to risks and coherent occupational risk prevention within the company (Malchaire *et al.* 2011; Petit and Roquelaure 2014). Nevertheless, risk assessments must not delay research into preventive solutions when it is apparent that the level of exposure to MSD-related risks is high.

The catalysts of change which have traditionally been most popular are technical and organisational measures (mechanisation, handling aids, alteration and adaptation of jobs, changes to work pace, etc.). These measures should ideally be deployed at the procurement or design stage in order to ensure that working situations, equipment, machinery and tools, etc. limit exposure to biomechanical factors such as repetitive movements and/or movements involving the application of force, manual handling of loads and uncomfortable positions of the limbs and torso. These measures may derive from regulatory requirements (directives on topics such as occupational health (Directive 89/391/EEC), the handling of loads (Directive 90/269/EC), work with display screen equipment (Directive 90/270/EC) and machinery (Directive 2006/42/EC), etc.) or from international standards on ergonomic design principles for machinery, warning devices and manual controls, on anthropometry, on working positions and on the handling of heavy or repetitive loads, etc. (see the website of the European Committee for Standardization). Yet, although interventions aimed at using technical measures to 'lighten the biomechanical load' in the workplace have demonstrated their merit in terms of reducing workers' exposure to intense and/or repetitive physical exertion (National Research Council 2001; Aptel *et al.*

2011; St-Vincent *et al.* 2011), scientific evidence of their effectiveness in reducing the onset of MSDs still remains limited (van der Molen *et al.* 2012; Verbeek *et al.* 2012; Van Eerd *et al.* 2016).

The limitations and problems inherent to technocentric primary prevention strategies which are based on a biomechanical and biomedical model of MSDs but which are implemented against a backdrop of moves to streamline production methods and work organisation while increasing job flexibility mean that questions should be asked about the relevance of these strategies. The interrelationships between MSDs and psychosocial and organisational factors at work justify an expansion of the preventive horizon to encompass a biopsychosocial and organisational model of MSDs. The latter allows simultaneous examination of the organisation of production, the organisation of work, management practices and psychosocial factors at work, all of which are pivotal elements in the onset or perpetuation of MSDs, and all of which have a domino effect on the conditions under which work is carried out and the biomechanical, psychosocial and environmental characteristics of the working situations encountered by workers. As far as MSDs and psychosocial factors at work are concerned, management practices and the organisation of work not only represent one of the causes of the problem but also offer a potential solution to it, since they dictate both the intensity of the constraints inherent to working situations and the individual or collective resources available to tackle them. Expanding the models which underpin MSD prevention interventions to include the psychosocial and organisational components as well as the biomechanical and medical components of MSDs is therefore a legitimate avenue to follow in order to make these models more effective (Wells *et al.* 2010; St-Vincent *et al.* 2011; Coutarel *et al.* 2013).

Preventing MSDs involves 'lightening the load', but it also involves asking questions about the methods of production and work organisation which are most likely to intensify physical, psychosocial and organisational constraints. In general terms, work organisation methods which keep the workforce healthy are those which increase workers' leeway to handle fluctuating and/or urgent situations and unforeseen circumstances as they go about their work (Bourgeois 2006; St-Vincent *et al.* 2011; Coutarel *et al.* 2013). The aim is not merely to reduce exposure to biomechanical constraints, but also to promote workers' capacity for action by re-establishing work collectives and promoting the value of working together. What matters most is providing workers with the skills to make the necessary adjustments to their working style, allowing them to produce goods or deliver services while protecting their own health.

Questions should also be asked about popular management practices which are likely to reduce the options for cooperation within working groups; these include widespread use of temporary staff, reliance on worker versatility and individualisation of working relations. Primary MSD prevention efforts take the opposite tack by aiming to improve the quality of working relations, since it has been proven that a hostile social climate, where workers receive little support from the management or their colleagues, is associated with a higher risk of MSD onset or perpetuation (Hauke *et al.* 2011; Inserm 2011; Lang *et al.*

2012). Attempts must accordingly be made to maintain or re-establish working collectives in order to reduce conflict and stress experiences at work (which are also MSD risk factors). Employees need to be given access again to the options they once had for individual and collective regulation, and allowed to utilise their know-how and skills to carry out work-related movements freely and deliver high-quality work, producing the goods or services required without damaging their health (Bourgeois 2006; St-Vincent *et al.* 2011; Falzon 2014). Cases studies are reported in the literature, but intervention trials are necessary to gauge the effectiveness of ergonomic prevention approaches in reducing the number of new cases of MSDs (Petit et Roquelaure 2014; Stock *et al.* 2018).

A primary MSD prevention policy should focus not only on reducing the constraints inherent to working situations, but also on collective health promotion efforts. In particular, the latter should involve the provision – within the framework of job-related training – of basic information on the physiology of exercise, how movements are learned, methods for warming up and stretching muscles and other types of exercise. The effectiveness of these measures is probably limited, however, and they do not have any impact on working conditions (Burton *et al.* 2006; Freak-Poli *et al.* 2013; Geneen *et al.* 2017). Job-related training for workers is too often overlooked as a potential way to make progress in this area, especially for workers in industrial workplaces who are at greatest risk of MSDs.

In companies where the incidence of MSDs is high, secondary prevention efforts and research into preventive solutions must draw on risk assessments and (where possible) aggregate data gathered during the medical surveillance of exposed workers, with a view to gauging the level of MSD risk. MSD prevention efforts must involve all stakeholders within the company, i.e. not only the departments responsible for occupational health and risk prevention and the health and safety committees, but also the managing director, the senior managers, the workers' representatives and the workers themselves. Consensus has been reached on the fact that what is needed is a holistic and participatory process which becomes a lasting and integral part of the company's DNA. In order to achieve this, the topic of MSDs must be debated calmly, and it must become a firm fixture on the occupational risk prevention agenda. The quality of social dialogue within the company and the effectiveness of the health and safety committee (or worker representation system) are therefore decisive parameters in the success of prevention efforts (Bourgeois 2006; Daniellou 2008; St-Vincent *et al.* 2011).

Any approach to the prevention of MSD-related health impairments must start by considering the methods used to make the company and its production processes efficient. After all, the problems that are encountered by employees in carrying out their tasks and that give rise to pathological musculoskeletal disorders also manifest themselves in production-related or quality-related issues, and both must be prevented or tackled at the same time.

Gaining clarity over the chain of determinants represents a key stage in the occupational diagnosis of MSDs. It necessitates a systematic approach to the working situation, based on a participatory ergonomic process which considers the working activities which are actually carried out and avoids a simplistic diagnosis in which the condition is attributed solely to 'incorrect movements'. Analytical reasoning must be based on an understanding of the activities carried out in existing situations and simulations of potential future activities. A work-based approach of this kind prevents the company's operations from being siloed in different 'areas' (health and safety, quality, productivity, marketing, etc.), and allows all of the different strategies followed by these areas to be leveraged as contributions to a conversation on the determinants of production activities.

Interventions will be effective only if they involve the entire company, enjoy strong backing from senior managers and shape the company's general management policy on a long-term basis. It is particularly important to achieve 'quick wins', no matter how limited in scale, to shake the belief among operators and senior managers that MSDs are something that 'can't be helped' (Daniellou 2008), since there is a risk that all attempts to discuss the severity of the MSD epidemic may be stymied by fatalism while defensive attitudes of this kind are entrenched at stakeholder level.

The causes of MSDs are technological, organisational and management-related in nature, and catalysts for change in this area must be sought in similar contexts. Nevertheless, action should be taken in a number of different areas simultaneously, i.e. product design, production processes, technical systems, organisation of work, induction of new workers, training, etc. It has been proven that one-dimensional interventions relating solely to training or workstation adjustments are less effective in reducing MSD risk than multidimensional interventions which combine the following components and methods (Kennedy *et al.* 2010; Van Eerd *et al.* 2016; Stock *et al.* 2018):

1. **Establishment of a project management structure in the field of ergonomics**.

2. **Participatory ergonomic workplace interventions**, aimed at increasing workers' leeway to tackle fluctuating and/or urgent situations and unforeseen circumstances, and including the following elements in varying proportions:

    — physical and technical adjustments to the working situation (dimensions, space, accessibility, layout, availability of equipment, etc.);
    — organisation of work (pace, work schedule, urgent situations, etc.), with a view to reducing exposure to biomechanical constraints, promoting decision-making control, improving the quality of working relations (between the management and workers and between colleagues) and building workers' skills;
    — working tools/equipment (availability, maintenance, design, ease of handling, etc.);

— products/loads (weight, contents, dimensions, variability, etc.);
— working environment (noise, humidity, temperature, lighting).

3. **Interventions targeted at individuals**, and including some or all of the following depending on the specific method:

— education and training on load handling techniques;
— education and training on ergonomics with a view to improving workers' abilities to overcome the constraints of working situations, assess risks to the spine and look for potential ergonomic solutions;
— physical exercise programmes (in many cases).

4. **Monitoring the impact of interventions**.

Although it appears likely that these multidimensional interventions are effective and even cost-effective, there is currently no scientific consensus on the most important components or their relative proportion (Kennedy *et al.* 2010; Petit and Roquelaure 2014; Van Eerd *et al.* 2016). Nevertheless, it is quite clear from the scientific literature and from the experience of bodies working in the field of prevention that early MSD prevention interventions must be multidimensional and must be focused on the organisation of work in order to target both the psychosocial component and the physical component of the working situations which give rise to MSDs.

## 4.2 Tertiary prevention and keeping people in work

The high prevalence of MSDs among workers in industrial workplaces means that prevention efforts must incorporate early treatment for workers suffering from MSDs and measures allowing them to remain in work or return if they are unfit for work on a temporary basis. Tertiary MSD prevention interventions complement primary and secondary prevention interventions, since actions aimed at reducing the incidence of MSDs and detecting at an early stage those workers who are at high risk of chronic MSDs play a major role in reducing the rate of occupational disability and the risk of professional marginalisation.

The disability prevention paradigm has generated multidimensional tertiary MSD prevention programmes aimed at reducing chronicity and occupational disability. They are focused less on treating the lesion than on the worker's ability to resume his or her work, and – on the basis of a systemic biopsychosocial model – take a holistic view of the multiple factors (medical, psychological, social, economic and occupational) which influence an individual's return to work. It is for this reason that these return-to-work programmes place a great deal of emphasis on the individual work-related psychosocial dimension of the disability, without ignoring the physical components of the working situation and the disability itself.

The aim of treatment is to ensure that the worker can return to his or her job. Contrary to the received wisdom, it has been established that, if a worker has

been absent from work, a gradual and early return to work (with ergonomic adjustments to the workstation) has a long-lasting therapeutic effect on MSD-related disability (Loisel *et al.* 2003; Loisel 2010; Loisel and Anema 2013; Fassier *et al.* 2015). Workers must be made aware of the importance of consulting their occupational physician or treating physician at an early stage rather than waiting until the point at which they struggle to do their job.

Both medical and professional support must be provided, based on an assessment of the medical, social and professional situation of the workers in question (Petit and Roquelaure 2014). A holistic and systemic approach must be taken to the determinants of chronic MSDs and MSD-related disability:

1. **Individual characteristics** (age, high BMI, lack of physical activity, previous history of MSDs, etc.) (Hasenbring *et al.* 2012; Loisel and Anema 2013);
2. **Individual psychosocial factors**, such as the worker's negative representations of his or her disease and his or her 'fears and beliefs' regarding its consequences in terms of future employment (Coutu *et al.* 2007; Vlaeyen and Linton 2012; Besen *et al.* 2015);
3. **Characteristics of working situations**: biomechanical constraints (high workload, manual handling, postural constraints, vibrations), work-related psychosocial and organisational factors (time pressure, job dissatisfaction, lack of social support or recognition, etc.) (Driessen *et al.* 2010; Kennedy *et al.* 2010; Loisel and Anema 2013).

Multiple stakeholders must be involved in the process, including first and foremost the worker in question, but also representatives of the healthcare system, the workplace (employer, trade union, work colleagues) and the insurance provider (Loisel *et al.* 2003; Durand *et al.* 2007; van Oostrom *et al.* 2009).

Multidisciplinary programmes which pursue the goal of keeping people in work and which combine physical and psychosocial rehabilitation with ergonomic adjustments to the working situation can help workers to remain in long-term employment. There is no typical solution, since the intervention must be tailored to the unique historical, technical, organisational and economic features of the company (Daniellou 2008). The multidimensional programmes which have proven effective incorporate both individual medical and psychological interventions aimed at increasing functional leeway and work-related interventions aimed at increasing professional leeway. The following components should be present in varying degrees, but there is no way of saying which are most relevant to an individual situation or which ratio should be used as a basis for combining them (Palmer *et al.* 2012; Loisel and Anema 2013; Petit and Roquelaure 2014):

1. **A physical rehabilitation programme** (exercise retraining) aimed at improving functional musculoskeletal capacities and reducing the physical deconditioning which is a secondary complication of chronic MSDs;

2. **A biopsychosocial rehabilitation programme** with a cognitive and behavioural basis, aimed at combating negative representations of the disease and 'fears and beliefs' concerning the difficulty of social and professional reintegration;
3. **Interventions targeted at working situations**, aimed at reducing the level of physical and psychosocial demand and increasing workers' leeway through technical and organisational measures and occupational training.

It is vitally important that efforts aimed at preventing disability remain centred on the worker, and that the medical and social care provided is not disconnected from his or her past and future working activities. These can be challenging goals to achieve, since responsibility for workers who are absent from work is often placed entirely in the hands of the healthcare sector with no attempt to maintain links with former workplaces or bodies involved in occupational risk prevention; the effectiveness of collaborative, medical and professional measures could instead be boosted by building shared representations and coordinating the various parties with an involvement in working practices. The technical and regulatory obstacles which stand in the way of cooperative efforts to help people remain in work must be overcome, and the establishment of organised networks is a promising idea in this respect (Petit and Roquelaure 2014). The evidence base for the effectiveness of interventions in reducing workplace disability from MSDs is satisfactory for lower back pain (Kennedy *et al.* 2010; Hasenbring *et al.* 2012; Loisel and Anema 2013) but remains limited for MSDs of the upper limbs (Driessen *et al.* 2010; Kennedy *et al.* 2010; Van Eerd *et al.* 2016) owing to the inadequate number of studies of good methodological quality (Palmer *et al.* 2012).

## 4.3 Integrated prevention of MSDs

MSD prevention efforts must move beyond a technocentric approach and adopt an ergonomic perspective while asking questions about the productive, organisational and management models applied within companies. Phenomena such as the intensification of work, rising socio-economic insecurity and the risk of 'technological' unemployment as a secondary effect of the ongoing technological revolutions, as well as ageing of the working population and the epidemic spread of chronic disease in a number of EU Member States, mean that the context in which these prevention efforts are implemented is inimical to occupational health. They must therefore be tailored to the changes which are occurring in the world of work, such as increased job flexibility and overexposure to risk of workers who are underskilled, in precarious employment, self-employed, etc. Prevention pathways must not ignore the problem of precarious work and must enable better coordination of interventions which have traditionally fallen under the purview of either occupational health or public health, since it is not only workers who are still working within companies who need help, but also those who have suffered occupational marginalisation.

Against this backdrop, it is more true than ever that long-term prevention of MSDs can be achieved only through a holistic and long-standing occupational health policy aimed at reducing musculoskeletal morbidity, improving quality of life at work and preventing occupational marginalisation among the working population. These goals cannot be attained solely through local and case-by-case action in response to requests by companies or worker representatives faced with situations in which the number or severity of MSD cases which have been detected or recognised as occupational diseases has become critical. Local interventions of these kinds do hold some merit, since they reduce the MSD risk for workers in the companies concerned and forestall catastrophic occupational health situations. Nevertheless, experience shows that one-off prevention interventions can be problematic and their impact short-lived owing to companies' hunger for flexibility, the ever-changing socio-economic context and new faces at senior management level (Daniellou 2008). A sustainable MSD prevention policy must cover a wider area and be implemented at the level of a professional sector or an employment catchment area. Given the wide range of work-related determinants and individual susceptibility factors, in particular of a psychosocial nature, prevention efforts must be based not only on population-level (i.e. public health) considerations with a view to building a general framework, but also on ergonomic considerations with a view to designing strategies for individual companies and their working situations. This public health/occupational health approach tallies with the WHO's Global Plan of Action on Workers' Health, which proposes a holistic prevention policy that combines public health interventions (health promotion) with occupational health interventions (WHO 2007). The implementation of public health or health promotion interventions (either in companies or at the level of the general population) alongside occupational health interventions is nevertheless a difficult task involving different stakeholders depending on the circumstances in which companies operate and the organisational culture of occupational health in the individual EU Member States.

It is becoming ever more apparent that MSD prevention efforts must be based on an *integrated occupational health policy*. Several ever-shifting groups of workers exist alongside each other in the working population and in companies, with these groups differing in terms of the musculoskeletal symptoms and discomfort they experience as they carry out their activities. Workers suffering from MSDs at various stages of their clinical course (acute, sub-acute, chronic or recurrent) work alongside other workers in the very same company who do not suffer from MSDs, and the workers in the first group frequently remain silent about their suffering for fear of losing their jobs. Looking more generally at the population as a whole, these workers co-exist alongside individuals who have stopped working because of MSD-related disability, and also (less frequently) workers experiencing occupational marginalisation because of their MSDs. The co-existence of these sub-groups provides grounds for a holistic and integrated prevention approach; firstly in order to avoid the onset of MSDs in workers who are present at the same time and in the same space but are not currently affected, secondly in order to avoid a percentage of cases of MSDs becoming chronic in nature, and thirdly in order

to ensure that more people suffering from severe and incapacitating MSDs are able to stay in work. MSD risk prevention cannot therefore be tackled merely on a case-by-case basis in response to the onset of symptoms and depending on whether or not the MSD is recognised as an occupational disease and whether or not the individual in question is absent from work for a prolonged period. On the contrary, it must form part of the occupational risk management policy of an entire company or sector, and incorporate all three levels of prevention (primary, secondary and tertiary). Even in working situations where primary intervention efforts have little effect, it is possible to reduce the severity of MSDs and improve their prognosis by implementing integrated prevention measures at all stages of their clinical course (acute, sub-acute, chronic). Integrated MSD prevention approaches of this kind are extremely rare, despite the fact that they are recommended by the WHO in its Global Plan of Action on Workers' Health (WHO, 2007). The three-level prevention model is based on a defensive understanding of health (prevention against identified risks), and it is therefore a good idea to combine it with a more constructive approach (positive prevention), based in particular on the promotion of health as defined in the Ottawa Charter adopted at the First International Conference on Health Promotion (WHO 1986), or on the more recently developed idea of constructive ergonomics, according to which companies should build 'enabling' working environments which facilitate ongoing worker development (Falzon 2014).

Integrating collective MSD prevention efforts into a holistic and long-term policy means that medical and social support for workers must be coordinated with workplace interventions, and that measures implemented within companies must be coordinated and planned on the basis of risk assessments and employment situations, alongside efforts to promote occupational health and ensure that workers can carry out their tasks in 'enabling' working environments throughout their professional careers and their lives. Combining and coordinating these three approaches to prevention, which in many cases rely on different models of work and MSDs and involve different stakeholders, can be problematic (Roquelaure 2016). One potential solution is increased coordination of primary care pathways (general medical practice) and occupational health prevention pathways, and it is therefore a good idea to investigate the arrangements and conditions most likely to promote geographically broad, long-lasting and effective cooperation between the stakeholders and institutions involved in occupational health prevention and keeping people in work (Fassier *et al.* 2011, 2015; Petit and Roquelaure 2014). Improved delivery of occupational health training to health professionals helps to build shared representations and facilitates coordination of the different individuals responsible for workplace interventions, which in turn improves the coherence and effectiveness of medical and work-related prevention efforts (Roquelaure 2016).

# 5. Concluding comments and future outlook

Research carried out in various disciplinary fields points to the interrelationships between psychosocial factors at work and MSDs. Psychosocial factors at work appear to be a key component in understanding and preventing MSDs, since they have a domino effect on the conditions under which work is carried out and the biomechanical, psychosocial and environmental characteristics of the working situations which workers encounter. MSDs can therefore be regarded as the pathological effects of dysfunctional work organisation and the resulting intensification of work.

Achieving a better understanding of the interrelationships between psychosocial factors at work and MSDs is a challenge which must be tackled in order to prevent these disorders among workers in the industrial and service sectors. MSD prevention efforts must incorporate psychosocial components as well as biomechanical and medical components in order to pave the way for holistic and integrated interventions and ensure increased effectiveness. All aspects of prevention must be integrated, but improvements to working conditions must be prioritised, and efforts must be made to move beyond a technocentric approach and ask questions about companies' productive, organisational and managerial models from an ergonomic perspective. The dual nature of the organisation of work as both the cause of and the solution to MSDs must be debated within companies, particularly within worker representation committees and the bodies responsible for health, safety and working conditions, since this is a key consideration when trying to identify preventive solutions. Increasing workers' individual or collective leeway can help to prevent MSD risks if it allows them to utilise skills and know-how they have learned on the job so that work-related movements can be carried out freely and high-quality work can be delivered. Efforts to prevent occupational marginalisation and ensure that workers can remain in their jobs must be better hierarchised and coordinated, and must form part of a development-focused approach which seeks to place the worker at the centre of the entire return-to-work procedure without any interruption in care.

MSDs and the associated social health inequalities represent both a public health challenge and a democratic challenge, and the dual nature of this problem means that we must engage in a debate at EU level on industrial policy and working conditions which are sustainable over an entire working life. We must also apply an interdisciplinary approach to occupational health issues, taking into account not only the economic, social, regulatory and organisational dimensions of occupational exposure, but also the constructive dimension of occupational health (Roquelaure 2017). In more general terms, any MSD

prevention policy must be incorporated into a holistic, integrated and long-term occupational health policy which covers the entire scale from 'occupational risk prevention' to 'occupational health promotion', and which promotes integrated multidimensional prevention interventions tailored to multifactorial diseases with an occupational component relating to the organisation of work, such as MSDs and psychosocial risks. In methodological terms, these policies must guarantee long-term support for companies and workers, and it is therefore apparent that labour inspectors must be provided with training on the complexity of MSD determinants, tools for analysing working situations and their determinants, and the means to carry out their tasks, including in SMEs.

European directives on occupational health, the handling of loads or work with display screen equipment are a step in the right direction, but do not go far enough as far as MSD prevention is concerned. Given the lack of progress on proposals for an 'anti-MSD' directive and a holistic occupational health prevention policy, there is a serious risk that the MSD epidemic will only worsen in the future as working conditions in the manufacturing industry and services sector undergo yet further intensification. MSD prevention efforts in industrial workplaces can be improved only if we expand prevention models and achieve a detailed understanding of the interrelationships between MSDs and psychosocial and organisational factors at work as a basis for identifying catalysts for long-term change in this area. The complexity of these interrelationships represents a major challenge when it comes to negotiating and drafting new 'anti-MSD' legislation at EU level with a view to introducing more sustainable and socially responsible production models within the European Union. This is a serious problem, because it entails the risk that the MSD epidemic will continue to spread in coming years unless a holistic prevention policy is introduced. This policy must be backed up by improved recognition of MSDs in the Member States with a view to increasing their visibility among the EU's workers and highlighting the importance of preventing them.

MSD prevention efforts must target different levels (micro, meso and macro) of the chain of determinants. Intervention-based changes to working situations at the level of individual departments and companies remain necessary in order to reduce the physical and psychosocial risk factors which exist prior to the onset of MSDs (primary prevention), but they must be supplemented by more generalised efforts to improve working conditions and management practices at the level of regions, industries or economic sectors. Promoting this generalised MSD prevention approach ('universal primordial approach') is vital in order to secure the long-term economic and social success of the European Union, and involves firstly a push for more sustainable and socially responsible production models based on the incorporation of social and health impacts into economic and managerial models, and secondly the backing of economic policies and business strategies centred around holistic and integrated occupational health prevention. Against this backdrop, there is a very real possibility that new ethical charters and labels could serve as guarantees that goods and services have been produced by people working in acceptable

working conditions, following the example of similar labels in the fields of sustainable development and the environment. It is likely that consumers – many of whom are or have been workers themselves – would be alert to any such charters and labels, making it possible to reward companies which adopt sustainable methods of production and introduce long-term MSD prevention measures. An encouraging example of a similar virtuous circle (as opposed to a race to a bottom) can be seen in the developments which followed the adoption of the EU's REACH Regulation on occupational chemical exposure.

Ultimately, the greatest challenge we face is primordial MSD prevention, which requires not only the establishment of working conditions which are sustainable throughout a worker's career, but also the development of individual capacities to cope with these conditions throughout his or her working life (Supiot 2010; Falzon 2014; Roquelaure 2017). MSD prevention can be achieved in the long term only if the European Union's social and industrial policy changes direction, and if the tactic of 'governance by numbers' is abandoned in favour of rediscovering the foundations of social Europe (Supiot 2015). This would help to reverse the intensification of working conditions – a central policy issue which must be tackled by the European trade unions owing to the fact that it is causing MSDs and mental health problems in ever-increasing numbers of workers and employees in industrial sectors, and affecting health, quality of life at work, job retention and the medium-term and long-term economic competitiveness of the European Union. We must remain true to the spirit of social justice enshrined in the 1944 Declaration of Philadelphia setting out the aims and purposes of the International Labor Organization by not allowing this problem to be overshadowed in the face of a crisis by clamours for economic competitiveness and promises of short-term employment (Supiot 2010).

# 6. The workplace of the future: future areas for research

A stepping-up of efforts to prevent MSDs among workers therefore calls for an expansion of the underlying conceptual models, firstly in order to gain a more granular understanding of the interrelationships between MSDs and psychosocial and organisational factors at work, and secondly in order to identify levers for long-term MSD prevention. The complex interrelationships between pain and musculoskeletal lesions, biopsychosocial stress mechanisms and psychological distress are still poorly understood. Studies still need to be carried out by major European research institutions in order to obtain a solid scientific basis not only for assessing and preventing MSDs, but also for preventing psychosocial risks at work.

Epidemiological research into MSDs and psychosocial factors at work should be broadened so that the impacts of economic, financial and organisational transformations on the health of European workers can be gauged more accurately. Longitudinal studies are needed to allow better modelling of the risks for MSD onset or perpetuation, including psychosocial factors at work, and to calculate the 'dose-effect' relationships and interactions between the various factors (both work-related and non-work-related). In particular, occupational disease statistics should be extended to include epidemiological surveillance data; these data are actuarial in nature rather than prevention-focused, and therefore serve as an indicator of the success of occupational health policies.

Interventional research into the prevention of occupational marginalisation must be stepped up as a basis for improving primary prevention of MSDs and fine-tuning complex and multidimensional job retention/return-to-work interventions tailored to each company's circumstances. Research must also be carried out into methods of better identifying individuals at high risk of occupational marginalisation and intervening at an earlier stage. Intervention trials must be carried out to ensure that job retention interventions are appropriately multidimensional ('just-in-need') and tailored to the severity of the working situation. This requires better hierarchisation and coordination of existing interventions while ensuring that the workers concerned remain at the centre of the return-to-work procedure and their care is not interrupted.

Interdisciplinary research into MSD prevention policies is essential as a foundation for steering, planning, implementing and evaluating integrated prevention interventions. In particular, it is important to identify the structural conditions which must be in place for occupational health promotion campaigns combining technical and organisational interventions focused on

working situations with interventions aimed at cooperation between bodies involved in occupational risk prevention.

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