Work-Related Musculoskeletal Disorders (WMSDs)

A BETTER UNDERSTANDING FOR MORE EFFECTIVE PREVENTION

ASP MÉTAL ÉLECTRIQUE

Association paritaire pour la santé
et la sécurité du travail
Secteur fabrication de produits
en métal et de produits électriques

irsst Institut de recherche Robert-Sauvé en santé et en sécurité du travail

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Association paritaire pour la santé et la sécurité du travail – Secteur fabrication de produits en métal et de produits électriques

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Preface

Practical guides are a crystallization of our knowledge, a topographical map which contextualizes a given problem and provides vital indicators to guide us in our choices to eliminate the problem. This is the mission accomplished by this guide on musculoskeletal injuries written by Serge Simoneau, Marie St-Vincent and Denise Chicoine.

The concept of work-related musculoskeletal disorders (WMSDs) is still rather vague and knowledge gaps on the subject still abound. The authors therefore had to work extremely hard to extract, weigh and evaluate this knowledge, in order to identify a series of elements that could be put into practice. The weighting was all the more critical as there is no shortage of purveyors of miracle solutions and dubious scientific ideas.

The development of this guide called for another important and indispensable aspect that requires special skills: a clear understanding of client needs and, more importantly, of the user's assimilation capacity. A guide can be as good as it wants, containing all the elements required to initiate a prevention process, but if the client/user does not find it useful, it will go unheeded.

It is also possible – indeed quite common – to overestimate the receptiveness of users, who may reject a document that they find too theoretical, overly complicated and, above all, not adapted to their current needs.

In this guide, the authors have effectively balanced the choice of knowledge and its suitability for the target clientele. Achieving this feat took the work and experience of the Institut de recherche Robert-Sauvé en santé et en sécurité du travail du Québec, along with the in-depth knowledge of the community by the Association paritaire pour la santé et la sécurité du travail – Secteur fabrication de produits en métal et de produits électriques. This collaboration led to the production of a solid guide, which has already won acclaim in several projects.

Ilkka Kuorinka, Director
Safety-Ergonomics Program, IRSST
January 1996

Foreword

This document is the result of a long and productive collaboration between the Institut de recherche Robert-Sauvé en santé et en sécurité du travail du Québec (IRSST) and the Association paritaire pour la santé et la sécurité du travail — Secteur fabrication de produits en métal et de produits électriques (A.S.P. Métal-Électrique). It is based on the expertise acquired during several interventions in electrical products manufacturing plants. The content was largely drawn from the reference book produced by the IRSST and coordinated by Ilkka Kuorinka and Lina Forcier.* Produced by a group of international experts, this report presents a summary of all scientific studies related to the prevention of WMSDs. In this guide, we have reproduced some of its elements, but in a much simpler form.

From the outset, our intention was to develop **a practical tool for people in the industry concerned about work-related musculoskeletal disorders** (WMSDs). To better meet this goal, we decided to publish two separate documents.

The first publication is designed for all those who want to improve their understanding of WMSDs in order to prevent them more effectively. It contains four chapters. The first defines and explains the characteristics of WMSDs. The second presents the main risk factors behind WMSDs. The third explains how to detect a WMSD problem, while the fourth outlines the main prevention avenues available.

The guide includes inserts (identified by a "+" in the top left corner), where we explain in more detail the concepts that would help readers understand the document. Each chapter ends with a summary, where we review the main points covered. A reader who is in a hurry may get a quick overview of the contents by consulting the summary pages.

The second document will be aimed at industries that are already facing WMSD problems and that want to implement a participatory ergonomic program to improve working conditions. The goal of this second publication is to give people in the industry the tools they need to apply such an intervention program, in light of the experience of "ergo groups" that have been established in many companies in the electrical sector for some years now.

We hope that this guide will help you improve your understanding of WMSDs and find solutions to this problem.

* Kuorinka, I., Forcier, L. (Eds.), Hagberg, M., Silverstein, B., Wells, R., Smith, M.J., Hendrick, H.W., Cayron, P., Pérusse, M. (1995). LATR, *Les lésions attribuables au travail répétitif;* ouvrage de référence sur les lésions musculo-squelettiques liées au travail, Éditions Multimondes, 486 p.

What is a WMSD ?

This document deals with work-related musculoskeletal injuries and their prevention. It is a complex issue that is not always easy to fully comprehend. There are many difficulties surrounding this issue, beginning with the confusion around nomenclature. This is why it is important for us to start with a clear definition

A matter of definition

Our focus here is on work-related musculoskeletal injuries. These types of disorders may affect the different parts of the body associated with movement: upper limbs, lower limbs and the back. In this document, we will limit our examination to disorders affecting the upper limbs. There have been far fewer studies done on work-related injuries to the lower limbs, while back pain is a highly complex issue that has enough singular characteristics to be treated separately.

REPETITIVE STRAIN INJURY (RSI)

CUMULATIVE TRAUMA DISORDER (CTD)

UPPER LIMB SYNDROME

CERVICOBRACHIAL DISORDER

Fig. 1.1
The same reality behind a multitude of names

It should be noted that all the different generic names that are used describe virtually the same problem. It is as if each author had decided to give a different name to the phenomenon. These names often underscore the association with repetitive work, which can suggest, wrongfully, that this is the only cause. Yet, the acronym "WMSD" (work-related musculoskeletal disorders) seems to stand out above the rest, which is why we have decided to use it.

Regardless of the generic expression used, WMSDs are relatively diverse disorders that may affect different structures: tendons, muscles, joints, nerves, and the vascular system. Depending on the structure affected and the type of affliction, the ailment would be referred to as tendonitis, tenosynovitis, bursitis, carpal tunnel syndrome, etc. It should also be noted that most of these disorders may appear in circumstances unrelated to work, as in the case of certain illnesses or following activities outside of work. Since our focus is prevention at the workplace, we will only deal here with their appearance in situations caused primarily by work.

EPICONDYLITIS

TENDINITIS

CARPAL TUNNEL SYNDROME

BURSITIS THORACIC OUTLET SYNDROME

Fig. 1.2
A group of musculoskeletal disorders caused by work

A major problem

Even though these problems have attracted much attention in recent years, the phenomenon is not new. For instance, Ramazinni established the link between musculoskeletal injuries and work over two hundred years ago. The phenomenon is becoming more and more widespread and a source of concern in most industrialized countries. Certain economic sectors are more associated with WMSDs, such as the food sector (slaughterhouses, meat packers), the sewing and clothing sector, the electrical and electronic products manufacturing sector, assembly plants in the manufacturing sector, and working with a video display terminal (VDT). These are all sectors characterized by repetitive manual work, but the problem tends to appear in several other sectors.

Hence, it is a major occupational safety and health issue, and specialists on the subject are not very optimistic about the future. They expect compensation claims for work-related musculoskeletal injuries to keep rising in the coming years, due to a certain number of trends, including the unfavourable economic context, which encourages a faster pace, and hence repetitive work. With the modernization of production methods and the mechanization of the most intensive efforts, the expectation was for repetitive tasks to have disappeared. Yet, there are no signs of this happening – on the contrary. Moreover, an ageing workforce could be more vulnerable to musculoskeletal injuries, particularly at a time of high unemployment, which discourages mobility. People who start feeling pain can no longer change jobs easily, which could help explain the increase in WMSDs

Serious consequences

The phenomenon of WMSDs must therefore be treated very seriously. These musculoskeletal disorders have a considerable socio-economic impact. First, they drive up costs for workers, companies, and society in general. This applies to both direct costs (compensation of victims, medicare, etc.) and indirect costs (loss of production, replacement costs, absenteeism, etc.) associated with occupational diseases and industrial accidents.

Yet, despite the scale of the economic repercussions, the serious and sometimes dramatic consequences of WMSDs on victims must not be overlooked. Physical and mental suffering, compensation difficulties, temporary or permanent limitations in their professional activities are just a few of the aspects of the tragedy that can strike people afflicted with WMSDs.

Characteristics of WMSDs

Work-related musculoskeletal injuries can take different forms. The onset and development of these injuries is still not well known. Many theories – some complementary and others contradictory – have attempted to explain the phenomenon, and it is clear that the issue is still not fully understood. Despite the diversity of afflictions and mechanisms involved, WMSDs show a certain number of similar characteristics.

WMSDs result from overuse

Although the onset mechanisms are not clearly established, it is generally agreed that the injuries result from overuse, beyond the body's recovery capacity. WMSDs occur because a structure is abused repetitively and is made to endure a work load that it cannot tolerate without negative consequences.

WMSDs develop gradually

It is easy to imagine such overuse that leads to the sudden appearance of an injury: a torn ligament or a sprain. Such a case is clearly a work-related accident and not a musculoskeletal injury associated with repetitive work. WMSDs develop over time; the process evolves gradually with repeated overuse and insufficient recovery.

The process may very well set in surreptitiously, with no apparent symptoms, only to one day appear suddenly and develop rapidly. More often, slight discomforts are felt, which worsen gradually until they lead to work stoppage. The disorder can only take a few days to develop, but more often, it stretches out for weeks, months and even years.

The fact that WMSDs appear in so many different ways creates confusion. For example, some work-related tendonitis cases are reported as industrial accidents, while others are declared occupational diseases. In fact, it is not at all obvious that these are distinct health problems. Moreover, it can reasonably be assumed that a good number of WMSDs do not result in any claims for work-related injuries, perhaps because the link with work is not always clear for victims. The official statistics could therefore seriously underestimate the scope of the problem

WMSDs prevention can be very effective

WMSDs do not constitute a disease that can be contracted, but a process that develops over time. The fact that WMSDs develop gradually is both an advantage and a disadvantage. It is an advantage because, unlike an accident, which is, by definition, unpredictable and sudden, tendonitis and bursitis can be anticipated, since they develop gradually. Action can therefore be taken before the process gets too far. If the overuse is stopped in time, the body can recover and the ailment can recede without leaving any trace. Complete recovery is possible, and prevention can be termed effective if it occurs early.

The gradual appearance of WMSDs can also be a disadvantage because, not being forewarned means not being forearmed against symptoms that appear very gradually. The body gets used to the pain, which can be blamed on age or other causes. It becomes a normal presence and the feeling is that the discomfort will go away. This increases the risk of the situation getting worse, to the point where complete recovery becomes impossible.

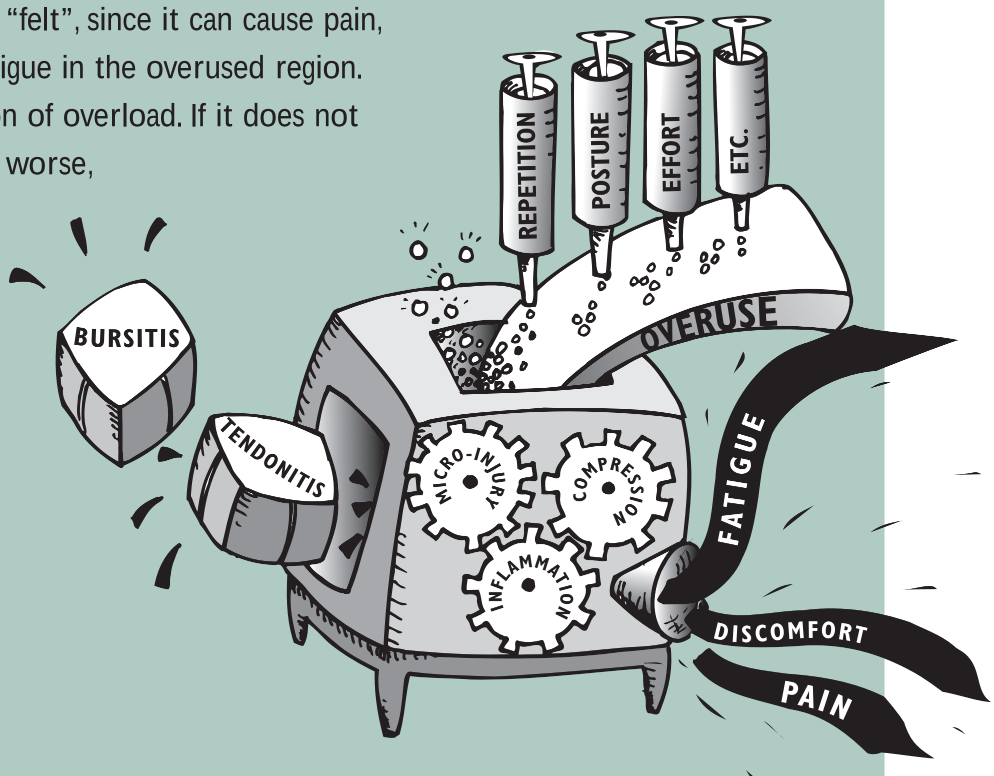
WMSDs have multiple causes

The starting point of WMSDs is overuse. But this overload generally stems from a combination of factors and not from one single cause. Be it repetition, posture or effort, no single risk factor is essential in and of itself. A very demanding effort made in a particularly bad posture can suffice to create musculoskeletal problems, even if the rate of repetition is very low. Conversely, a less demanding task performed in a more or less adequate posture can cause damage if it is repeated thousands of times per day. Because of these multiple causes, prevention must often rely on a combination of solutions based on a good knowledge of the situation. And because the situations can be so diverse, a universal solution is also impossible.

How WMSDs appear

The mechanisms through which injuries occur are not well known. Given the current state of knowledge, the process can be likened to a black box. The starting point is known: overuse, to which many factors may contribute. The result is known: well-identified illnesses, such as tendonitis and bursitis. But what happens in between the two is not very clear. In fact, it is possible that different mechanisms are involved, depending on the types of injuries and joints. Evidence suggests that, in certain cases, overuse of structures creates microscopic injuries which together may ultimately constitute a significant ailment. It is also known that inflammatory processes are often a culprit and that, in certain cases, space for swelling is limited (by bony structures such as the wrist or the shoulder). In these cases, the compression of tissues further complicates the situation.

Whatever the exact nature of the processes that cause WMSDs, the fact is, after a while (depending on the scope and nature of the overuse), the situation can be clearly diagnosed. By that time, it is an illness. Before there is a real illness, the process may be "felt", since it can cause pain, discomfort or localized fatigue in the overused region. This ailment is an indication of overload. If it does not disappear and instead gets worse, a risky situation may be suspected.



The different WMSDs have similar symptoms. The overloaded region is often painful and sensitive when touched. Certain movements or efforts may cause pain which, in the most serious cases, is felt even when the region is at rest. There is very often a swelling* and sometimes numbness. Mobility may be limited by the swelling or the pain.

The first symptoms of WMSDs: early indicators

By the time the illness is fully declared, it is already late to intervene. By that stage, the victim's health has already been compromised and there may be permanent aftereffects. Action must be taken early before the situation reaches a critical point.

But how can workers tell when they are in a risky situation? How do they know if they are not developing tendonitis?

Most often, when a region of the body is overused, it will let the worker know, well before the overuse generates negative consequences, through a feeling of localized fatigue or discomfort. Although these manifestations are often innocuous, they are considered early indicators of a more serious affliction.

This does not mean being alarmed at the slightest discomfort, which may occur especially when carrying out demanding and unaccustomed tasks. However, more attention must be paid to ailments that do not disappear over time and that tend to worsen. This may be an early signal of a situation that may degenerate into a WMSD if timely action is not taken.

Knowing how WMSDs develop for timely intervention

It is not always easy to clearly distinguish between an acceptable situation and one that demands preventive action. All ailments do not lead to tendonitis. Everybody suffers, at one point or another, from work-related ailments, without necessarily being in danger. As well, people often tolerate pain by telling themselves that it will go away, only to end up with an "itis" ailment that forces them to quit work.

Unfortunately, there is no clear and unequivocal demarcation between an innocuous situation and one that will develop into a WMSD. Judgment must be exercised, based on what is known about the onset of a typical WMSD and the risk factors present.

At the outset of the process, the discomfort is confined to an articular region. It is often associated with certain movements or efforts that contribute to overuse. Such discomfort which, in the early stages, is merely symptomatic of fatigue, disappears rapidly and fully after work.

** Swelling is part of the inflammatory response. It is a protective mechanism of the body as it tries to "repair" an injury. Inflammation allows more blood to be sent to the injured region (which consequently grows larger and swells), in order to support the healing process.

At the other extreme, by the time a WMSD is declared, pain is truly present. It has often, but not always, radiated to the surrounding structures, such that it is the entire elbow, shoulder or wrist that is painful, not just a specific region. Sometimes, the pain may radiate to another region (from the shoulder to the arm, for example). Hence, by the time a WMSD is declared, pain is often present even in the absence of movement or effort; it persists outside work and can take several weeks without exposure before disappearing. In fact, if the ailment is serious, full recovery cannot be guaranteed. Partial healing may very well have after-effects. Just like with a scar, the tissues may tighten or thicken, and remain particularly vulnerable in case of future overuse.

Similarly, the development of the first innocuous stage toward a clearly defined WMSD can be established. Action must be taken when the situation starts getting more serious; for example:

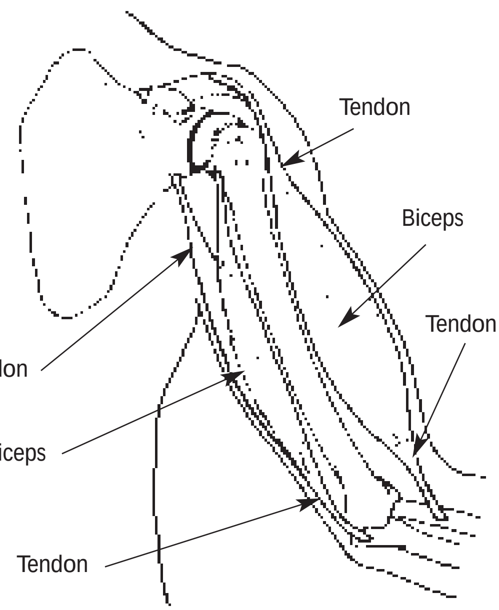
- when the ailment gets more intense or when there is pain;
- when the ailment radiates from one very limited region to a bigger and more diffuse region;
- when the discomfort is associated with increased movement or effort (for example, at the outset, the discomfort is felt only when pressure is applied to insert a piece. Then, the feeling sets in gradually when screwing or unscrewing the cover of a container. If action is delayed, any movement of the forearm will cause pain);
- when the discomfort persists longer and longer after work and the recovery is very slow.

Fig. 1.3
Development of a WMSD.

The most common WMSDs and structures affected

There are dozens of musculoskeletal injuries that affect the upper limbs and that may be caused by work. It would be impossible to list them all here. They are sometimes referred to as "itis" diseases, since several of their names have that ending. In medical parlance, "itis" is a suffix indicating an inflammation. We will take a look at four of the best known and most widespread, and we will identify the structures affected more clearly.

Fig. 1.4
Tendons are what connect muscles to bones

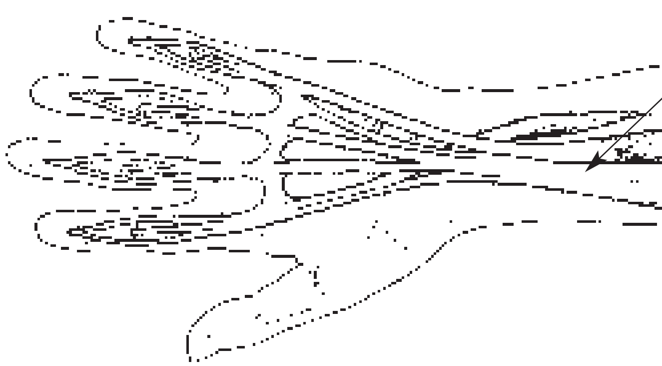


Tendonitis

As its name indicates, tendonitis is an inflammation of a tendon. Tendons are structures that connect muscles to the skeleton. Figure 1.4 shows that the biceps are attached to the shoulder and the forearm by the tendon. When this muscle contracts and shortens, it pulls on the tendon and causes the forearm to bend.

The tendon "works" each time the muscle works. Hence, it is when the muscle is overburdened, for example, by considerable and repeated effort, that the tendon may be overused. If the tendon is injured – and theories abound that WMSDs are caused by an accumulation of microscopic injuries – the body may try to repair it. This is when inflammation occurs, with signs of swelling. If the overuse persists, an injured tendon, swollen by inflammation, may be even more vulnerable to overload. This produces tendonitis.

Fig. 1.5
The fine movements of the hand are controlled by many muscles. Most of them are attached to the finger bones by long tendons.



Tenosynovitis

Tendons could face terrible ordeals in certain circumstances if they were not protected by the synovial sheath. An example is what happens when the hand is completely flexed and the extensor muscles of the finger are put to work. The tendons are pressed against the bones of the wrist, and the resulting friction can injure the tendon. Fortunately, the tendons that require protection are shielded from excessive friction by the synovial sheath. These sheaths serve as lubricating covers that enclose the tendon in a space where it can glide freely in a lubricating fluid called the synovia.

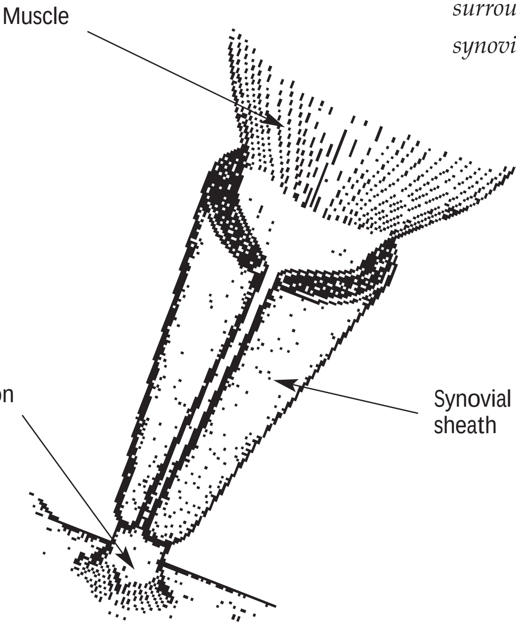


Fig. 1.6
Certain tendons are surrounded by a synovial sheath.

Although the tendons that are surrounded by a synovial sheath are so protected, they are nevertheless not completely shielded from overuse. If tendonitis sets in and the tendon swells, the sheath is compressed by the swollen tendon. The sheath itself then becomes irritated and inflamed. Tenosynovitis is the simultaneous inflammation of a tendon and its surrounding synovial sheath.

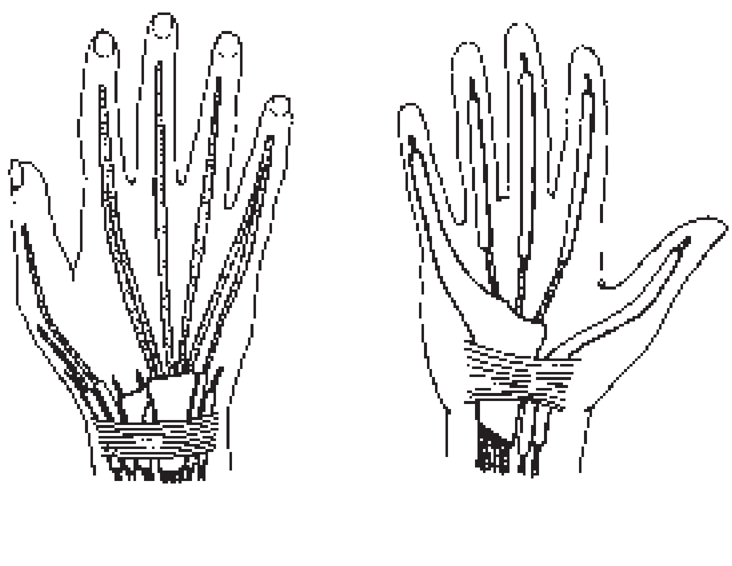
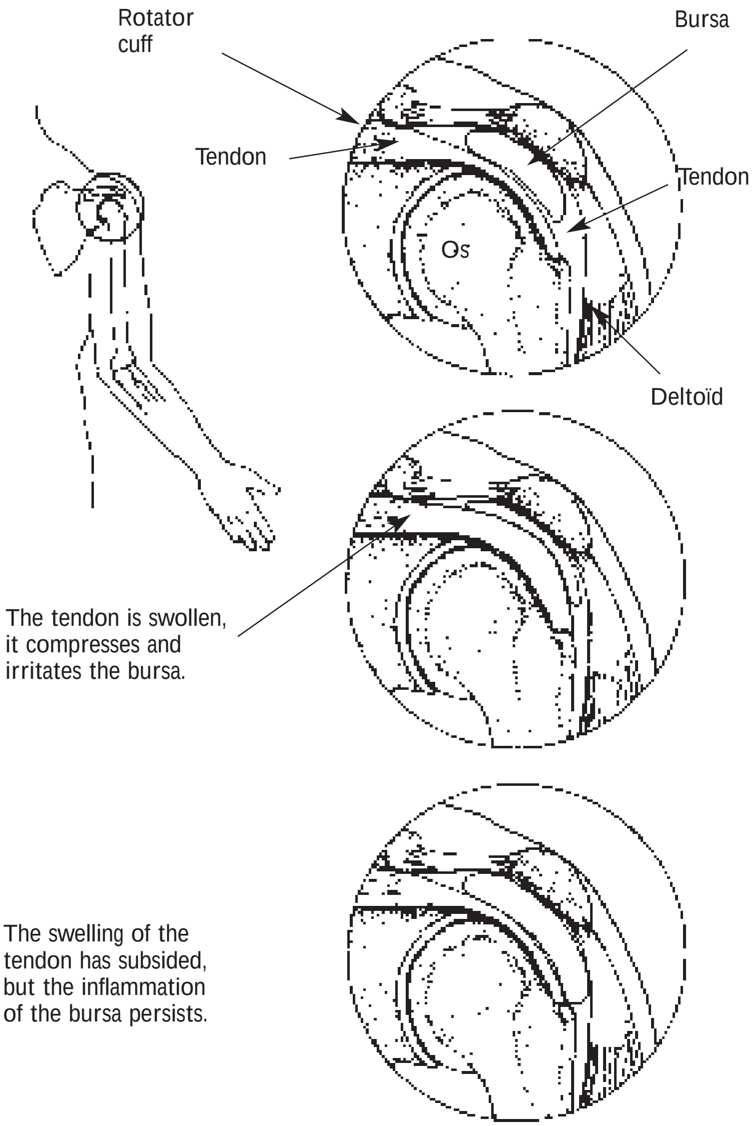


Fig. 1.7
Synovial sheaths are located around the tendons, where they are needed. They are found on the wrist on the back of the hand and virtually everywhere inside the hand.

Fig. 1.8
Bursitis



Bursitis

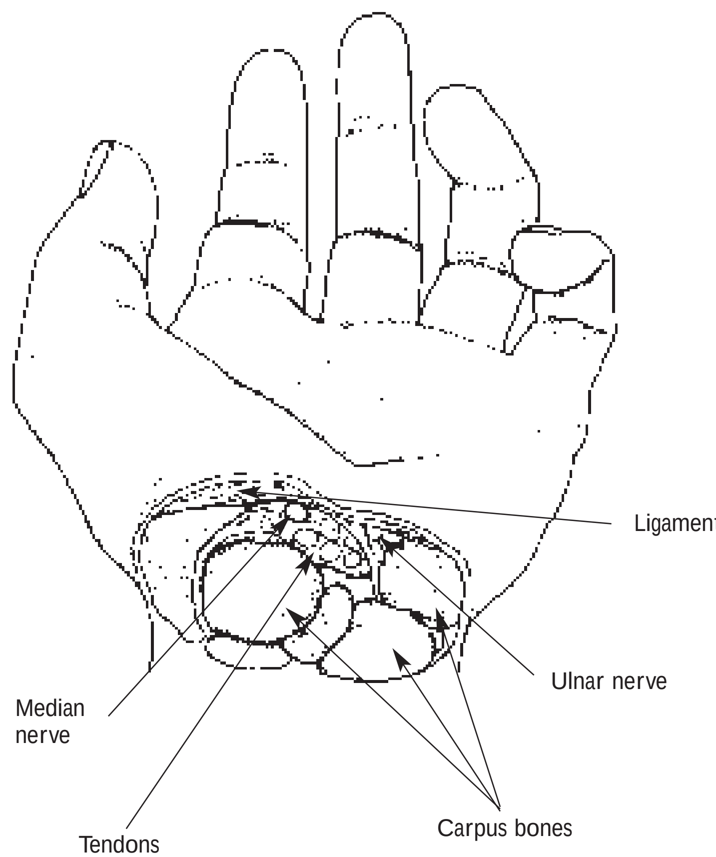
Tendons are also found in the shoulder. Because they are located just above a bone (head of humerus), they could be injured by friction if there was no protective mechanism. Indeed, there is a sac containing synovial fluid between the tendon and the bone, called the bursa. It acts as a lubricating cushion that allows the tendon to glide on the bone prominence without damage. As the name clearly suggests, bursitis is the inflammation of the bursa.

This inflammation of the bursa generally follows an inflammation of the tendon. With the swelling that accompanies tendonitis, the bursa ends up being compressed between two bones. The friction and compression can injure the bursa and cause bursitis. The swelling of the tendon can also subside, while the bursa remains swollen. The swelling of the bursa can in turn compress the tendon and rekindle the tendonitis. Hence, bursitis is sometimes a complication of shoulder tendonitis (swimmer's shoulder).

Carpal tunnel syndrome

The wrist joint is made up of several carpus bones. These bones form a cavity – called carpal tunnel – in which many tendons, nerves and blood vessels pass. Carpal tunnel syndrome is an affliction of the nerves that get compressed, generally by the swelling of tendons passing nearby, in a limited space that constitutes the carpal tunnel. The affliction of the nerve leads to numbness and muscle weakness. Carpal tunnel syndrome is also unique in that it is more painful at night, when the swelling is at its peak. Victims are often awakened by the pain.

Fig. 1.9
Carpal tunnel



What is a WMSD?

- **WMSDs** may affect the different parts of the body associated with movement, we will limit our examination to disorders affecting the upper limbs.
- **WMSDs** are a major problem with serious consequences for workers, companies, and society in general. Experts believe that the situation could worsen with time.
- **WMSDs** result from overuse of the musculoskeletal system. They generally develop gradually. Prevention is an effective means of combating WMSDs, if action is taken early enough in the process.
- Certain symptoms of **WMSDs** may be considered early indicators, such as fatigue or pain associated with work. Aggravation of the symptoms over time is an alarm signal that must not be overlooked.
- **WMSDs** are sometimes called "itis" diseases. The most common WMSDs are tendonitis, tenosynovitis, bursitis and carpal tunnel syndrome.

Causes of WMSDs

As we have indicated already, WMSDs have multiple causes. Repetition, which is referred to most often, is not the only factor. For the purposes of this document, we will not look at factors related to non-professional life or individual characteristics that may play a role in the onset of WMSDs. We will focus our analysis on the risk factors present in the workplace, since they affect the vast majority of individuals, and the purpose of this guide is prevention at the workplace.

Many risk factors

The causes of WMSDs constitute a complex web of inter-related factors that exert their influence simultaneously. Hence, singling them out for individual description is not an easy task.

In this chapter, we will introduce several risk factors that will be described later. We will present them one by one, so that they are easier to grasp, but it should be understood that they are often intertwined. A case in point is the relationship between exerting force and posture. Both factors can contribute to the onset of WMSDs and also influence each other. For instance, a given posture determines musculoskeletal geometry and, depending on this geometry, the structures will be more or less well-positioned to generate a given force. Hence, a more or less strong effort will have to be made to exert the same force, according to the posture adopted. Conversely, having to make a more or less significant effort may lead a worker to change his or her posture.

Another example is the fact that monotony of work is considered in certain studies as a risk factor associated with WMSDs. Yet, the monotony and boredom generated by a task are often tied to its repetitive nature, which is certainly another risk factor.

What is a risk factor?

A risk factor is a condition present in the workplace, such as the requirement of a strong force, and whose presence has been associated with the onset of a health problem. The risk factor may be directly responsible for the appearance of a health problem, may act as a trigger or may create conditions conducive to the appearance of a problem. The presence of a risk factor does not mean that an exposed worker will automatically develop a health problem; it means that he will run a greater risk of developing it than someone who is not exposed. It is therefore a matter of probability. Likewise, when several workers are exposed to different risk factors, all will not react the same way. The effect caused by the risk factor depends on several conditions, including the workers' individual traits and occupational history. However, it is important to understand that, overall, the scope of the health problem depends on the severity of the risk factors present.

Three major modulators: intensity, frequency, duration

The mere presence of a risk factor is not enough to evaluate the risk. It is not a matter of being present or not, but a matter of degree. Generally speaking, the seriousness of a risk factor depends on three main characteristics: intensity (or amplitude), frequency and duration.

Intensity

Most of the time, the contribution of the intensity of a risk factor goes without saying: the more intense the risk factor (the greater the effort or extreme the posture), the higher the risk. However, there are times when the relationship is not that obvious. For example, saying that the complete and forced immobility of a body segment can contribute to the risk does not mean that its opposite – uninterrupted mobility – is desirable. The relationship here is a more complex one, where too little can be just as harmful as too much.

Frequency

Frequency refers to the number of times that a risk factor is present within a given time interval. Being exposed to vibrations twice a day is a lower risk factor than being exposed two hundred times per day. The risk therefore increases most of the time with the frequency*.

Duration

The third characteristic that affects the seriousness of risk factors is duration, a concept that has several meanings. It can be the amount of time spent in a given posture within a work cycle or the duration of the effort made within the cycle, such as the shoulder being flexed for 45 seconds in a two-minute cycle. The longer the time spent in the cycle, the higher the risk factor. Duration can also mean the number of hours in a work shift when a worker is exposed to a given risk. For example, doing repetitive work for 30 minutes does not have the same impact as when such work is done for the entire shift. Duration can also refer to a much broader scale. It this case, it may mean the number of years during which the worker has been exposed in his or her professional life. In all three cases, one simple principle generally stands out: risk is proportional to duration of exposure.

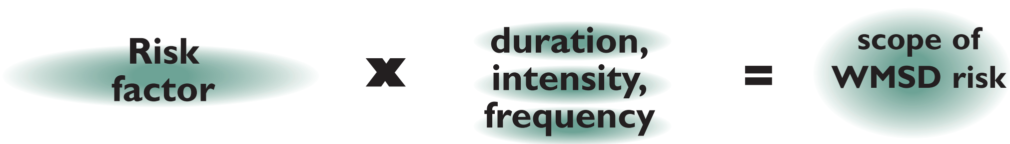


Fig. 2.1
These three elements are used to characterize most risk factors.

* This statement is, however, not etched in stone. Certain risk factors do not always have a linear relationship with the danger. For example, while considerable and frequent effort can constitute a risk, this does not mean that immobility and absence of effort are advisable. Nevertheless, when an effort is deemed to contribute to the risk through its intensity and frequency, reducing the frequency will always be a step in the right direction..

It is not always easy to recognize a risk factor. In scientific documents, the list can vary according to the author. We have selected six categories of risk factors which we will discuss in the following pages.

- Awkward postures
- Effort and force
- Static muscular work
- Exposure to certain physical aggressors
- Repetition and invariability of work
- Organizational factors

Awkward postures

Often, because of the characteristics of the workplace or the methods adopted, workers have to use awkward or demanding postures. Inadequate work posture can constitute a risk factor.

How can inadequate posture be recognized? For each joint, there is a basic posture that creates the least amount of constraints. This posture is usually far from the limits of the joint's range of motion; it requires little effort to maintain and does not put the anatomical structures in an unfavourable position. Conversely, posture can be inadequate for three types of reasons. It is extreme if it is near the limits of the joint's range of motion. Anyone can experience some discomfort if their wrist is fully flexed or extended. Posture can also be demanding if it can only be maintained by fighting against gravity. For example, the position where the arm is kept fully stretched in front of the body (shoulder flexion) is not extreme in that it is far from the limits of the joint's range of motion. However, having to fight against gravity makes this posture particularly demanding (see static muscular work on page 25). Finally, certain postures are risky because the anatomical structures are placed in a position where they cannot function effectively. For example, maintaining the arm above the shoulder makes blood flow difficult, thereby reducing muscle capacity. Moreover, in this posture, the tendon of a muscle is jammed between two bone masses, thus putting the muscle in a difficult position. The same applies to wrist tendons that can be compressed in a limited space when the wrist is flexed.

The pain caused by a posture will obviously depend on how far it is from a relaxed posture (this refers to amplitude of posture, which is about the equivalent of intensity of posture), the frequency with which this posture is adopted, and its duration.

The main postures for each of the joints are shown on the following pages.

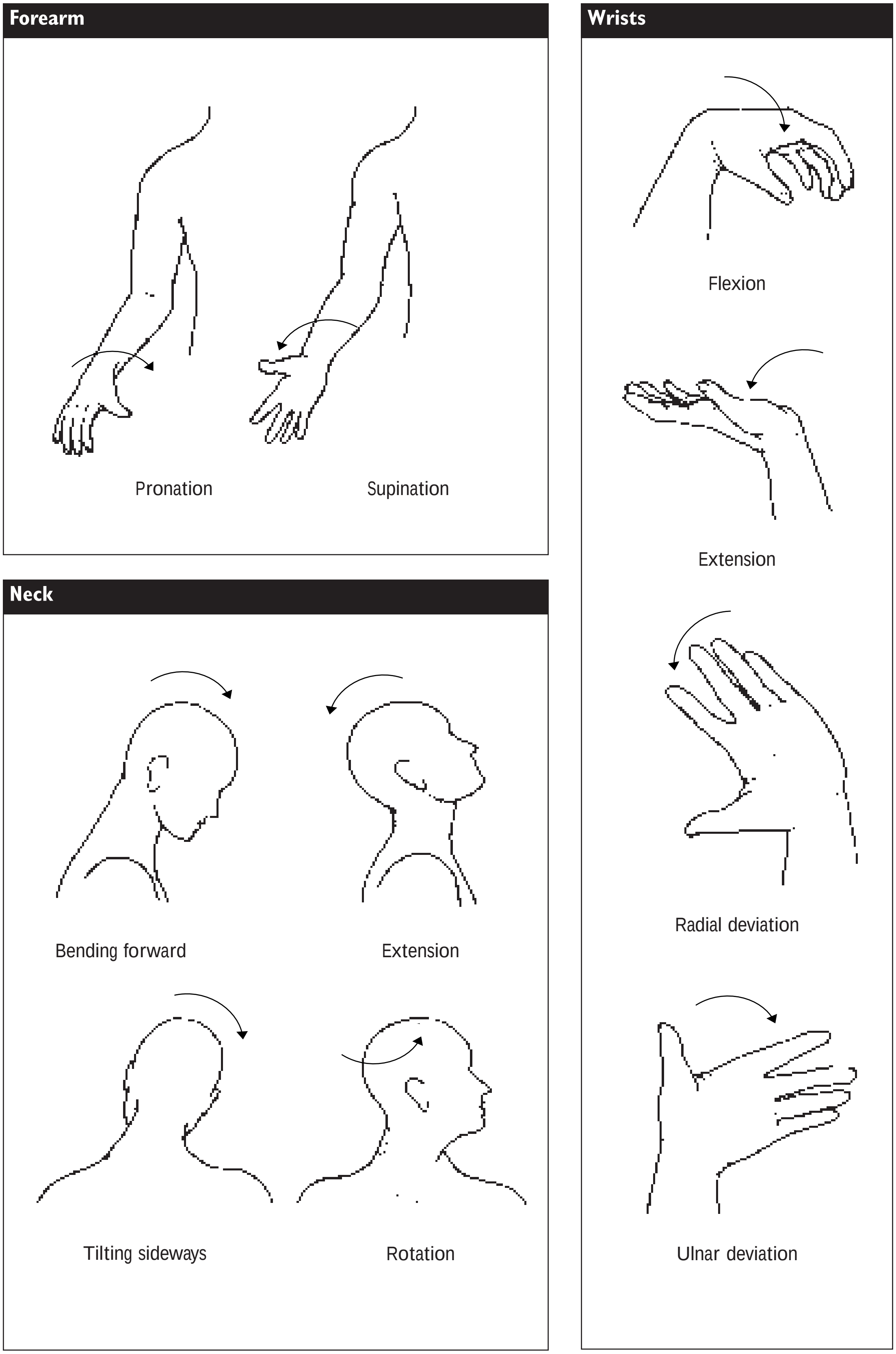
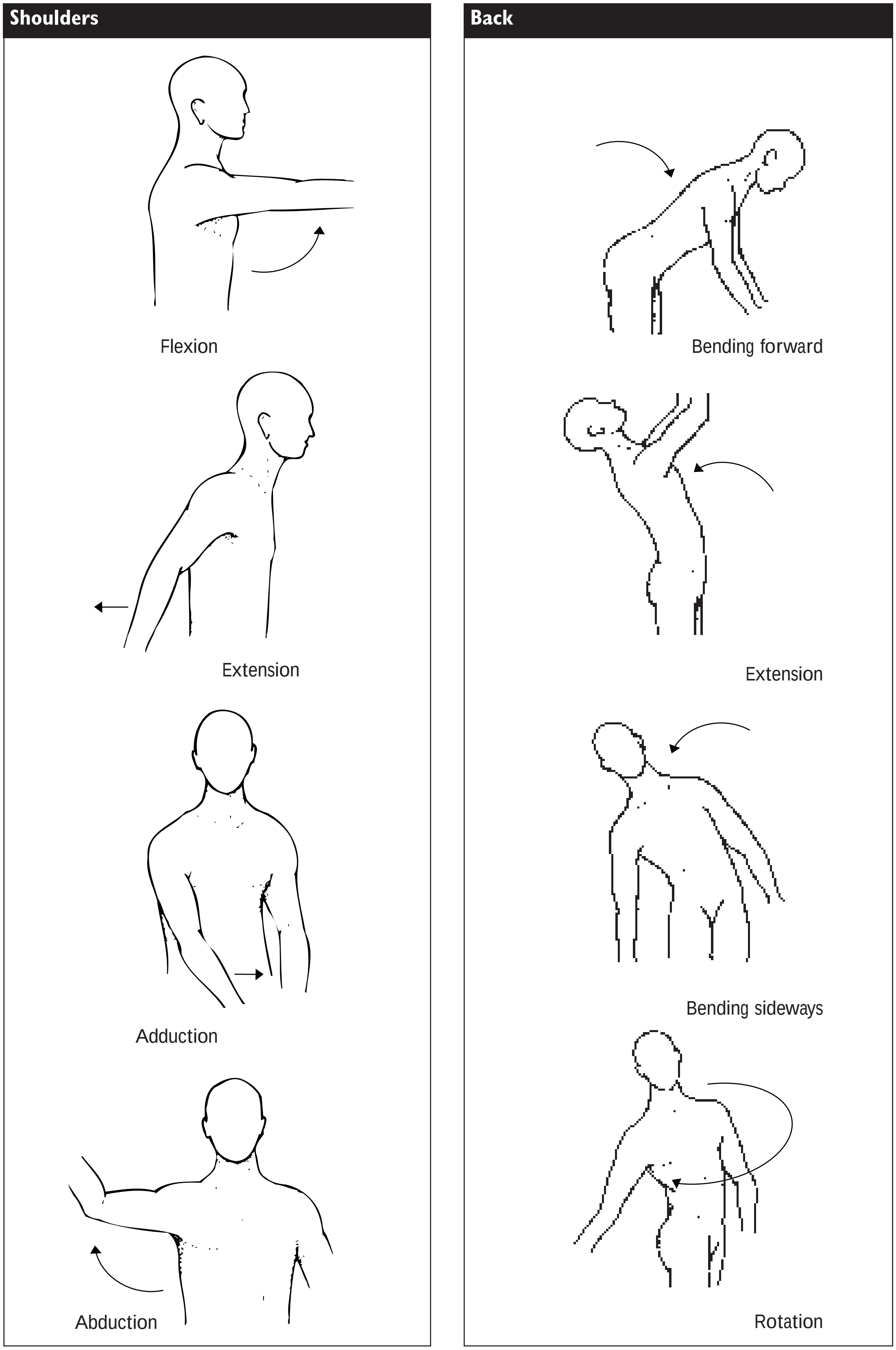


Fig. 2.2
Main postures

Fig 2.2 (cont'd)
Main postures



What determines posture?

Given that most awkward postures are uncomfortable, why are they so frequent? The answer is that the work posture adopted depends on the entire work context. Workers may sometimes adopt extreme postures because the material is poorly located, or because the work surface is not adequate (Fig. 2.3 and 2.4).

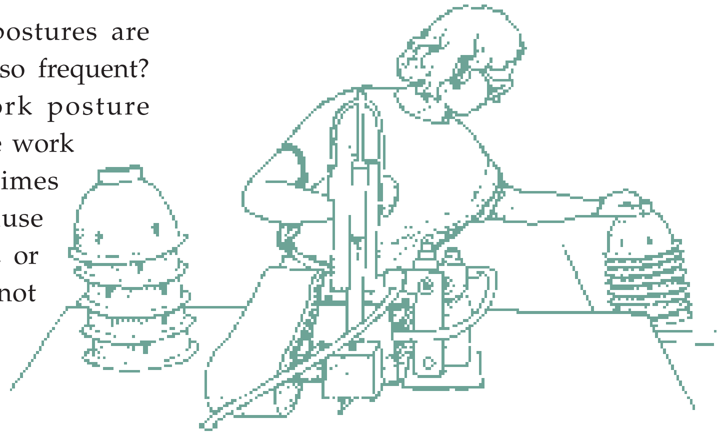


Fig. 2.3
Placing the reflectors behind the worker creates a demanding posture

Often, posture is determined by the shape of a tool and its conditions of use. Figure 2.5 shows a worker with a marked deviation of the wrist caused by the shape of the tool she is using. This tool is not adapted to work on a horizontal surface at this height. An awkward posture can also result from access to the product. The worker has no other choice but to adopt an awkward posture, given the shape and location of the product.

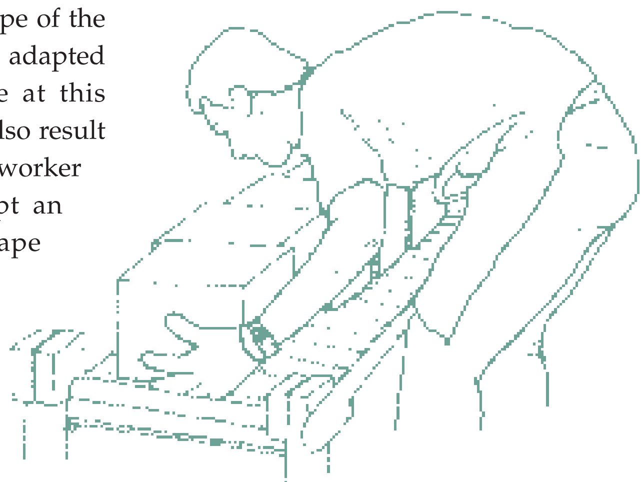


Fig. 2.4
The worker has to lean forward considerably to reach the boxes because the conveyor is too low.

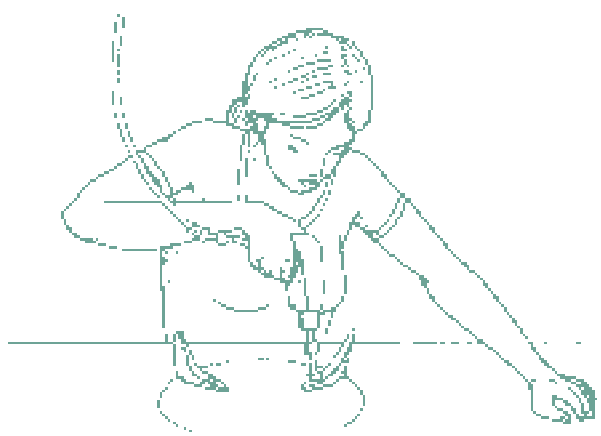


Fig. 2.5
The shape of the tool is not adapted for the work. Its use leads to ulnar deviation of the wrist

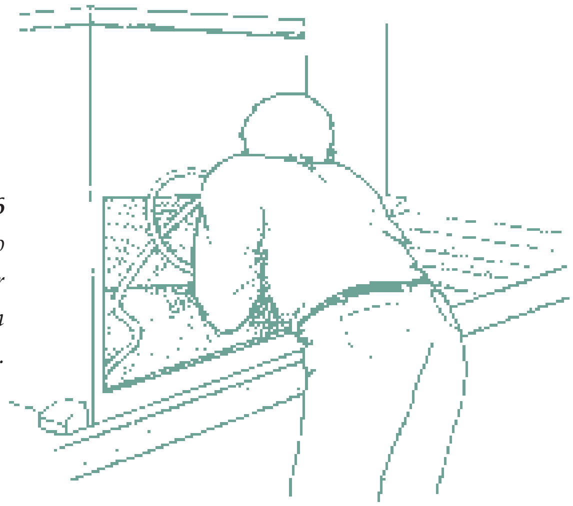
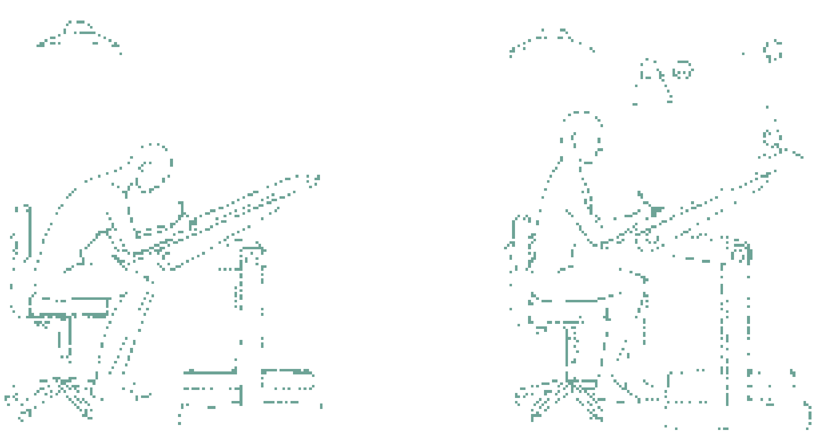


Fig. 2.6
Because of the access to the product, the worker is forced to adopt an awkward posture.

Figure 2.6 shows a worker installing a fan belt inside a dryer. The space available and the height of the product force the worker to adopt a constraining posture for his back and arms.

Work posture can also be determined by environmental conditions, such as congestion or insufficient lighting. In fact, when visibility is poor, the worker must often bend his neck and back forward to see better (Fig. 2.7).

Fig. 2.7
Insufficient lighting forces the worker to bend forward in order to see better. Adequate lighting corrects the posture



Force, effort and musculoskeletal load

Force is a complex notion to define. Something can be referred to as force or effort, depending on the point of view adopted. In fact, it really boils down to the forces exerted on musculoskeletal structures, whether it is the tension of a muscle, stretching of a tendon, intramuscular pressure, or friction of a tendon in its sheath. This is referred to as musculoskeletal load.

Everyday language is not very precise when it says that some force is required to accomplish a given task. Does this refer to the force applied (one that can be measured), or to the fact that it requires a more or less significant effort? It is useful to clearly distinguish between force and effort. When we talk about force in this document, we mean the force generated by a musculoskeletal system to be applied on the external environment. This is applied force that can be measured.

It should be noted, however, that exerting a 20 kg force to move a box, for example, can require more or less significant effort, depending on the individual, his or her posture, and many other factors. Applying the same force can require more or less significant effort according to the circumstances. Effort is more like the cost that the body has to pay to exert a force.

Whether it is estimated from the outside by measuring applied force, or whether the cost for the individual based on the effort made is considered, the risk will always be proportional to the load that the tissues must endure.

Characteristics of work requiring force

The word "force" immediately conjures images of the handling of heavy objects. It is, of course, a situation that requires considerable effort, but there are many other situations that require the use of force. For example, when using manual tools, it is often necessary to make an effort, if only to support the tool. Often, pneumatic tools are not suspended, and the retaining system is poorly adjusted. In these cases, the worker must support some of the load of the tool when handling the object.

Force may also be exerted when working with a tool on a product, such as when bending an object with pliers. Using a pneumatic or electric screwdriver requires effort by the forearm to immobilize the tool and to apply pressure on the head of the screw. A poorly adjusted tool with inadequate torque, for example, can also require additional effort.

Assembling pieces, even without a tool, can mean exerting force. If the basic materials are of uneven quality, if the product does not fully comply with specifications, the pieces may not fit together properly, forcing the worker to apply considerable force. In the example in figure 2.8, the worker has to attach a reflector to a deflector. This operation is painful and demands considerable effort. The situation is made worse by the fact that the work is performed in a less-than-optimal posture.

Finally, force may be exerted when activating the command to lower a lever or to activate a pedal, for example.

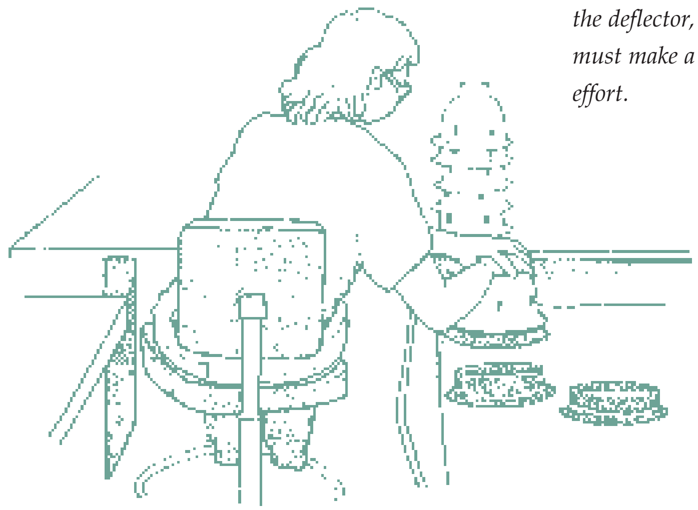


Fig. 2.8
To attach the reflector to the deflector, the worker must make a significant effort.

Factors affecting intensity of effort

The effort required to generate external force or, as we have defined it, the cost for the body to exert force, depends on six factors: intensity of force required, joint involved, direction of effort, grip, posture used, and individual traits. Let us examine the effects of these different factors.

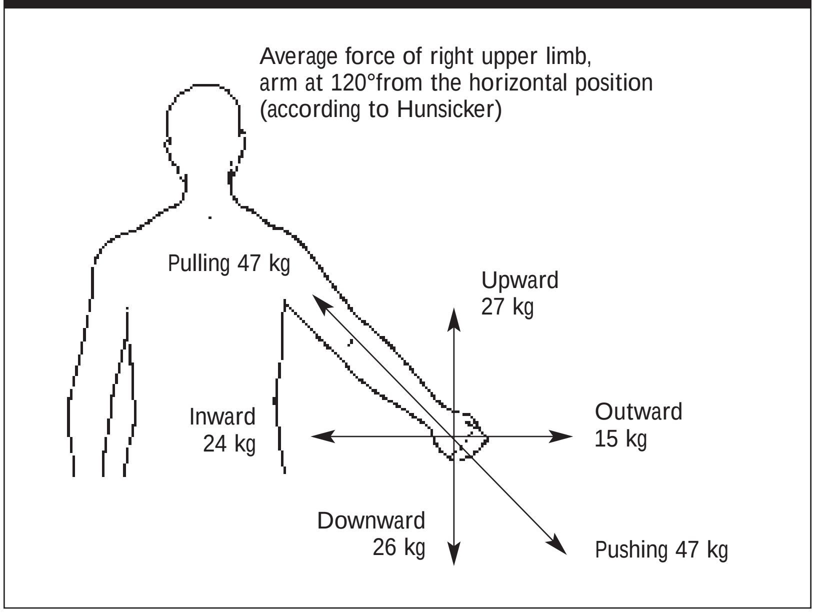
Intensity of force required
This relationship is fairly obvious: the greater the force requirements, the greater the effort to be made. The efforts made are directly proportional to the force that should be applied. A greater effort is required to move a 50 kg container than a 10 kg container. The physiological cost will therefore vary accordingly.

Joint involved

Force is easier or harder to generate, depending on the group of muscles used. If major muscles such as those of the lower limbs are used, or if the weight of the body can be used, it would be easier to apply a given force because these muscles are powerful. However, if the force is to be generated by smaller muscles such as those of the hand, the effort required would be greater. For this reason, even if the forces applied are not particularly significant, there may still be a considerable risk if the effort is made by small muscles. An example would be assembling small parts or connecting terminals using the finger tips.

Fig. 2.9

Effort depends on direction

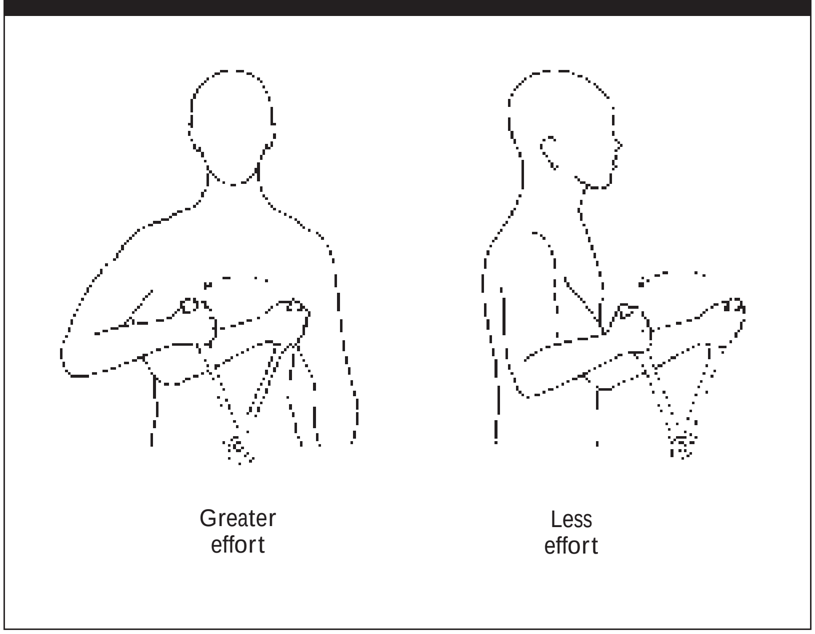


Direction of effort

The same group of muscles can produce a different maximum force, depending on the direction of effort. This is because the geometry of internal structures varies with direction. Figure 2.9, for example, shows that the arm is much stronger for pulling or pushing than for abducting (outward movement) or adducting (inward movement). Hence, applying 20 kg on a torque wrench requires less effort if the worker pulls inward than if the worker has to force from left to right (Fig. 2.10).

Fig. 2.10

More effective effort



Grip

Effort is also affected by the quality of the grip on the object, beginning with the nature of the grip. Basically, there are two main types of grip: power grip and pinch grip (Fig. 2.11). The power grip is an encompassing grip that involves the palm and all the fingers; it is the most powerful and most appropriate grip for exerting force. With a pinch grip, the object handled cannot be encompassed, hence less force is generated. The only difference between the two illustrations in figure 2.12 is the nature of the grip. It is obvious that the pinch grip, which is less effective for exerting force, is much more demanding and requires much greater muscle effort as compensation. The hand is quite simply "poorly used".

The existence of handles reduces the effort considerably by allowing the worker to use a power grip.

A similar situation occurs each time a worker uses a pinch grip to exert force. This happens, for example, when wires have to be connected by inserting a terminal onto a metal connector (Fig. 2.13). Depending on the compatibility of the two pieces, the insertion effort can be considerable, albeit only in relative terms, since it is a pinching effort using the finger tips.

More generally, the quality of the grip should also be considered. The grip of the object to be held or on which a force is applied can be too small or too big. These are circumstances that would add to the effort. Wearing gloves can also increase the grip effort to compensate for a loss in adherence. The effort generated is also affected by other factors related to the object handled. For instance, a greater effort is required to handle an object with a slippery surface or an awkward shape that makes it difficult to grip properly.

Grips

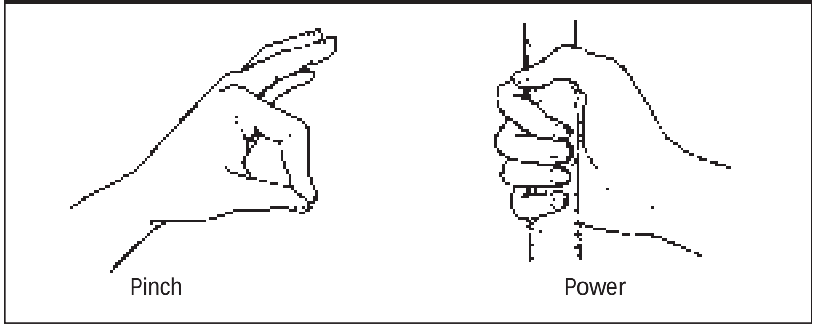


Fig. 2.11

Effort depends on grip

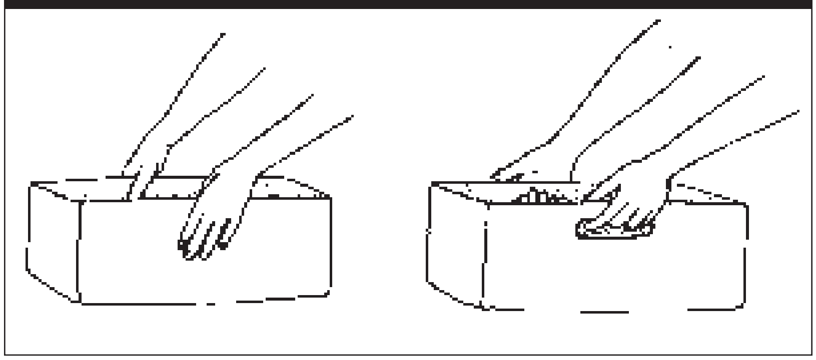


Fig. 2.12

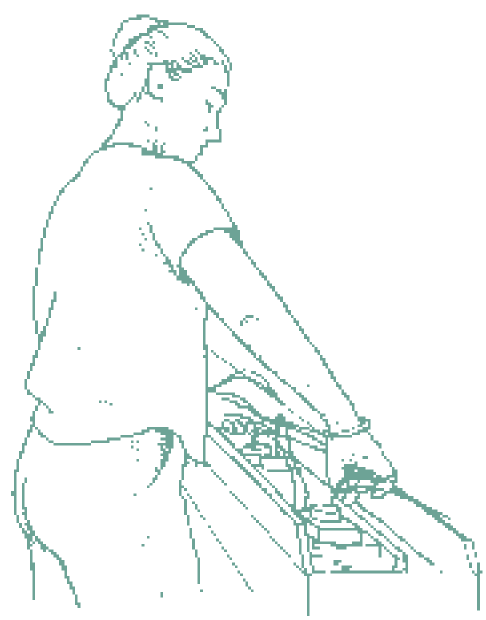


Fig. 2.13
This worker uses a pinch grip to connect wires.

Posture

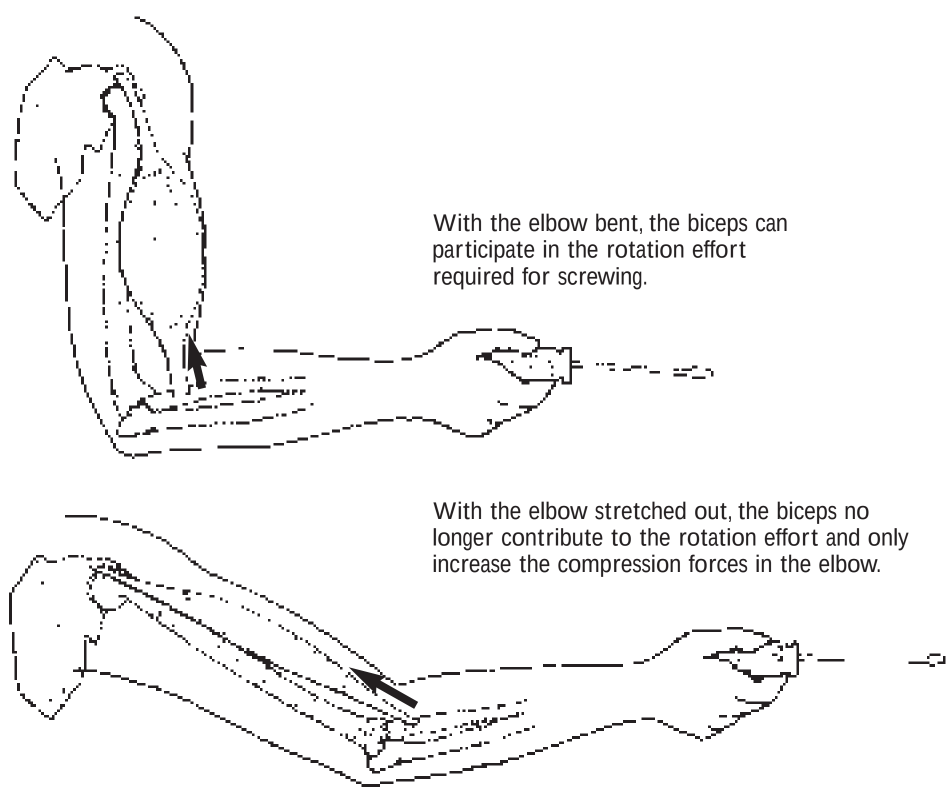
The posture adopted when generating force also affects the effort to be made. This concept can be understood through a simple analogy with arm wrestling. The best way to overcome your opponent is to "break his wrist". When fully extended, the wrist is not in a good position to exert force. Another example is given in figure 2.14. This time, the action of screwing is compared under two conditions: with the elbow bent and with the elbow extended. This activity will be much more demanding with an extended elbow because, in this posture, the biceps cannot contribute to the effort.

Individual traits

Force is frequently expressed with reference to the maximum force that an individual can exert. For example, pushing 20 kg in a certain posture can represent 40 percent of an individual's maximum capacity, while the same task can represent only 15 percent of a stronger and more muscular person's maximum capacity. The cost of such effort differs from person to person. Hence, it could be tempting to conclude that a stronger person would be less at risk than a weaker person. However, such a conclusion would be misleading. Indeed, although applying a given force requires more effort for a less muscular person, it

Fig. 2.14

Effort depends on posture



does not follow automatically that such a person faces a higher risk. Risk depends on a multitude of factors, including various personal traits, such that the same person with less muscular capacity would perhaps be more resistant than a more muscular person. In conclusion, it can be stated that risk varies from person to person, due to interpersonal differences. In addition, the effort associated with a given force will depend on individual characteristics.

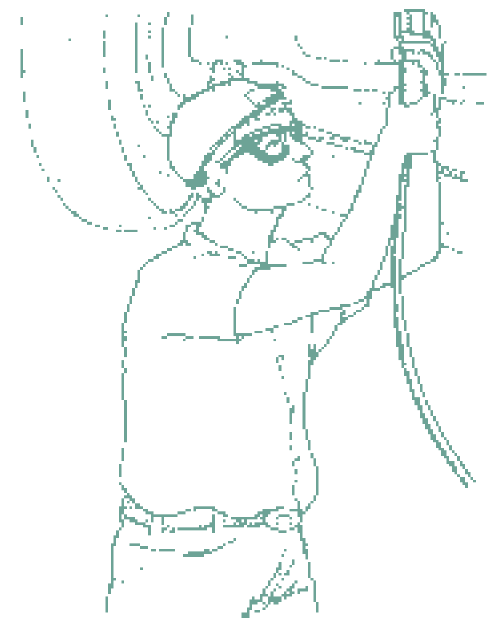


Fig. 2.15
Static effort with the arms above the shoulder is particularly painful.

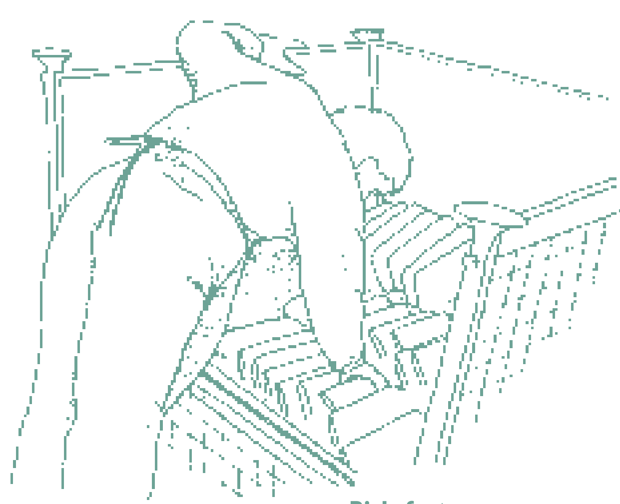
Static muscular work

As was stated earlier, a risk exists when a limb has to be kept in position by fighting against gravity, when the musculoskeletal structures must support the weight of a limb. This is the case, for example, when working with the arms above the shoulders. Such a situation is described as static muscular work. The intensity of the risk depends on the amplitude and duration of the posture. The longer the posture is maintained, the higher the risk.

Static muscular work involves keeping the muscles contracted without interruption. It is the opposite of dynamic muscular work, which refers to an alternation between contraction and relaxation. There are numerous examples of static work in industries as well as in offices. A case in point is a person who works with a video display terminal (VDT) and who remains stationary, the neck bent forward and the hands maintained in radial deviation above the keyboard. Also, due to poor design, an operator may be forced to work with the arms above the shoulders (Fig. 2.15). Such a posture cannot be maintained for long without causing significant muscle fatigue. Figure 2.16 shows a worker carefully putting pieces in a basket. To do this, his back has to be extremely flexed for a fairly long time; this static load requires great effort by the back muscles.

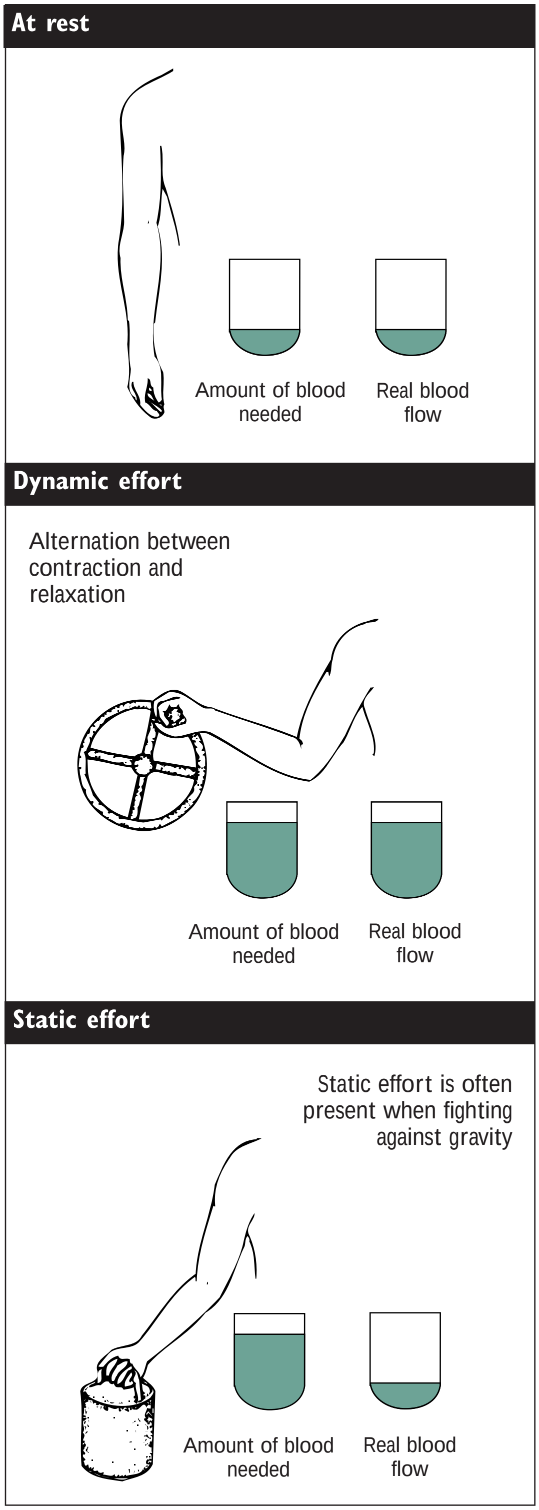
If the posture is maintained for a long time, the risk can be considerable, even if the amplitude of the posture is not extreme.

Fig. 2.16
This task causes the back to lean forward



Static work is identified as a risk factor for WMSDs because it can reduce the supply of blood to the muscles, which rapidly leads to muscle fatigue.

Fig. 2.17
Static Muscular Work



As figure 2.17 shows, to function normally, the muscles need adequate blood supply. It is the blood that provides the muscles with oxygen and glucose, its main source of energy. It is also the blood that evacuates combustion waste (carbon dioxide).

The muscle requires more blood when it is working than when it is resting. In the case of dynamic effort, when there is alternation between contraction and relaxation of the muscle, the active muscle needs more fuel. It is relatively easy to increase the blood flow, since the contraction and relaxation alternation facilitates circulation. The muscle then receives sufficient blood supply.

The situation is different during static effort. In this case, the muscle contraction is sustained and there is no alternation between contraction and relaxation. Since the muscle is working harder, it needs more energy. But, during contraction, the pressure inside the muscle increases, thereby compressing the blood vessels, which impedes the entrance of new blood. Indeed, it is more difficult to push blood into a contracted muscle. If the contraction is strong enough, the entrance of blood could be blocked completely. Whether the entrance of blood is blocked partially or completely, the muscle must still work in unfavourable conditions where fatigue sets in much more rapidly.

Compression inside the muscle is related to the intensity of effort required to maintain a posture. The more extreme the posture, the stronger the contraction and the lower the blood supply to the muscle.

Likewise, if force has to be exerted or a load has to be carried with static work, the scope of the load will increase the pain related to the work proportionately.

Is my work repetitive?

This is a question that you have probably been asking yourself for some time now, without getting a definitive answer. If only someone could define exactly what is meant by repetitive work! If someone could give a clear definition to help distinguish between repetitive and non-repetitive work! Despite our desire to please the reader, such an answer does not exist. There is no clear boundary between the two concepts. It is generally agreed that the problem revolves around the cyclical use of the same tissues.

In fact, talking about repetitive work can be misleading, because repetition is only one of the risk factors for "itis" diseases. Repetitiveness is a matter of degree; it is not something that is present or absent. Even though it has already been suggested, for the purposes of a specific study, that work be considered repetitive if its cycle is less than 30 seconds or if it represents a repetition of the same actions during half of the work time, this in no way constitutes an absolute reference or a safety criterion. It is easy to imagine work that does not meet this definition but constitutes a major WMSD risk, due to the posture or effort required. Conversely, the fact that the cycle is less than 30 seconds does not necessarily mean that a danger is imminent.

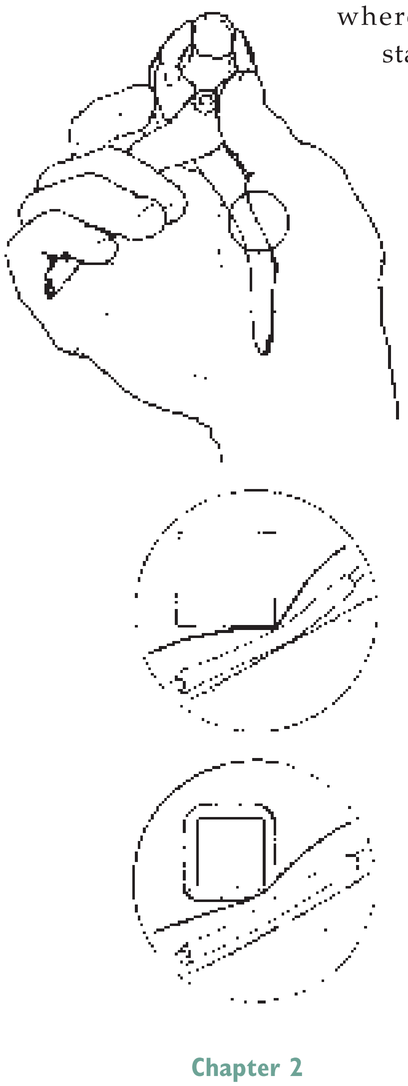
The label repetitive work can also mask the real problem by shifting the focus to just the issue of repetitiveness. It is thought that the problems are caused by the repetitive nature of the task and that the only possible solution is to reduce the repetition, something that can be very difficult to accomplish. In the mean time, no thought is given to improving postures or reducing effort.

Instead of trying to prove whether a work process is "repetitive" or not, it is preferable to identify all the risk factors present. This means determining the extent to which the work is repetitive, along with other factors, in order to obtain a much clearer picture of the risk.

Repetition and invariability of work

While repetition is itself a risk factor, it is also a modulator for the other risk factors. In this regard, repetition creates a multiplier effect. Invariability of work refers to an activity that remains relatively unchanged over time; hence this concept is closely associated with repetition. In both cases, the risk increases when the same musculoskeletal structures are solicited all the time. However, considering the task from the standpoint of invariability shows the importance of the moments, during the work process, when the structures can recover. Monotonous tasks, where the worker remains stationary because of the requirements, seem to present a higher risk of WMSD.

Fig. 2.18
A poorly designed grip can compress the tendons at the base of the thumb



Exposure to certain physical aggressors

Certain environmental features can also contribute to the risk of WMSDs. For example, exposure to cold, vibrations, impacts and mechanical pressures has been associated with WMSDs.

Mechanical pressures

Mechanical pressures occur when the soft tissues of the body are "crushed" by direct contact with a hard object present in the work environment. The skin and underlying structures such as nerves, tendons and blood vessels can be injured by this direct pressure. The hands are most often exposed to mechanical pressures when handling tools or products. If the objects have sharp edges, or if a handle has right angles, the palm, the base of the thumb or the fingers can be subjected to strong local pressures. Figure 2.18 shows how using pliers can compress a tendon at the base of the thumb. Another scenario is where scissors can compress the nerves running along the sides of the fingers.

Other regions of the body can be subjected to local pressures when using hard surfaces or unpadded surfaces for support during work. This happens with the wrists, forearms, elbows and knees.

The effects of mechanical pressures obviously depend, like most other risk factors, on the frequency, duration and intensity of the pressure. The latter factor is in turn often associated with intensity of effort. Indeed, everyone has a good idea of the difference that may exist between cutting a thin fabric with scissors and cutting a thick fabric. The pressures exerted on the fingers become uncomfortable very quickly as the force required for cutting increases.

Shocks and impacts

It has been shown that using the hand as a striking tool can increase the risk of certain vascular disorders in the hand. Figure 2.19 shows a worker trying to hammer a part into place with his hand. The danger obviously increases with repetition.

Tissues are generally subjected to a tremendous ordeal when holding a tool that generates a sudden and intense jolt. This is probably what happens when using a percussion tool or when turning a screw with a pneumatic or electric tool. Unless the device has a clutch, the screw driver tends to continue turning after the screw has stopped. It is the forearm muscles and tendons that feel the effect. The risk also increases because a greater effort is generally required to properly hold a tool that generates jolts.

Fig. 2.19
Using the hand as a hammer

Certain efforts to counter the effect of vibrations can sometimes add to the problem. An example is wearing certain types of gloves covered with absorbent materials. The goal is to absorb the vibrations before they reach the hand, but the tool often has to be held tighter to keep it in position, thereby increasing the muscular effort and facilitating the transmission of vibrations. Coverings can also be used on tool handles to limit the transmission of vibrations. However, the advantage is less clear if the handle is so big that it is difficult to grip.

Vibrations

It is generally when handling electric or pneumatic tools that workers are exposed to the type of vibrations that constitute a WMSD risk for the upper limbs. The stronger the grip, the better the transmission of vibration to the hand and forearm. Exposure to vibrations can contribute to the onset of vascular disorders such as white fingers syndrome, neurological problems such as carpal tunnel syndrome, and joint disorders of the wrist, elbow and shoulder, such as osteoarthritis. It also adds to the musculoskeletal load, because the tendons suffer the effects of vibrations directly, not to mention the fact that a vibrating tool often needs to be held with greater force.

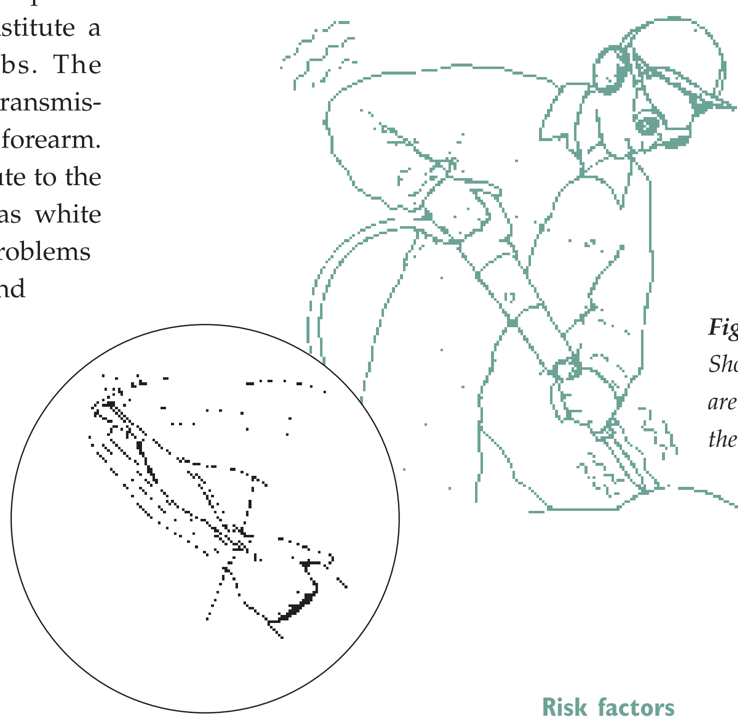


Fig. 2.20
Shocks and vibrations are very hard on the tendons

STATE OF LABOUR RELATIONS
PACE
METHOD OF REMUNERATION
TYPE OF SUPERVISION
WORKING ALONE
WORKING IN A TEAM
WORK CLIMATE
QUALITY OF INTERPERSONAL RELATIONS
WORK SCHEDULE

Fig. 2.21 *Work organization is also a source of risk factors*

Cold

Cold is also a risk factor that can contribute to the development of WMSDs. It can act directly by increasing the musculoskeletal load on the upper limbs. It is well known that cold reduces the dexterity and strength of the hands for manual work; doing the same work is therefore more demanding under cold conditions. It is difficult to distinguish this direct effect of cold from the effect of wearing gloves because of the cold. Indeed, gloves can reduce the grip force and impede the transmission of tactile information, which forces the worker to tighten his grip even more – often more than necessary – in order to hold a tool or an object. It has also been observed that muscular tension rises around the shoulders among workers exposed to a current of fresh air on the shoulders, no doubt due to the stooped posture they adopt instinctively to protect themselves in such circumstances.

Organizational factors

Work organization encompasses another set of factors that determine the risk of work-related injuries. It refers to all the determinants of the terms and conditions of a work process. Organizational factors can themselves be risk factors for WMSDs, but they are also very important because they largely determine the other risk factors we have already mentioned.

Risk factors related to work organization have a complex effect on the risk of WMSD and one that is not always easy to identify clearly. It is reasonable to assume that organizing work around autonomous units rather than on an assembly line would have all sorts of consequences on working conditions, and hence on the postures and methods adopted at each work station. Indeed, work organization largely determines the intensity of the other risk factors such as posture, effort and repetition. As a result, the type of work schedule, working alone or in a team, method of remuneration, type of supervision, and the state of labour relations are all parameters that can affect the risk of WMSDs at one point or another. Simply changing supplier for a given component can lead to an increase in the effort required for its installation.

The effect of work organization on the risk of WMSD is not only due to the fact that organization ultimately determines the conditions for executing a particular task. Work pace, especially if it is imposed, method of remuneration, work climate and quality of interpersonal relations can also affect the risk of WMSD by generating more or less stress. Stress is both a physiological and a psychological state. When working in a tense or stressful environment, there is an increase in muscular tension that can contribute directly to musculoskeletal load. In addition, behaviour can be changed, for example, by adopting a different work method to meet increased production requirements, perhaps at the expense of safety or comfort.

It is impossible here to present all the characteristics of work organization that can have an impact on the risk of WMSD, either by generating stress or by influencing the scope of other risk factors. We will nevertheless present a few that merit discussion.

Work load and work pace

Work load is a risk factor when the amount of work requested is too heavy. Speed of execution, intensity of effort and lack of recovery time are generally associated with an extremely heavy work load. In addition, when the pace is imposed by a machine, workers usually cannot adjust their pace of work throughout the work day or week according to their state or level of fatigue. It is recognized that a work pace controlled by external factors is more constraining than one that is not imposed. Apart from the risk factors that are often present when a pace is imposed, such as a heavy work load, a high rate of repetitiveness and strong psychological pressure, workers characteristically have little decision-making leeway. Yet, the lack of control that workers have over their work has a significant impact on the tension that they can feel and is considered a major factor for the onset of WMSDs.

Work pace is obviously affected by other factors associated with work organization, such as method of remuneration. For example, piecework pay and other forms of performance-based salaries lead workers to push themselves to the limits of their physical capacity. It has been observed in sewing shops that sewing machine operators paid for performance suffer from WMSDs nine times more than those paid by the hour*.

Work schedules

Work schedules can affect the level of risk of WMSDs because they can extend the duration of the work day, which constitutes an increase in work load. Schedules also represent a stress factor (night shifts, for example), which can shorten the periods of rest needed for recovery.

When the amount of work accomplished is significant, the musculoskeletal load stems not just from the sustained work process, but also from the absence or reduction of recovery time. Breaks during the shift are very important to allow the muscles to rest between work periods. For example, three 10-minute breaks may be more effective, in terms of recovery, than a work day shortened by 30 minutes.

Overtime and 12-hour shifts affect the musculoskeletal load by extending the work process and exposure to risk factors already present in the workplace. In these cases, the rest period is also reduced. Finally, shift work also increases the general level of fatigue and stress.

* Vézina, M., Vinet, A., Brisson, C. « *Le vieillissement prématuré associé à la rémunération au rendement dans l'industrie du vêtement* », Travail humain, vol. 52, n0 3, 1989, p.202-212.

Technological changes
It is difficult to predict all the consequences of the technological choices made today. New technologies sometimes create new problems concerning the musculoskeletal load. Who could have predicted 10 years ago that working in front of a computer screen would cause such an epidemic of musculoskeletal problems? It seemed much easier to use a computer keyboard than the old typing machines. Few people had anticipated that the nature of the task would change and that new problems would emerge. It is therefore crucial to remain alert with regard to the impact of new technologies.

Any time there is a major change in production method, the possible impacts on work processes should be analyzed. Will workers have to acquire new skills? Will work be easier or more demanding? What would be the impact on work postures, on efforts to be made, and on work pace?

Social environment
The social environment can be a major source of motivation, but also a source of concern and stress.

The climate can contribute even more directly to the risk of WMSD if it prevents the expression of musculoskeletal problems experienced when executing a task. In an environment where workers can feel blamed or accused if they complain about discomfort or pain, they may tend to wait until the last minute to report a musculoskeletal problem. The consequences then are more serious. An environment that fosters expression and communication will also benefit from the workers' expertise in implementing a continuous improvement process for work situations.

Causes of WMSDs

- **WMSDs** are a complex phenomenon. Several risk factors interacting with one another contribute to their development. Repetitiveness is not the only factor.

- **A risk factor** is a condition present in the workplace that is associated with the onset of a health problem. The presence of a risk factor does not automatically lead to a WMSD; it is a matter of probability. This is why it is normal, because of individual differences, for workers to be affected differently.

Synopsis of risk factors

Risk factors		Modulators		
Awkward postures Effort and force Static muscular work Repetition Invariability of work Shocks and impacts Mechanical pressures Vibrations Cold Organizational factors	X	Intensity, duration, frequency	=	**Risk of WMSD**

How to detect a WMSD problem

It is certainly very useful to know what WMSDs are, as well as their possible risk factors. However, this knowledge must be applied concretely when answering the following question: does the problem exist at our facility, in this plant, or in this department? Before taking action, and in order to determine the amount of resources to be devoted to the issue, it is essential to understand the scope of the problem in the workplace. This can be achieved through a set of measures designed to document the existence of an occupational health problem. These measures constitute what is known as monitoring.

Monitoring: two possible targets

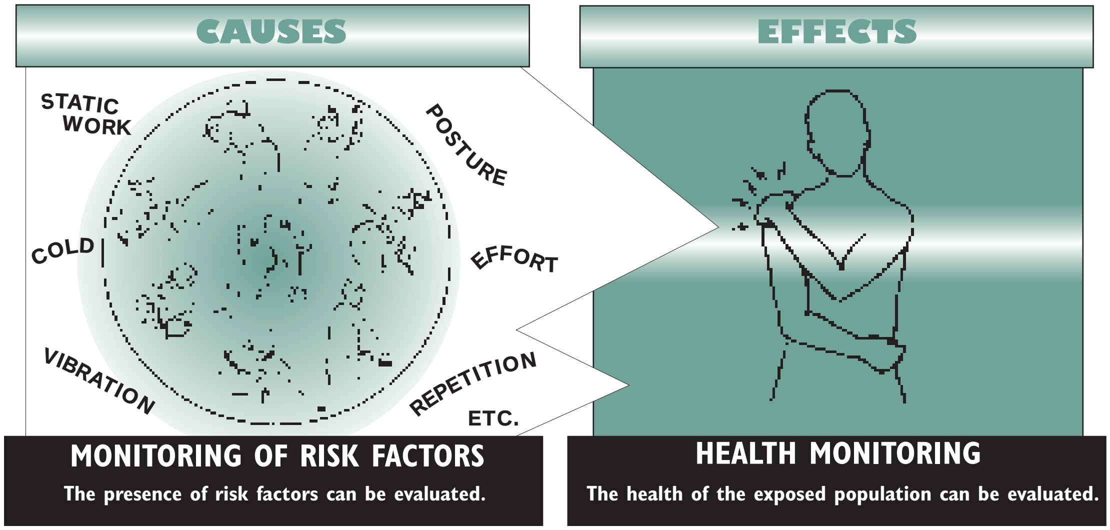
The data on the problem are now known: certain working conditions have been identified as risk factors, namely, effort, posture, repetition, etc. The presence of these risk factors can lead to the development of WMSDs, preceded by signs such as pain, discomfort and localized fatigue. In short, certain working conditions have an effect on health. To evaluate the presence of this problem in a workplace, two options are worth exploring: evaluation of the health status of the exposed population, and evaluation of the risk factors.

Health monitoring

Health monitoring is certainly very effective in detecting WMSD problems. There is, indeed, no better proof of the existence of a problem that to observe its effects. The data most frequently used in this regard are those related to CSST claims, but they are not the only ones that can be consulted.

Most WMSDs do not really stem from an accident, yet when reported, they are often counted as work-related accidents. It is important, therefore, to analyze accident

Fig. 3.1



data in order to detect musculoskeletal disorders that affect the upper limbs, in addition to any possible "itis" injuries that have been reported as occupational diseases. Obviously, the number of WMSDs occurring during a given period can be counted and compared against the total number of accidents and diseases occurring during the same period. This gives the proportion of WMSDs in relation to total injuries. Yet, it is still more useful to evaluate the number of days lost due to WMSDs, which gives a better indication of the contribution of WMSDs to workmen's compensation. Indeed, WMSDs often account for a low proportion of accidents as opposed to cuts and contusions. However, when the duration of absences and the proportion of the costs incurred are taken into account, WMSDs figure more prominently most of the time.

It should be noted, though, that WMSDs that are compensated are often only the tip of the iceberg. The impact of WMSDs is not only felt on claims for work-related injuries, but also on general absenteeism. Hence, a number of WMSDs are not reported as work-related accidents, resulting in a relatively large number of absences being recorded by the company's health insurance plan.

This raises the question as to whether someone who has to undergo wrist surgery is a victim of a WMSD even though the link with work has not been established. The effect of the "tip of the iceberg" can also be seen in the fact that, for every one person who is the victim of a recognized WMSD, there are many others who have less serious symptoms that can nevertheless lead to an absence.

Finally, workers sometimes complain about feeling pain or discomfort that they associate with their work. In certain companies, these complaints and episodes of discomfort are noted. This is another indicator that can shed some light on the problems that produce WMSDs.

The data that we have referred to so far (statistics on accidents, absenteeism, complaints) are those usually found in companies and that generally suffice to establish that there is a WMSD problem. If the data are non-existent, it is important to establish measures through which they can be collected.

Nevertheless, it is possible to go further, if necessary. One method frequently used is a pain questionnaire. These are fairly simple questionnaires with diagrams of the human body on which workers indicate the regions where they feel pain (Fig. 3.2). The questionnaires are used to gather information before people even feel obliged to report their discomfort. It is also possible to obtain indications on the seriousness of the ailments: intensity and frequency, consequences on work life and leisure, taking of medication, absence from work, etc.

Another possibility is medical screening, notably by clinical examinations to show reduced force of grip or limitations in amplitude of movement. Obviously, these measures usually require help from specialists or health professionals.

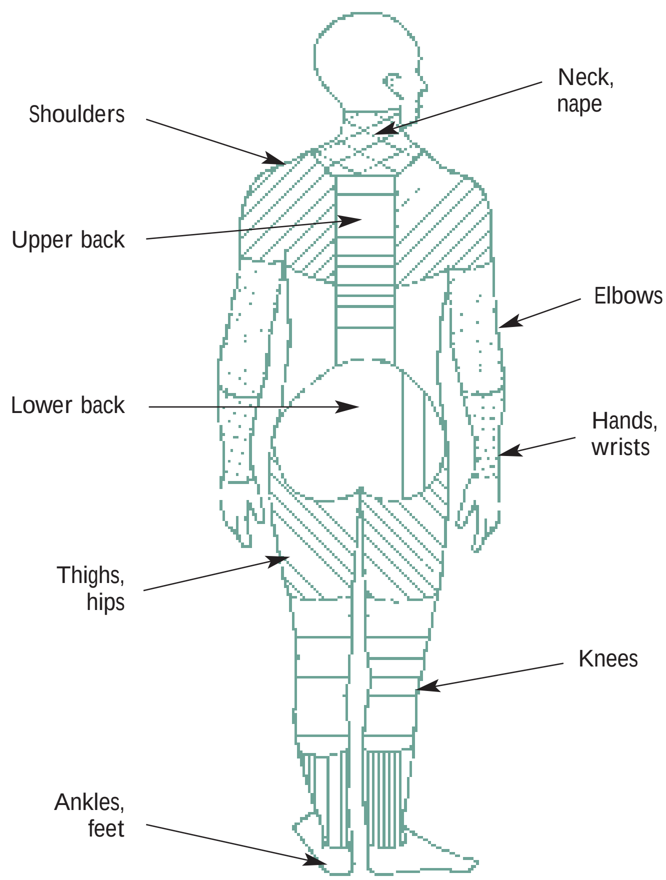
Likewise, a high rate of employee turnover at a given station or average seniority below that of the rest of the plant are often pain indicators. This may be associated with other risk factors unrelated to WMSDs, but the question clearly deserves to be studied.

Additional information on risk factors can also be sought more actively, if the available data are not sufficient. This could be achieved by carrying out inspections using evaluation grids or check lists, keeping records of the various stations, and conducting analyses. However, these tasks are not always easy and it is often profitable to have them performed by an ergonomist.

Monitoring of risk factors

To establish the existence of a WMSD problem, it is also important to evaluate the working conditions in order to document the presence of risk factors that are known causes of WMSDs. There too, the process may begin by consulting the existing data. But, most often, companies do not have direct data on the presence of risk factors at the workplace. The situation gets further complicated because certain risk factors are so "normal" that their presence alone is no longer considered proof of the existence of a risk. Merely noting that work cycles are less than 15 seconds does not always seem to be sufficient to establish the WMSD risk. The comparison between different work stations is sometimes more "eloquent". In this regard, workers' complaints about their work are often good indicators. If they report that a work station is "too hard on the shoulder", they are no doubt reporting, in their own words, that WMSD risk factors are present.

Fig. 3.2
Body chart



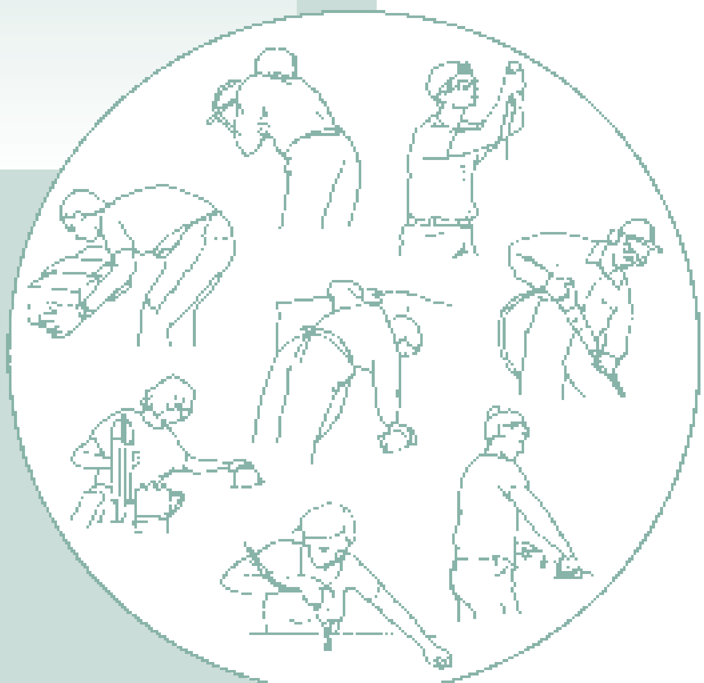
Monitoring to evaluate the efficacy of an action

The first time that the question of monitoring arises is when trying to determine whether the situation requires intervention or when documenting the need to take action. But monitoring is always useful and should be part of a regular prevention program. It helps keep track of the situation and evaluate the impact of measures taken. Once certain data have been identified as constituting a valid indicator of the situation, such as statistics on accidents, the number of complaints or force requirements, attention can then shift to how these indicators evolve over time. Effective preventive actions will help improve these indicators. It should be noted, of course, that just as WMSDs develop gradually, preventive actions can also take time to produce concrete results.

How to detect a WMSD problem

The presence of risk factors must be evaluated **and** The health of the affected population must be evaluated

	CAUSES	EFFECTS
	Monitoring of risk factors	Health monitoring
AVAILABLE DATA	• Complaints or reports from workers • Certain indirect indicators such as turnover per work station	• Data on CSST claims • Ailments reported by workers
TO GO FURTHER	• Inspection • Evaluation grids • Work analysis	• Symptoms survey • Medical examinations, clinical evaluation



How to handle WMSDs

Once the presence of a WMSD problem has been confirmed and recorded, the next step is to take action. But what measures should be implemented? Various prevention options can be considered and some are more effective than others. Here is an overview.

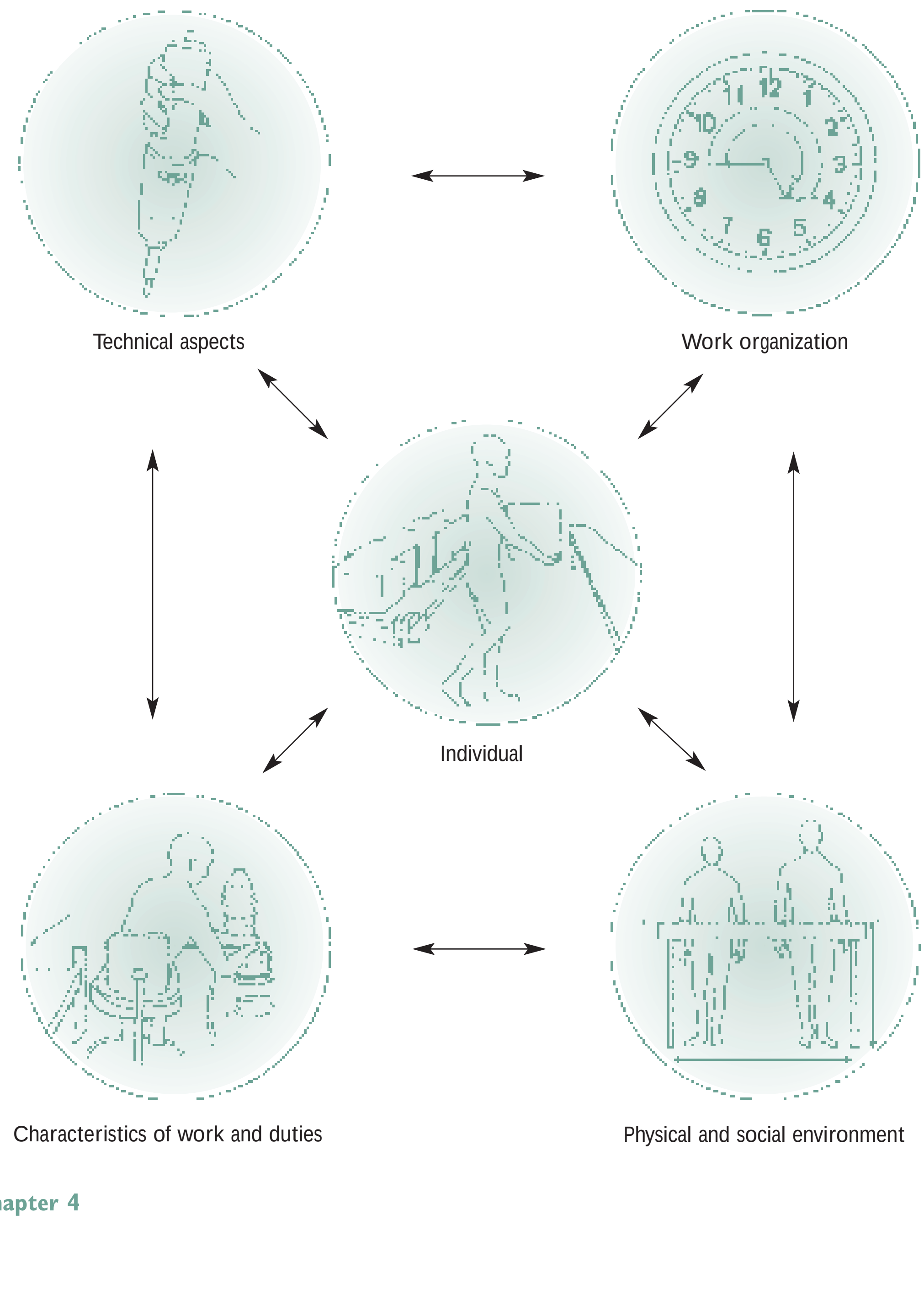
A comprehensive approach

Whatever the prevention methods considered to fight WMSDs, the issue should be addressed comprehensively. As we saw previously, WMSDs are a complicated, multi-dimensional problem. Given the complexity of this issue, an effective strategy should also involve concerted actions at various levels. While work station adaptation is the backbone of a prevention-at-source strategy, the value of a training program or the monitoring of injured workers cannot be overlooked.

The comprehensive approach is also essential in reducing risk factors by improving work stations. The workplace can be seen as a system with five main components: the individual, technical work aspects, work organization, job characteristics and physical and social environment (Fig. 4.1). At the heart of the system is the individual or worker, with his physical or psychological features, who is affected by the four other components of the system. The interaction between the worker, with his particular traits, and these components constitutes the work process, namely a specific set of gestures and actions involved in performing the work.

First of all, the technology used largely determines the knowledge required by the worker, as well as the work methods to be used. General work organization also has a direct impact on the individual, the work station and the conditions of work performance. Organization determines the worker's level of participation, the nature of interactions with colleagues, the type of supervision and control at the work station, etc. Job characteristics also affect the individual and the work process, as in the degree of precision required, the type of efforts to be applied - in short, the physical and mental requirements of the job. Lastly, the individual works in a physical and social environment where variables as diverse as work table height and work atmosphere have a crucial effect on the work process. Experts agree that a comprehensive approach has a greater chance of success than an approach focused solely on a few specific features, such as work postures. As has already been indicated, risk factors are interrelated and interdependent, so it is difficult to have a significant impact if the focus is only on one or two of these

Fig. 4.1
Main components of the workplace.



factors in isolation. Risk factors must be dealt with as a whole. Hence, to solve an ergonomic problem, the intervention must take into account the five main components of the work system: the individual with his special traits, work organization, job design, the technology used and the physical and social environment. Work improvement is contingent upon a better balance of these main components of the work system. The preventive approach must also be comprehensive because action needs to be taken in a complicated system governed by dictates other than health protection alone. For example, ergonomic improvements are suggested in a context dominated by production and quality requirements. Workers do not always have the leeway they would like. Thus, if the system is considered as a whole, certain negative work characteristics can be offset by reinforcing other more positive aspects. For example, if it is difficult to change the repetitive nature of a particular job, this problem could perhaps be offset by improving work postures, reducing the efforts required, and getting workers more involved in determining the content of their jobs.

Several possible options

A complete intervention program for preventing WMSDs will comprise several complementary segments and be designed to have a multi-level impact. Hence, even though the most effective action is to try to eliminate the risk at its source, action must also be taken to help workers who have already been or are in the process of being affected.

Ergonomic improvement of working conditions

Prevention requires taking action at the source. In the case of WMSDs, this means reducing risk factors through the ergonomic improvement of working conditions. This can involve specific modifications, in terms of work station layout, as well as changes in work organization. Ergonomics is a strict, systematic process used to collect relevant information through interviews and observations, identify the key elements involved, and propose possible solutions. Ergonomics offers analysis and intervention tools that are particularly well-adapted to the problem of WMSDs. Instead of describing these tools and this process here, we will illustrate the main steps of an ergonomic intervention through a few examples that will be presented at the end this chapter.

Typically, there are two approaches to ergonomics. In the first, more traditional option, known as expert ergonomics, work improvement is entrusted to an ergonomics expert, who analyzes the work stations and presents a report to the company. This approach is direct and efficient, but the ergonomics expertise remains outside the company. The other option is to implement a participatory ergonomics process. In this case, an ergonomics work group, dubbed an "ergo group", is formed within the company. This group, whose work is initially monitored by an ergonomics expert, develops know-how in this field that remains within the company. The following examples will illustrate these two scenarios.

Rotation

While rotation can be used as part of the ergonomic improvement of working conditions, it is often proposed in isolation to correct the effects of particularly demanding stations. Consequently, it merits further discussion.

In fact, rotation among several work stations is recommended in order to reduce exposure to the risk factors presented by one of these stations. The idea is particularly effective if the task can be diversified and total exposure reduced. It is therefore necessary to ensure that rotation takes place among jobs with different requirements, so as to allow the most overburdened joints to recover. This condition is not so easy to meet on an assembly line where major demands are made on the upper limbs.

Rotation is not a universal solution. It may be unadvisable for work stations that require a lot of training and a long learning curve for workers to be able to keep up. In these cases, changing jobs too rapidly would mean always being in the learning stage and never being able to optimize operating methods. Changes would then have to be made less frequently, thereby reducing the advantages of rotation.

Training

Training is often a very important aspect of an integrated WMSD prevention strategy. However, most of the time, it will play a complementary role to other preventive measures.

In fact, the idea of worker training often alludes to training that focuses on "proper methods" or "proper postures". In other fields, notably that of handling, several studies have shown that training programs based solely on the teaching of work methods have produced disappointing results. There are various reasons for the failure of these programs. Often, the "theoretical" methods taught cannot be applied as is, given the restrictions of the workplace (limited space, characteristics of load handled, etc.). In addition, it is often forgotten that there is no single "proper work method" that applies universally to all workers and all conditions. Workers will adopt different strategies based on the situation at hand. For WMSDs, like handling, training aimed solely at teaching "proper work methods" would likely produce unsatisfactory results.

This does not mean that training is useless – on the contrary. However, rather than shooting for "proper work methods", training can focus on the transfer of information and knowledge. This approach seems more promising in terms of WMSDs. Training, for example, can be geared toward teaching workers how to detect early symptoms of WMSDs and identify the main risk factors at their station. Such training could enable workers to make adjustments to their work station themselves and help them recognize the development of a WMSD in time. Management staff, particularly foremen and team leaders, as well as engineers and mechanics, also constitute an ideal training clientele. They are important company players when it comes to WMSDs, since they are often responsible for work transformations, at both an organizational and a technical level. They can therefore benefit from a sound knowledge of basic ergonomic concepts, which is why training focusing on WMSD causes and prevention methods can be a very valuable asset. Lastly, decision-makers can also profit from training on the relevance of different prevention options to help them improve their planning.

It should also be noted that, for WMSD prevention and prevention in general, it is always useful for new workers to have on-the-job training so that they can learn their work properly before they are forced to adopt the regular, often quite rapid pace. Training upon hiring can inform and forewarn workers about WMSDs, while promoting the adoption of appropriate work methods.

In conclusion, training based on knowledge transfer seems to offer more potential than highly specialized training focusing solely on "proper work methods". Training can target various clienteles: workers, foremen, engineers, mechanics, managers, health and safety committee members, purchasing and maintenance supervisors, etc. Themes are geared toward the specific needs of the targeted clientele: type of WMSDs, recognition of early symptoms, identification of risk factors, ergonomic concepts, main prevention approaches, etc.

Follow-up of affected workers

Any good prevention program should include secondary and tertiary prevention elements, in order to take into account workers who show symptoms of WMSDs, as well as those who are absent due to a work-related accident or disease. Thus, it is recommended that when workers at a given station show WMSD symptoms, this is a sign to take action to reduce the risk factors.

The return to work of workers affected by WMSDs must also be considered. Even if measures have been taken to reduce the risk of WMSDs at the work station, a gradual return to the work station is generally recommended. It may be useful to develop mechanisms that provide workers with working conditions adapted to their health status. For example, a worker suffering from bursitis or shoulder pain would not be assigned a job involving awkward shoulder postures. The goal is to provide workers with work stations adapted to their capacities, whatever they may be.

Other avenues

When all is said and done, WMSD prevention is a relatively new field and new intervention avenues may still emerge. It is important to keep an open mind. Some have already been explored, with moderate success.

When it comes to preventing a work-related illness, many wonder if it is possible to identify "workers at risk", that is those who would be the most vulnerable to this illness, in order to assign them to less demanding work stations. This is based on the assumption that, using various tests or indicators, it is possible to predict which individuals would most likely develop a WMSD. At the present time, there is no scientific evidence suggesting that this is possible. In the absence of a valid indicator of WMSD vulnerability, it must be concluded, given the extent of current knowledge, that identifying workers at risk is simply not a viable means of preventing WMSDs.

Workplace fitness programs

Some companies have set up workplace fitness programs. For example, twice a day, work is interrupted for ten minutes of stretching and warm-up exercises for over-taxed joints. Some have expressed doubt as to the true effectiveness of these programs, others say that certain exercises can be harmful, while still others give a glowing report of the programs in progress. This issue will continue to be the subject of numerous studies in the years to come.

Ergonomic improvement of work: concrete cases

To illustrate the ergonomic approach, we have decided to outline some concrete examples. The first case is presented by an expert in cooperation with the health and safety committee, while the second describes the application of a participatory ergonomics approach.

Hanging components on a paint conveyor

In a paint workshop, the health and safety committee discovered that work stations for hanging components on an overhead conveyor were relatively demanding on the back. The committee called upon the services of the joint sector-based association, which promptly sent an ergonomist to the site. The latter first met with a few committee members to find out their intentions and their perception of the problem. After a short tour of the premises, he suggested a more in-depth study.

His initial meetings with the workers at the hanging stations helped redefine the problem. In fact, while workers sometimes experienced back fatigue, they complained mainly about shoulder pain, which they attributed to having to work with their arms in front of them, often above their shoulders. Workers also reported often being in a hurry.

Observing the work made it possible to take stock of demanding postures and other risk factors. Arms have to be lifted high, especially when taking large-sized objects from the row at the top of a pallet, or when hanging small objects at shoulder level or higher. The back is also taxed as a result of the flexion required to pick up components in the bottom of a basket and to bend over to hang them at the base of the supports.

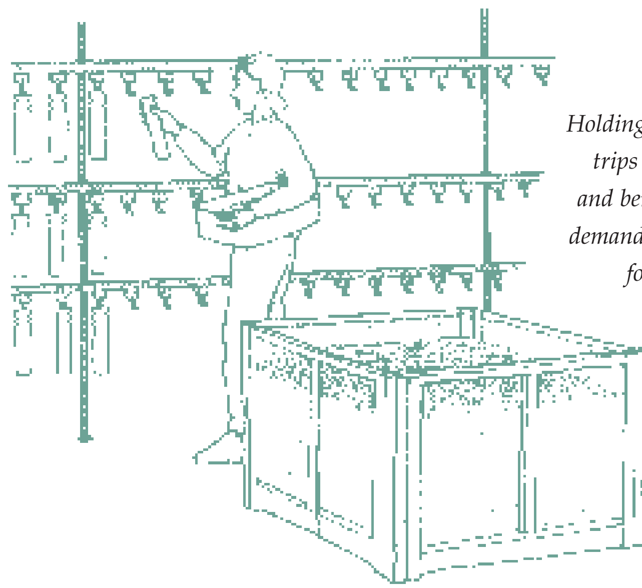


Fig. 4.2
Holding a box reduces trips back and forth and bending, but is a demanding static load for the shoulder.

Observations also revealed certain unique behaviour patterns in workers' attempts to reduce the limitations of the work station. For example, when they have to hang small components at the base of the conveyor, some workers sit on an overturned bucket. To avoid frequent trips between the conveyor and the basket of small components, many workers fill a cardboard box with a large number of components, holding the box with one hand while hanging with the other (Fig. 4.2). The sustained effort required to hold the box and the fact that all the hanging is done with one hand

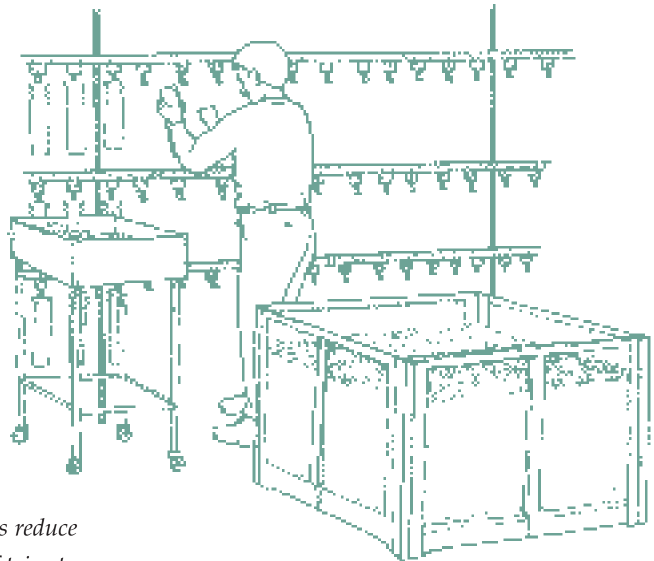


Fig. 4.3
The table helps reduce the number of trips to the basket and frees up both arms for work.

definitely puts a lot of strain on the shoulders. When people fall behind, and this happens relatively often (when they go to the basket to fill their box, for example), they play catch-up, resulting in more trips, strained postures and accelerated execution. Thus, the catch-up phenomenon is an aggravating circumstance. After analyzing the situation, the ergonomist asked to meet with members of the work group to inform them of his diagnosis and to work with them to find concrete solutions for changing the job. This work committee comprised two workers, two group leaders, the personnel manager and the worker representative. The ergonomist reviewed particularly demanding postures and efforts. Workers were already well aware of some risk factors, but had not considered the difficulty of holding a box in their arms (static muscular work) or the catch-up phenomenon, which aggravates all postures and efforts.

The committee, together with the ergonomist, looked at several possible solutions and came up with three changes that could be implemented quickly and economically. Other measures will be considered later on, notably, to raise certain baskets when they are nearly empty.

- Install a table on casters to support a large box filled with small hanging components (Fig 4.3). This eliminates the static muscular work required to hold the box, results in fewer trips to the basket because the box contains more components, and gives the worker two hands free for hanging components;
- Provide a small bench on casters to replace the reversed bucket;
- Build wooden steps so that workers can access the higher row of pallets without having to lift their arms excessively.

Assembly of surge arrestors

Analyzing this work station serves as an illustration of a participatory ergonomics approach involving the establishment of an ergonomics work group. The mandate of this committee, composed of six people and one ergonomist, is to improve work stations most likely to cause WMSDs. The ergonomist's role is to guide the group in learning the work station analysis method developed by the IRSST.

The first work station this committee chose to study was the assembly of surge arrestors. In fact, this station, which the company plans to reorganize shortly, is characterized by a high staff turnover and very repetitive work. To practice prevention, the committee members found it important to formulate their recommendations before proceeding with reorganization. Thus, accident frequency was not a deciding factor in this case.

This station is part of a mini-assembly line comprising five work stations (Fig. 4.4). The product consists of a moulded plastic base in which the worker places and screws together components. Assembly takes place within tracks, in a seated position. The bases are routed manually from one work station to another through tracks attached to the middle of the table. The final product is used as a surge arrestor for telephone lines.

Fig. 4.4
Overview of the first three work stations of the mini assembly line for surge arrestors.

The committee began by looking at the reorganization plans. The purpose of the reorganization was to dismantle the assembly line and establish individual stations. The bases would then be completely assembled on trays instead of the current tracks. The worker would take an empty tray from a cart to his right, place it on a table in front of him, and start assembling the bases. He would then place the tray on another cart to his left (Fig. 4.5)

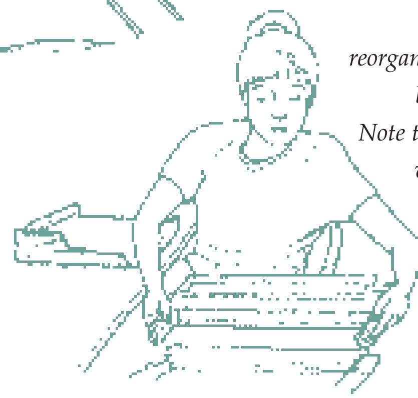


Fig. 4.5
A look at the reorganization planned by the company. Note the back rotation when depositing the tray.

It was then that they noted that the job reorganization project was mainly geared to the physical layout of the work tables and the circulation of the product. The committee planned to broaden this perspective by conducting an in-depth analysis of the actual product assembly activity.

The ergonomics committee began the analysis of the station by holding discussions with the team leader and all the workers concerned. Most of the workers identified the shoulder as the most painful area. Some workers experienced pain when reaching for the material, which they found too far away.

These data were also used for planning video observations of the station. Next, the work activity was analyzed, action by action, using a WMSD risk factor identification grid. The riskiest actions were then highlighted and listed according to importance.

Among the actions selected were those related to reaching for components, due mainly to the awkward shoulder postures, but also because they are repeated frequently throughout the cycle (Fig. 4.6). Priority was also given to the screwing of fuses and bolts. These actions are performed with the arms raised in front of the body, since the tracks are too far away from the worker (Fig. 4.7). In addition, these actions involve pushing efforts when screwing in the component.

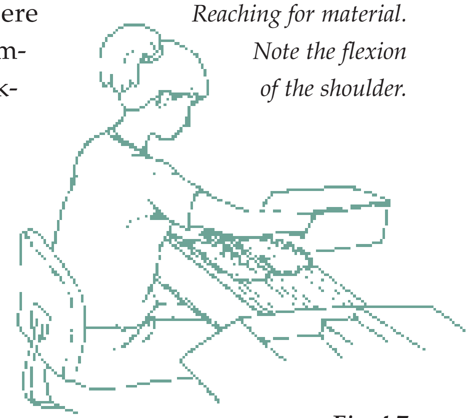


Fig. 4.6
Reaching for material. Note the flexion of the shoulder.

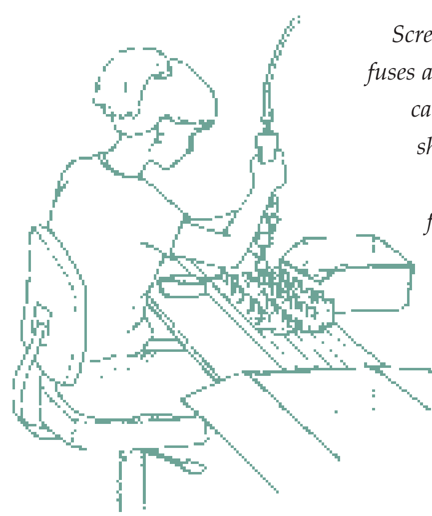


Fig. 4.7
Screwing in fuses and nuts causes the shoulders to bend forward.

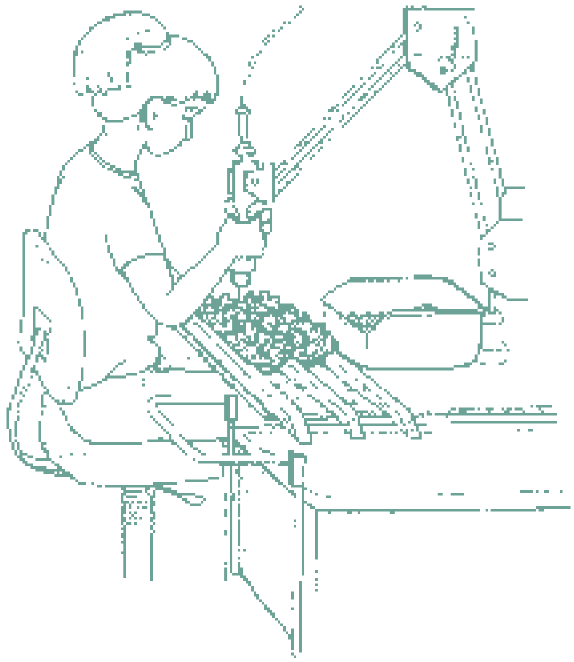


Fig. 4.8
View of the reorganized work station. Note how bringing the tracks closer to the worker and installing a pantograph reduces stress on the shoulders and the amount of effort required for screwing

The committee was also able to simulate the assembly of surge arrestors according to the reorganization. This simulation made it possible to anticipate certain risk factors associated with the use of trays. In fact, transferring the trays would have caused awkward shoulder postures and back rotation (Fig. 4.5), in addition to the efforts involved in handling trays.

The committee therefore decided to formulate a new reorganization proposal to better take into account identified risk factors, production requirements and product quality. At this step, the manager, the engineer in charge of thereorganization and the team leader joined the committee. The discussion focused initially on the worst actions, beginning with the circulation of the bases and the assembly support. Several scenarios were developed, two of which were selected for testing in the department. The first prototype, in accordance with the reorganization put forward by the company, kept the assembly and emptying of the bases on trays. The second prototype proposed maintaining the assembly on tracks with the addition of a chute at the end of the table, to facilitate the emptying of the bases. The chute and the tracks offered the advantage of eliminating tray handling. Following the prototype tests, the workers opted for assembly on tracks with a chute as the system best adapted to their work. At the same time, the committee made sure that the chute system would not affect product quality.

Regarding the use of the screwdriver, the committee suggested moving the tracks closer to the worker, which would reduce the amplitude of shoulder postures and allow the arms to work closer to the body. The committee also proposed adding a pantograph (Fig. 4.8) to reduce screwing efforts and keep the tool straight. Bringing the tracks and component containers closer to the worker would make it easier to reach the components.

After implementing the recommendations, the committee conducted another work station analysis to evaluate the impact of the improvements on work activity. Workers said they appreciated the extended work cycle, the individualized stations, the pantograph for the tool, the chute system and the reduced effort required for screwing. In terms of posture risk factors, observations show that most risk factors have decreased.

How to handle WMSDs

- **To prevent WMSDs** it is important to take a comprehensive approach and to intervene in an integrated manner through a series of complementary measures that will impact technical work aspects, work organization, the physical and social environment and work characteristics and tasks.
- **An effective prevention strategy** must eliminate the danger at the source while at the same time helping workers who are already affected.
- **Several prevention options can be considered:**
  - Ergonomic improvement of working conditions remains one of the most effective intervention routes, since it goes to the source by targeting the reduction or elimination of risk factors.
  - Training is an important aspect of an integrated intervention, but cannot constitute a complete intervention in itself.
  - Monitoring affected workers can be done through work station adaptation measures and gradual return-to-work measures.
  - Some explore the option of workplace exercise programs.

Conclusion

There are many causes of WMSDs, and to prevent them, the whole work situation must be taken into consideration; it is therefore a difficult issue to handle. First, it is important to understand what is going on, to get rid of any biases, to find out the facts. Then, it is necessary to address and evaluate the seriousness of the situation prevailing in the workplace. If the situation is acceptable, it may be sufficient to simply remain alert and ready to intervene at the slightest sign of deterioration. If, however, it becomes obvious that the situation is problematic, either because there are already signs of identified WMSDs or because it is just a matter of time before they appear, action must be taken, and it is at this point that many may feel overwhelmed.

In fact, there are no quick fixes or ready-made solutions. The reader will no doubt have noted that, in the chapter describing how to detect a problem, there are no exposure standards to help decide whether or not a problem exists. There are no reliable standards because too many variables are involved. Evaluating the problem remains basically a judgement call.

Likewise, it is also not realistic to draw up a list of possible solutions, and even less so, to develop a guide indicating under what circumstances each of these solutions can be used effectively. In this regard, reading Chapter 4 may leave the reader yearning for more, since the possible options it offers are very general. The concrete examples presented at the end of the chapter, however, explain how the ergonomic approach can be applied.

To better meet this need for concrete intervention tools, a second document, *Le groupe ergo : un outil pour prévenir les LATRs* has been prepared as a follow-up to this work. The first focuses on identifying the problem, while the second provides methods for correcting it.

Aimed at those who want to take action to prevent WMSDs, this second publication also cannot provide recipes, in that it will not offer direct methods of modifying a given work station. It contains an in-depth presentation of a particular intervention method; the ergonomics work group, commonly known as the ergo group.

We favour this participatory approach to the point of devoting an entire publication to it, because it offers numerous advantages, the main one being to develop ergonomics expertise within the company. Through training and experience, the members of the ergonomics work group acquire a method through which they can analyze and solve their problems themselves. Another advantage is that, generally speaking, since they are developed by people in the plant, solutions are incorporated quickly into company practices and are therefore more readily accepted by the workers. Another significant advantage is that the participatory approach tends to improve communication within the company, because of the consultations and discussions that it involves. Lastly, the entire working atmosphere is affected by the fact that the participatory approach actively involves the workers, making them feel more respected, more listened to and more motivated.