Part 1

Objectives

1.1 *Work-related musculoskeletal disorders* - a definition

The term *musculoskeletal disorders* denotes health problems of the locomotor apparatus, i.e. of muscles, tendons, the skeleton, cartilage, ligaments and nerves. Musculoskeletal disorders include all forms of ill-health ranging from light, transitory disorders to irreversible, disabling injuries. This booklet focuses on musculoskeletal disorders, which are induced or aggravated by work and the circumstances of its performance. Such work-related musculoskeletal disorders are supposed to be caused or intensified by work, though often activities such as housework or sports may also be involved.

Most important localization of work-related musculoskeletal disorders

Upper extremities (shoulder – arm – hand)

Main articulations (e.g. knee)

1.2 *Characteristic health problems*

Lower back

Health problems occur, in particular, if the mechanical workload is higher than the load-bearing capacity of the components of the musculoskeletal system. Injuries of muscles and tendons (e.g. strains, ruptures), ligaments (e.g. strains, ruptures), and bones (e.g. fractures, unnoticed microfractures, degenerative changes) are typical consequences. In addition, irritations at the insertion points of muscles and tendons and of tendon sheaths, as well as functional restrictions and early degeneration of bones and cartilages (e.g. menisci, vertebrae, intervertebral discs, articulations) may occur.

To prevent musculoskeletal disorders, a balance between mechanical load at work and load-bearing capacity of the musculo-skeletal system is most important.

There are two fundamental types of injuries, one is acute and painful, the other chronic and lingering. The first type is caused by a strong and short-term heavy load, leading to a sudden failure in structure and function (e.g. tearing of a muscle due to a heavy lift, or a bone fracture due to a plunge, or blocking of a vertebral joint due to a vehement movement). The second results from a permanent overload, leading to continuously increasing pain and dysfunction (e.g. wear and tear of ligaments, tendovaginitis, muscle spasm and hardening). Chronic injuries resulting from long-term loading may be disregarded and ignored by the worker because the injury may seemingly heal quickly and it may not result in an actual significant impairment.

The number of such injuries is substantial. In industrialized countries, about one-third of all health-related absences from work are due to musculoskeletal disorders. Back injuries (e.g. lower back pain, ischiadics, disc degeneration, herniation) have the highest proportion (approximately 60%). The second position is taken by injuries of the neck and the upper extremities (e.g. pain syndromes of the neck, shoulders, arms, “tennis elbow”, tendinitis and tendovaginitis, carpal tunnel syndrome, syndromes related to cumulative traumata, the so-called cumulative trauma disorders (CTDs) or repetitive strain injuries (RSIs)), followed by injuries of knees (for example, degeneration of menisci, arthrosis) and hips (e.g. arthrosis). It is generally accepted that working conditions and workload are important factors for the development and continuance of these disorders.

1.3 Basic risk factors for the development of musculoskeletal disorders

1.3.1 Mechanical overload, repetition frequency, exposure time, posture and accidents

Work-related musculoskeletal disorders are supposed to be causally linked to physical load resulting from occupational activities.

Disorders or injuries affecting muscles, tendons, joints, ligaments and bones are mainly caused by *mechanical overload* of the respective biological structures. Potential overload of tissues results from high intensity forces or torques acting on and inside the body. Examples of occupational activities coinciding with high mechanical requirements are handling of objects, as in transportation jobs, or the application of pushing or pulling forces to tools or machines. The detrimental effect of mechanical overload depends mainly on the magnitude of the force.

Furthermore, the duration of exposure is an important factor in the development of musculoskeletal disorders. It is mainly determined by the *number of repetitions per unit time (e.g. per day)* as well as by the *total exposure time (e.g. hrs per day or days per month)*. Regarding the character of exposure, occasional vocational loading events can be discriminated from long-lasting activities occurring over many years during the entire occupational life. Short-term loadings may primarily lead to acute health disturbances whereas long-lasting exposure may, in a final stage, cause chronic disorders.

The risk for the musculoskeletal system depends to a great extent on the *posture* of the operator. Especially, twisting or bending the trunk can result in an increased risk for the development of diseases at the lower back. Postural demands play an important role, particularly, when working in confined spaces.

Besides such types of occupational loading resulting from usual work-site conditions, musculoskeletal disorders can also be caused by unique, unforeseen and unplanned situations, e.g. by *accidents*. The origin of disorders due to accidents is characterized by a sudden overstrain of the organs of locomotion.

1.3.2 Total mechanical loading

Accident due to an unplanned situation

The total load affecting the musculoskeletal system depends on the level of the different load factors, mentioned before, such as

- the level and direction of forces,
- the duration of exposure,
- the number of times an exertion is performed per unit of time,
- postural demands.

1.3.3 Risk qualities

According to the factors mentioned before, different risk categories can be derived using different combinations or qualities thereof, such as

- high intensity forces,
- long exposure duration,

- highly repetitive exertions,
- strong postural demands,
- strong or long-lasting muscular strain,
- disadvantageous environmental or psychosocial conditions.

1.3.4 Factors contributing to the development of musculoskeletal disorders

In the following, musculoskeletal load is characterized with respect to the main influences, such as the level of force, repetition and duration of execution, postural and muscular effort as well as environmental and psychosocial factors.

1. Exertion of high-intensity forces may result in acute overloading of the loaded tissues. High-intensity forces are active within the body tissues particularly during lifting or carrying heavy objects. Furthermore, pushing, pulling, holding or supporting an object or a living being are a matter of high-intensity forces.

2. Handling loads over long periods of time may lead to musculoskeletal failures if the work is continued for a considerable part of the working day and is performed for several month or years. An example is performing manual materials-handling activities over many years, which may result in degenerative diseases, especially of the lumbar spine. A cumulative dose can be regarded as an adequate measure for the quantification of such types of loadings. Relevant factors for the description of the dose are duration, frequency and load level of the performed activities.

3. Musculoskeletal disorders may also result from frequently-repeated manipulation of objects, even if the weight of the objects handled or the forces produced are low. Such jobs (e.g. assembling small workpieces for a long time, long-time typing, supermarket checkout work) may induce

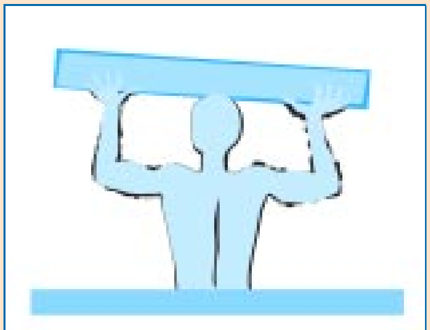
disadvantages for the musculature, even if the forces applied to the handled objects are low. Under such conditions, the same parts and fibres of a muscle are activated for long periods of time or with a high frequency and may be subject to overload. Early fatigue, pain, and possible injuries are the consequences.

Repeated manipulation of objects

4. In a well-designed workstation, work can be performed most of the time in an upright posture with the shoulders unraised and the arms close to the trunk. Working with a heavily bent, extended or twisted trunk can result in an overload of spinal structures and increased activity of entire muscles. If the trunk is simultaneously bent and twisted the risk of spinal injury is considerably increased. If movements or postures with the hands above shoulder height, below knee level or outstretched are performed over prolonged periods or recurrently, working conditions should be changed. Working in a kneeling, crouching or squatting position augments the risk of overloading musculoskeletal elements. Also, long-time sitting in a fixed posture is accompanied by long-lasting muscular activity which may lead to an overload within muscular structures. Such working positions should be avoided and the time for working in such positions should be kept to a minimum, if such work is not completely avoidable.

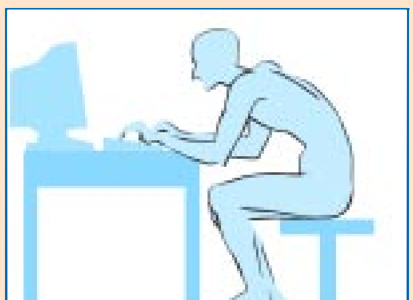
Continuous sitting in a fixed posture: disadvantageous for musculature

5. Static muscular load is found under conditions where muscles are tensed over long periods of time in order to keep a certain body posture (e.g. during work with the hands overhead in drilling holes into the ceiling, holding the arms abducted in hair dressing, holding the arms in typing position above the keyboard, working in a confined space). A characteristic of static muscular load is that a muscle or a group of muscles is contracted without the movement of the corresponding joints. If the muscle has no opportunity to relax during such a task, muscular fatigue may occur even at low-force levels, and the function of muscles may be impaired and it may hurt. In addition, static load leads to a deficiency in blood circulation in muscles. Under normal conditions, the permanent change between contraction and relaxation acts as a circulation-supporting pump. Continuous contraction restricts the flow of blood from and to the contracted muscle. Swelling of legs, for example, is an indicator of such a lack in blood circulation.



Static work with holding the hands overhead

6. Muscular inactivity represents an additional factor for the development of musculo-skeletal disorders. Muscles need activation to maintain their functional capacity, and the same is true of tendons and bones. If activation is lacking, a deconditioning will develop, which leads to functional and structural deficits. As a result, a muscle is no longer able to stabilize joints and ligamental structures



Deconditioning due to low muscular demand and long-lasting physical inactivity adequately. Joint instabilities and failures, incoordination connected with pain, movement abnormalities and overloading of joints may be the consequences.

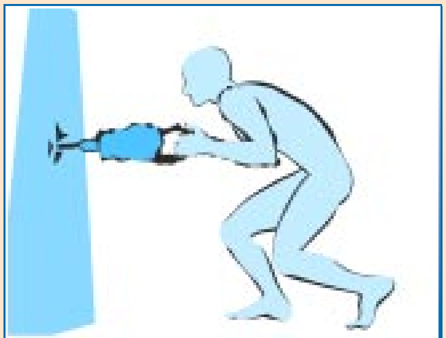
7. Monotonous repetitive manipulations with or without an object over long periods of time may lead to musculoskeletal failures. Repetitive work occurs when the same body parts are repeatedly activated and there is no possibility of at least


Monotonous repetitive manipulations


Continuous keyboard and mouse use during data entry

a short period of relaxation, or a variation in movement is not possible. Relevant determining factors are the duration of the working cycles, their frequency and the load-level of the performed activity. Examples of repetitive work are keyboard use while typing, data entry, clicking or drawing a computer mouse, meat cutting, etc. Unspecific complaints due to repetitive movements of the upper extremities are often summarized in the term "repetitive strain injury - RSI".

8. Strain on the locomotor system may also occur due to the application of vibration. Vibration may result from hand-held tools (e.g. rock drill) and, therefore, exert vibration strain on the hand-arm system. Hand-arm vibration may result in the dysfunction of nerves, reduced blood circulation, especially in the fingers (white finger syndrome) and degenerative disorders of bones and joints of the arms. Another risk concerns


Exposure to vibration: Use of vibrating tools

whole body vibration generated by vibrating vehicles and platforms such as earth-moving machines, low-lift platform trucks or tractors and trucks driving off-road. The vibration is transferred to the driver via the seat. Whole-body vibration can cause degenerative disorders, especially in the area of the lumbar spine. The effect of vibration may be intensified if the vehicle is driven in a twisted body posture. A vibration-attenuating driving seat may help to reduce the effect of vibration.

9. Physical environmental factors such as unsuitable climatic conditions can interact with mechanical load and aggravate the risk of musculoskeletal disorders. In particular, the risk of vibration-induced disorders of the hands is considerably enhanced if low temperature coincides with the use of hand-held vibrating tools. Another example of environmental factors influencing the musculoskeletal strain is the lighting conditions: If lighting and visual conditions are deficient, muscles are strained more intensively, particularly in the shoulder and neck region.


Physical environmental factors:Work at heat

10. Besides the mechanically-induced strain affecting the locomotor organs directly, additional factors can contribute to the beginning or aggravation of musculoskeletal disorders. Psychosocial factors can intensify the influence of mechanical

strain or may induce musculoskeletal disorders by themselves due to increasing muscle tension and by affecting motor co-ordination. Furthermore, psychosocial influences such as time pressure, low job decision latitude or insufficient social support can augment the influence of physical strain.

A summary of the main factors contributing to the risk of developing work-related musculoskeletal disorders is provided in the table.

Table : Main factors contributing to musculoskeletal disorders

Factor	Possible result or consequence	Example	Good practice example or solution
Exertion of high-intensity forces	Acute overloading of the tissues	Lifting, carrying, pushing, pulling heavy objects	Avoid manual handling of heavy objects
Handling heavy loads over long periods of time	Degenerative diseases especially of the lumbar spine	Manual materials-handling	Reduce mass of objects or number of handlings per day
Frequently repeated manipulation of objects	Fatigue and overload of muscular structures	Assembly work long time typing, check-out work	Reduce repitition frequency
Working in unfavourable posture	Overload of skeletal and muscular elements	Working with heavily bent or twisted trunk, or hands and arms above shoulders	Working with an upright trunk and the arms close to the body
Static muscular load	Long-lasting muscular activity and possible overload	Working overhead, working in a confined space	Repeated change between activation and relaxation of muscles
Muscular inactivity	Loss of functional capacity of muscles, tendons and bones	Long-term sitting with low muscular demands	Repeated standing up, stretching of muscles, remedial gymnastics, sports activities
Monotonous repetitive manipulations	Unspecific com-plaints in the upper extremities (RSI)	Repeated activation of the same muscles without relaxation	Repeated interruption of activity and pauses alternating tasks
Application of vibration	Dysfunction of nerves reduced blood flow, degene-rative disorders	Use of vibrating hand-tools, sitting on vibrating vehicles	Use of vibration-attenuating tools and seats
Physical environmental factors	Interaction with mechanical load and aggravation of risks	Use of hand-held tools at low temperatures	Use gloves and heated tools at low temperatures
Psychosocial factors	Augmentation of physical strain, increase in absence from work	High time pressure, low job decision latitude, low social support	Job rotation, job enrichment, reduction of negative social factors

1.4 Factors to be considered in *prevention*

1.4.1 The ideal balance

With regard to maintenance and promotion of health, a weighed balance between activity and rest is necessary. Rest pauses are a prerequisite for recovery from load-induced strain and for preventing accumulation of fatigue. Movement should be preferred to static holding, the aim should be a combination of active periods with loading and inactive periods of relaxation. The individual "favourable load" can vary from subject to subject depending on functional abilities and individual resources. Overload as well as inactivity should be avoided. Appropriate load effects training of muscles leading to adaptation and thus an increase in the capacity of muscles, tendons and bones. This is essential for health and well-being.

CAVEAT: This general view, however, needs refinement in special cases, since parts of the musculoskeletal system may not adapt to loads in the same way. For example, repetitive lifting of heavy loads probably does increase muscle capacity, but probably does not increase the capacity of the spinal discs to withstand mechanical loading. As a consequence, strength training could mislead individuals to believe they could safely lift greater loads and thus risk back problems. Jobs should, therefore, be so designed that most people are able to carry them out, rather than only a few strong individuals.

1.4.2 The principle of ergonomics

A risk for disorders of the musculoskeletal system appears if the load and the functional capacity of the working person are not balanced. The basic principle of ergonomics is to create an appropriate balance between the requirements of the work and the capacity of the working person, by either adapting the work to the person by design of the respective work, or by developing the capacity of the humans to the work by training and vocational adjustment.

The primary aim should be the adaptation of working conditions to the capacity of the working persons, whereby it is of particular importance to consider the dependency of individual capacity on age and gender. The adaptation of human beings to work should not be preferred, as here the work cannot be performed by all persons, but only by selected and specifically trained groups. Additionally, the possibility of developing human abilities during work execution should not be misused as a pretence for maintaining poorly designed conditions of work or work environment.

1.4.3 Work performance strategies

A risk factor for overloading the musculoskeletal system results from the method of performing the work by the worker. There are risky and less risky strategies to execute the task. An example is lifting heavy objects having the centre of gravity near the body. To fulfil this demand, heavy objects should be lifted, whenever possible, by bending the knees instead of bending the back. Further measures to reduce overloading risk are avoiding twisted and laterally bent postures, working continuously at a moderate pace and not during short time-periods with high time-pressure. The worker must be informed about those possibilities and should be motivated to use them.

1.4.4 Avoid accidents and injuries

The avoidance of accidents is another important field for the prevention of musculoskeletal disorders. Hazardous situations, in particular for plunges, can occur during work at greater height, for example on a ladder, a scaffold or a construction site. The risk for plunges can be reduced by securing the standing position and by stabilizing the equipment on which the worker climbs. In particular, the use of steady ladders and fixing the ladders to the floor or on stable objects is indispensable. Only sufficiently stable and steady scaffolds should be used and these should be fixed to the building. Furthermore, securing the position of the worker by roping to the climbing aid (ladder; scaffold) or building is an important measure for preventing plunges.

Injuries to head, hand and foot can be avoided by using protective helmets, gloves or shoes, respectively. Another important measure is to avoid objects from falling down by fastening or covering them in an appropriate manner. In particular, during the transportation of goods with cranes or other hoisting devices, goods should be fixed by covering them or by spreading a plane underneath.

Part 2 Guidance

2 Guidance on main risk factors

In this part, some of the main risk factors for the development of musculoskeletal disorders are listed, and examples of tasks and working conditions are provided. Additionally, potential causes for health disturbances and injuries as well as suggestions as to how to avoid these are made.

Risk frequently results from exposure to mechanical loading. The main influencing factors are high forces resulting from lifting and pushing or pulling heavy objects, high repetition frequency, long duration of force execution, unfavourable posture, uninterrupted muscle force exertion or working on or with vibrating machines. In some cases, the degree of handling precision, rather than the actual force exerted, constitutes an additional hazardous factor.

2.1 Risk factor: Manipulation of heavy loads

2.1.1 Where are heavy loads manipulated?

Examples are:

- lifting and carrying of heavy objects in transportation jobs, construction sites, etc.,

Manipulation of heavy loads: Transportation job at construction sites

- transferring persons in health professions, in old-age care and hospital care.

2.1.2 Why are heavy loads harmful?

Holding and moving of heavy loads requires high muscular force; this may lead to acute overload and/or fatigue of *muscles*. Examples: Repeated manipulation of heavy bricks in construction work, loading of coffee sacks, cement bags or other loads in ships, containers or lorries.

The risk for musculoskeletal disorders depends on the relation between the load-weight and the functional capacity of the working person

During holding and moving of heavy loads, high forces occur in the *skeletal system*, too. Risk of acute overloading and damage may result. Loadings being incurred over a long period of time may cause or promote degenerative disorders, especially in the low-back area (e.g. when handling loads with a bent back).

For the individual risk of manual materials-handling activities, the functional capacity of the working person plays an important role.

2.1.3 How can heavy loads be handled with low risk for harm?

The most important factors concerning the risk are the *weight of the object* to be manipulated, the *horizontal distance* between the load and the body and the *duration* and *repetition frequency* of task execution. This leads to some important measures for handling objects.

Advice to the employee:

- Lift loads close to the body.
- Lift with both hands, symmetrically to the mid-sagittal plane, bring the load as close as possible to the body.
- Lift heavy loads with an upright trunk by extending the initially flexed legs and avoid manipulation of loads in unfavourable postures (e.g. lateral bending or twisting).
- Use cranes, lifters, dollies, hoists, pallet jacks, mobile elevators, or similar devices, if available, for lifting and transporting heavy loads.
- Carry heavy and/or unwieldy loads with two persons.

Advice to the employer:

- Avoid manual handling tasks, especially of heavy loads. If manual handling is still necessary, introduce ergonomic measures to minimize the resulting risk.
- Avoid moving loads over obstacles.
- Avoid carrying over uneven or slippery routes, over steps or stairs.
- Avoid high or frequent handling procedures.
- Avoid large masses (e.g. instead of one heavy sack use two sacks of smaller weight).
- Provide aids (hoists, or similar devices).
- Mark heavy loads.
- Mark non-symmetrical load distribution within the object. Mark containers or barrels with movable content (fluids, granules, etc).
- Suggest and carry out training on “handling”.

2.2 Risk factor: Work with high force exertion

2.2.1 Where is high force exertion found?

Examples are:

- pushing or pulling of heavy objects
- pulling of trolleys and other means of transportation
- positioning of packages in a transportation vehicle
- manipulation of scaffold parts
- transfer of patients.

High force exertion: Pushing of heavy objects

2.2.2 Why is high force exertion harmful?

The exertion of force requires high muscle forces. This may lead to an acute overloading and/or fatigue of muscles.

During such work high forces also occur in the *skeletal system*. This may lead to an acute overloading and injury of the skeletal structures. Force exertion, where the force acts distantly from the body, bears a high risk of damage to the lumbar spine tissues. For tasks with long-lasting or frequently repeated high force exertion, there is risk of degenerative diseases especially of the lumbar spine. This is true, in particular, if force exertion is carried out in unfavourable body postures.

2.2.3 How can high force exertion be avoided?

Advice to the employee:

- Carry out pushing and pulling in such a way that the force acts close to the body.

- Avoid pushing or pulling with only one hand.
- Avoid pushing or pulling with strong lateral bending and/or twisted trunk.

Advice to the employer:

- Provide conditions for secure standing.
- Provide wheeled vehicles, trolleys, dollies, or similar devices.
- Avoid pushing or pulling in confined rooms because of constrained postures.
- Avoid obstacles and uneven ground.

2.3 Risk factor: Working in unfavourable body postures

2.3.1 Where do unfavourable postures occur?

Examples are:

- work overhead
- work in constrained positions
- work in confined rooms
- work in extremely bent, twisted or extended postures
- work in a continuously inclined posture (e.g. construction work, concrete reinforcement work)
- work out of reach
- work in a kneeling, lying, crouching or squatting position.

2.3.2 Why are unfavourable postures harmful?

The keeping up of a certain body posture demands high muscle force; acute overload and/or fatigue of muscles can, therefore, be the result.

Examples are:

- Construction work far from the body demands high activation of musculature for holding the arms
- Twisted or extended body postures demand high muscular strain and tension of trunk muscles.

During unfavourable body postures, high forces occur also in the skeletal system. This may lead to acute overloading and damage of skeletal structures. For long-lasting activities with an inclined trunk, degenerative disorders, especially in the lumbar region, can arise if such work is executed over a period of many years.


Body posture: Avoid unfavourable postures

Maintaining unfavourable body postures for long periods of time is connected with long-term activation of certain muscles which may lead to muscular fatigue and considerable reduction in blood circulation. Such partial decrease in the functional ability of the musculature leads to a reduced ability to react on sudden impacts and may therefore result in increased *accident risk*.

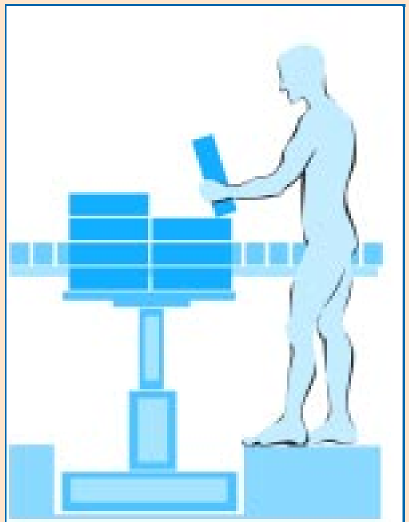
2.3.3 How can unfavourable postures be avoided?

Advice to the employee:

- Bring body close to the position where the object must be handled, or where force application is performed.
- Avoid strong lateral bending or twisting of the trunk.
- Approach the working area and body close enough to enable carrying out the task within reach; use aids such as scaffolds and ladders, if suitable.

- Change posture often to activate different muscles alternately while carrying out tasks; consider alternating between standing and sitting postures.

Use of adjustable equipment: Platform



Use of adjustable table

Advice to the employer:

- Offer adjustable equipment: chairs, tables, scaffolds, etc.
- Supply rooms of sufficient size to avoid constrained postures.
- Arrange tools within reach.
- Set time-limits when constrained postures are unavoidable and/or alternate tasks of different nature.
- Avoid giving tasks that require a kneeling, lying, crouching, or squatting position.

2.4 Risk factor: Monotonous repetitive tasks

2.4.1 Where do monotonous repetitive tasks occur?

Execution of similar or identical movements during a large part of the working time with a high rate of repetition (i.e. several times per minute). During the course of work the working person has often little influence on the working pace, speed, task sequence and work and break schedule. Commonly, the working person cannot abandon the workplace without being replaced by another person.

Monotonous repetitive task: Assembly line

Examples are:

- assembly line
- cash registration
- loading of packing machines.

2.4.2 Why are monotonous repetitive tasks harmful?

Long-lasting repetitive muscle load leads to *muscle fatigue*, which - if sufficient recovery is not guaranteed - may lead to irreversible *changes in the muscular structure*. Not only high-level forces but also low-level forces may cause such an effect. Repetitive movements are often superimposed with static loading, in particular postural load.

2.4.3 How can monotonous repetitive tasks be avoided?

Advice to the employee:

- Avoid continuous loading of the same muscles for longer periods of time.
- Strive for changes in motion in order to avoid identical muscular activation patterns. For strongly monotonous work, changes in the execution of movements may be limited.

- Change body posture frequently in order to reduce static loading.
- Use rest pauses.

Advice to the employer:

- Provide for organizational changes, such as job rotation, job diversification or job enrichment, to reduce the extent of task repetition for individuals.
- Enable autonomous decisions about the timing of breaks.
- Mechanize unavoidable monotonous tasks with high load.

2.5 Risk factor: Long-lasting loadings

2.5.1 Where do long-lasting loadings occur?

Examples are:

- maintaining a static posture (e.g. during bricklaying at floor level; concrete reinforcement work; picking of fruits and vegetables at floor level; writing; typing; work with computer mouse).

Long-lasting loading: Picking up vegetables at floor level

- holding of objects or tools (e.g. drilling in a ceiling; overhead painting; holding of operation instruments in surgery, carrying a tray uninterruptedly).

Long-lasting loading: Hawker's tray

2.5.2 Why are long-lasting loadings harmful?

Long-lasting muscle load leads to *muscle fatigue*. Fatigue without sufficient recovery can lead to irreversible *changes* in the muscular structure. Even the exertion of low-level forces (for example, long-lasting fixed posture) can lead to over-exertion and fatigue of small muscles or muscle groups. Long-lasting contraction of muscles may result in insufficient blood circulation.

In the skeletal system long-lasting loading (e.g. due to long-lasting work in an inclined posture) can lead to deficient nutrition of the spinal discs.

2.5.3 How can long-lasting loading be avoided?

Advice to the employee:

- Move instead of holding a static position.
- Use tools for holding objects.
- Strive for frequent change in body position.
- Strive for frequent upright positions from inclined positions.
- Stand up from time to time when working in a sitting position, for example, while making a telephone call.

Advice to the employer:

- Provide tools for holding (e.g. screw-clamps; handles, which enable holding with low muscle force).
- Provide scaffolds, ladders, or similar devices.
- Supply arm supports at computer workplaces.
- Supply handles or grips which can be used with right as well as left hand.
- Place handles/grips to enable use in a neutral position of wrist and arm.

2.6 Risk factor: Physical environmental conditions

2.6.1 Where is the risk on account of physical environmental conditions?

Vibration:

Hand-arm vibration encountered through hand-held tools may lead to degenerative disorders or to blood circulation problems in the hand (especially the fingers - white finger syndrome).
Whole-body vibration in vehicles may lead to degenerative disorders, in particular, of the lumbar and thoracic spine.

Climate:

High temperatures during the manipulation of heavy loads may lead to blood pressure problems and to an increase in body temperature. At *low temperatures*, a decrease in dexterity may occur.

Lighting:

Insufficient lighting or dazzling may induce constraint postures. Furthermore, it may increase the danger of stumbling or falling.


Physical environmental conditions: Lighting

Slips and falls:

Unsuitable, uneven, unsteady or slippery working surfaces and floors can cause tense, strenuous working postures and movements, in particular, in tasks entailing the handling of loads.

2.6.2 How can the risk of physical environmental conditions be reduced?

Vibration:

The effect of *hand-arm vibration* can be reduced by using tools with low vibration, reducing the time of usage of vibrating equipment, wearing gloves and avoiding coinciding influence of low temperatures.

The effect of *whole-body vibration* can be reduced by using vibration-absorbing seats and reducing the time during which vibration is applied to the body.

Climate:

Wearing of appropriate garments, regular change of stay in rooms with high and low temperatures, limited stay in rooms with high or low temperature.

Physical environmental conditions: Climate

Lighting:

Supplying sufficient and undazzling lighting equipment.

Slips and falls:

Avoid *unsuitable, uneven, unsteady or slippery working surfaces, floors and transportation routes* whenever it is possible.

Appendix

Basic rules for preventive actions in practice

A risk for disorders of the musculoskeletal system appears if the load and the functional capacity of the worker are not in balance. With regard to maintenance and promotion of health, the following points have to be considered:

- There is a need for a weighed balance between physical activity and recovery.
- Movement should be preferred to static holding. The aim should be a combination of active periods with higher load and periods of relaxation.
- Overload should be avoided. Effective measures for preventing overload are reducing the required forces and repetitions.
- Manual handling should be avoided. If avoidance is not completely possible, it should be restricted by applying ergonomic and organizational measures; the employees should be educated and trained so that they can help to minimize the overall risks.
- Too low load should be avoided. An appropriate load for the organs of locomotion is essential in order to keep up their functional ability.
- The individual “favourable load” can vary from person to person depending on functional abilities and individual resources.

The primary aim of ergonomics is the adaptation of working conditions to the capacity of the worker. High human capabilities of the employees should not be misused as a pretence for maintaining poorly designed conditions of work or work environment. Thus it is important to take into account influencing factors such as age, gender, the level of training, and the state of knowledge in an occupation. The working conditions should be arranged in such a way that there is no risk from physical load for anyone at the workplace.

Fundamental points influencing the physical load functions of an employee at worksite are:

- requirements of work with respect to body positions and postures of the employee
- design of working area
- configuration of body supports
- light and visual requirements
- arrangement of controls and displays
- movement sequences of operations
- design of work-rest regimen
- type of energetic loads with respect to force, repetition and duration of work
- magnitude of mental loads by increasing the latitude and control of work or job enrichment.

A secondary way is to develop the capacity of the humans to the work by training and vocational adjustment. The possibility of development of human abilities while executing work should not be the pretence for keeping a poorly designed condition of work or the work environment. The selection of workers according to individual capacity should be limited to exceptional situations.

Successful prevention of work-related health risks requires a scheduled and stepwise procedure:

- analysis of the working conditions
- assessment of the professional risk factors
- consideration/provision of measures for diminishing the risk factors by ergonomic design of the workplace (prevention in the field of working conditions)

- introduction of measures for the diminution of the risk factors by influencing the behaviour of employees (prevention in the field of behaviour)
- coordination of the prevention measures with all subjects involved
- discussion of alternative prevention approaches
- specific and scheduled application of the prevention approaches
- control and assessment of the results.

Summary

Disorders of the musculoskeletal system are a major cause of absence from work and lead, therefore, to considerable cost for the public health system. Health problems arise if the mechanical workload is higher than the load-bearing capacity of the components of the musculoskeletal system (bones, tendons, ligaments, muscles, etc). Apart from the mechanically-induced strain affecting the locomotor organs directly, psychosocial factors such as time-pressure, low-job decision latitude or insufficient social support can augment the influence of mechanical strain or may induce musculoskeletal disorders by increasing muscle tension and affecting motor coordination.

A reduction of the mechanical loading on the musculoskeletal system during the performance of occupational work is an important measure for the prevention of musculoskeletal disorders. The main risk factors are high forces resulting from lifting and pushing or pulling heavy objects, high repetition frequency or long duration of force execution, unfavourable posture, static muscle forces or working on or with vibrating machines. Effective measures for the reduction of forces acting within or on the skeletal and muscular structures include adopting favourable postures, reducing load weight, limiting exposure time and reducing the number of repetitions.

Conclusion

Prevention of musculoskeletal disorders can be achieved by engineering controls and appropriate organizational arrangements. The first-mentioned aspect involves the whole working environment and deals with the ergonomic design of tools, workplaces and equipment. The latter concentrates upon factors such as training, instruction and work schedule. The primary aim of ergonomic work design is the adaptation of the working conditions to the capacity of the worker. It is supplemented by a secondary way, which is based on the development of the persons' capacity to the working requirements by training and vocational adjustment.

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