

Vibrations in the workplace

– as an employer, preventing injuries –

Tohr Nilsson
Lage Burström

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The Swedish Work Environment Authority has published this book as an aid and guide to achieving a better working environment. It describes how, based on available knowledge and experience, injuries from vibrations at work can be avoided. The content of the book is based on science, supplemented by an expanded prevention strategy and regulations on vibrations and medical checks in the workplace.

Vibrations in the workplace

– as an employer, preventing injuries –

Preface: 2025 edition

In 2005, the Swedish Work Environment Authority published the book "Vibrations at work – how to reduce the risk of injury". It clarified the EU directive on vibrations with exposure action and limit values and recommended health surveillance with medical checks ([Annex 2002/44/EC, \[3\]](#)). The book was primarily aimed at occupational health services and those performing medical checks.

The new, extensively revised edition of "Vibrations in the workplace – how employers can prevent vibration injuries" is aimed specifically at employers and those who use vibrating machinery. The book is a digital e-book with links in the text and replaces the previous printed paper edition. The book aims to provide knowledge and understanding of how you as an employer can prevent injuries. It is intended to provide you with help and practical guidance on how to prevent and reduce adverse effects on health and work ability. It is a standalone supplement to the Swedish Work Environment Authority's regulations AFS 2023:10, AFS 2023:15 ([AFS 2023:10, \[1\]](#), [AFS 2023:15, \[2\]](#)) and Prevent's vibration guides [\[11, 12\]](#).

The book describes the risks associated with vibrations transmitted from the surface you are standing or sitting on (whole-body vibrations) and vibrations transmitted from machinery to your hands (handtransmitted vibrations). Both types of vibrations can cause injuries that cause great suffering and affect your ability to work.

The book emphasises the importance of a broad inventory of indicators for unfavourable working environments and risk assessment. This means broadly identifying the risk exposures that exist in the workplace and then implementing measures to reduce these risks. The book describes this process as systematic injury prevention work in accordance with AFS 2023:1.

The book is based on the question of whether various exposures at work can pose a risk and whether the risks can be reduced regardless of exposure levels and limit values.

The book contains eight separate chapters, a list of supplementary information sources and three appendices. The book begins with a summary aimed at employers, supervisors and employees respectively.

The first chapter describes vibrations, the second chapter describes the injuries that can occur when working with vibrating machinery. Chapter 3 discusses various strategies for injury prevention measures. The fourth chapter highlights various indicators that can motivate further injury prevention measures. The fifth and sixth chapters deal with the identification of risk exposures and risk assessment. Chapter 7 provides recommendations on strategies for preventing injuries. Chapter 8 presents material to be used in practical injury prevention work. Chapter 9 provides examples of literature sources.

The book is supplemented with three appendices that provide interested readers with the opportunity for further study.

*Umeå, 4 June 2025
Tohr Nilsson, Lage Burström*

Preface: 2005 edition

In 2005, the Swedish Work Environment Authority issued two regulations concerning vibrations: AFS 2005:15 on vibrations and AFS 2005:6 on medical examinations in the workplace. Preventing vibration injuries and assessing the risks can be difficult, and there is a great need for knowledge in this area. The regulations impose certain requirements on employers to reduce the risk of injury. We have produced this book to provide help and guidance in this work.

There is good reason to work actively with vibrations, as the injuries often affect young workers. They can occur after a short period of time, and the prognosis for improvement, if you have suffered an injury, is very poor.

The book has been produced in collaboration between the Swedish Work Environment Authority, the Swedish Institute for Working Life and the Occupational and Environmental Medicine Clinic in Västernorrland. We would like to express our sincere thanks to Professor Lage Burström and Clinic Manager Tohr Nilsson for their contribution to this work.

Swedish Work Environment Authority, September 2005
Kenth Pettersson

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Summary

For employers and supervisors

As an employer/supervisor, you can create a safe and healthy working environment. The following points summarise important measures and areas of responsibility:

- **Focus on the vibration worker:** Put the person working with vibrations and their well-being and health at the centre.
- **Promote dialogue and participation:** Establish a continuous and open dialogue with your employees about cooperation, participation, health and work environment issues.
- **Ensure competence:** Ensure that all staff have the training and competence required to perform their duties safely.
- **Introduce and follow up on procedures:** Ensure that clear checklists are in place, that they are followed in practice and that identified measures are implemented effectively.
- **Evaluate and improve:** Systematically follow up and evaluate the effect of implemented work environment measures to ensure continuous improvement.
- **Document and share information:** Ensure that investigations, results and action plans are documented in writing and shared with those concerned.

1. Legislation and monitoring

- **Compliance with legal requirements:** Ensure that the Swedish Work Environment Authority's regulations are well known within the organisation and that the business actively complies with them.
- **Documentation and communication:** Carefully document the results of surveys of risk exposures in the work environment, risk assessments and the associated action plan. Share this information openly with all employees.
- **Regular checks:** Conduct systematic and regular checks of the working environment and other work-related health monitoring, and document the results.

For those who work with vibrating machinery

Your participation is essential for a good working environment! The following points summarise important measures and areas of responsibility

1. Laws and regulations

- **Help your employer** comply with the Swedish Work Environment Authority's rules and regulations. This protects you from the risks of vibration.
- **Support your employer in** carrying out regular checks and investigations of risk exposures in the workplace.
- **Inform your supervisor/manager** if you see anything that does not feel safe or correct.

2. Minimise vibration exposure

GENERAL MEASURES:

- **Invest in new technology:** Gradually replace machinery with high vibration levels with modern, low-vibration alternatives.
- **Optimise work processes:** Analyse and improve production and working methods with the aim of reducing vibration exposure for employees.
- **Limit exposure time:** Review work schedules and routines to minimise the time individual employees are exposed to vibrations.
- **Ensure maintenance:** Establish and follow a strict schedule for regular maintenance of machinery and tools to ensure optimal performance and reduce vibration.

SPECIFIC TO HAND-TRANSMITTED VIBRATIONS:

- **Quality-conscious purchasing:** When purchasing, choose machinery with documented low vibration levels and high quality and ergonomics.
- **Right tools and accessories:** Provide and ensure the use of recommended and ergonomically designed tools and accessories.
- **Preventive maintenance:** Perform regular service and maintenance specifically on hand-held machinery.
- **Long-term planning:** Include machine replacement in your budget and planning to gradually phase out older, more vibrating equipment.
- **Personal protective equipment:** Provide appropriate personal protective equipment and ensure it is used correctly.
- **Ergonomic guidelines:** Ensure that employees use the least possible grip and feed force when handling vibrating machinery.
- **Work organisation:** Plan work so that there is time for micro-breaks and recovery breaks.
- **Optimised working conditions:** Create good working premises and clear working routines that minimise unnecessary exposure to vibration.

SPECIFIC TO WHOLE-BODY VIBRATIONS:

- **Vibration-dampened vehicles (mobile machinery):** When purchasing vehicles and machines, prioritise models with low vibration levels.
- **Ergonomic driver's seats:** Equip vehicles and machinery with good, adjustable driver's seats and effective damping.
- **Regular maintenance:** Ensure continuous service and maintenance of the vibration-dampened components of vehicles and machinery.
- **Infrastructure:** Maintain roads and work surfaces to reduce vibrations from the ground.
- **Work organisation:** Schedule regular breaks and rest periods to limit continuous exposure time and allow for micro-breaks.
- **Training in techniques:** Train drivers and operators in good, vibration-reducing working techniques.
- **Speed limits:** Introduce appropriate speed limits for mobile machinery within the work area.

2. Reduce vibrations

GENERAL MEASURES:

- Encourage your employer to replace old machinery that vibrate a lot with low-vibration ones.
- Discuss with your employer how you can change working methods to reduce your exposure to vibrations.
- Keep the time you spend using vibrating machinery to a minimum.
- Always use the lowest possible gripping force and feed force when operating vibrating machinery.
- Ensure that maintenance schedules for machinery and tools are followed – report any deficiencies you notice.

SPECIFIC TO HAND-TRANSMITTED VIBRATIONS:

- Always use machinery and tools according to the instructions.
- Use the recommended protective equipment (gloves, ear protection, eye protection).
- Report any faults in machinery immediately.
- Respect and take micro-breaks and your scheduled breaks.
- Bear in mind that exposure during your free time also affects the risk of injury.

SPECIFIC TO WHOLE-BODY VIBRATIONS (E.G. FROM VEHICLES/MOBILE MACHINERY):

- Use vehicles and machinery that have good seats and suspension.
- Drive carefully and avoid unnecessarily high speeds.
- Make sure you take regular breaks from exposure.

3. Minimise other adverse workplace exposures

- **Climate adaptation:** Continuously evaluate and adapt the physical environment (cold, work clothing, ventilation, humidity, noise) to create a good and safe working environment.
- **Ergonomics:** Ensure that ergonomic principles are applied in the design of workplaces and working positions.
- **Recovery:** Create conditions and encourage regular breaks and micro-breaks during the working day.

4. Consider the specific circumstances of individual employees

- **Individual adaptation:** Be responsive to and take into account individual factors and circumstances that may affect individual employees' sensitivity to exposure.
- **Work adaptation:** Adapt work tasks and the work environment to their individual needs.
- **Health monitoring:** Monitor employees' health regularly through regular health checks and by arranging and offering medical examinations.

5. Training

- **Risk awareness:** Provide mandatory and regular training for all employees on the risks of vibration exposure.
- **Proper use:** Train employees in the proper use of personal protective equipment and safe working techniques.
- **Health information:** Provide information about the purpose and conditions of medical examinations and other health monitoring.
- **Provide information about coping with cold:** Provide information about the risks associated with cold, rapid temperature changes and the need for appropriate work and protective clothing.
- **Inform about the importance of limiting vibration transmission:** Inform about the importance of reducing vibration transmission.
- **Inform about why micro-breaks are important:** Inform about the importance of taking regular micro-breaks to allow blood flow.

3. Take care of the overall working environment

- Be aware of temperature and cold, noise levels, ventilation and air quality at work, and speak up if something needs to be addressed.
- Make sure your workplace and working positions are as good as possible for you.
- Make sure you take micro-breaks as well as your regular breaks – it is important for your health and safety.

4. Consideration for everyone

- Bear in mind that you and your colleagues may have different sensitivities to vibrations, cold and stress.
- Inform your supervisor if you have special needs or feel more affected, and in which situations.

5. Training

- Participate actively in training on the risks of vibrations.
- Make sure you understand how to use protective equipment and the correct working techniques – ask if you are unsure!
- Learn more about your rights in connection with medical examinations.
- Acquire knowledge and skills that can help you manage risk exposure.

6. Early detection and treatment of injuries

- **Increased awareness:** Raise awareness among managers and employees of the early signs of vibration-related injuries.
- **Medical check-ups:** Arrange regular medical check-ups and other work-related health monitoring in order to identify any adverse effects or injuries at an early stage.
- **Rehabilitation and adaptation:** Offer adequate medical rehabilitation and give injured workers the opportunity to adapt to work within the framework of work-oriented rehabilitation.
- **Follow-up:** Follow up on the results of medical examinations and exposure surveys in order to take further preventive measures.

7. Support health factors

- **Increase knowledge and skills:** Strengthen employees' understanding of and ability to manage adverse health effects from risk exposures.
- **Health promotion initiatives:** Promote healthy habits, for example by offering support for smoking cessation and information on diet and exercise.
- **Flexible solutions:** Choose a pay system and work organisation that allows employees to take breaks and adapt their work as needed.

6. Early detection and treatment of injuries

- Pay attention to how you feel and do not ignore early signs of discomfort.
- Inform your employer if you experience problems that you believe are related to your work.
- In particular, inform them if you suspect that you have suffered a vibration injury.
- Attend all medical check-ups that are arranged or offered.
- Carefully answer any health questionnaires, even between the statutory medical check-ups.
- Accept that your employer may use the results of medical checkups as a basis for improving the working environment.

7. Support health factors: What can you do yourself?

- **Medication:** Always inform your doctor about your work and any vibration-related problems before taking other medication (e.g. for cardiovascular disease, migraine, hormones, ADHD) so that the choice of medication does not aggravate your problems.
- **Other substances:** Avoid other substances that increase the risk of white fingers (e.g. cocaine, hashish, hallucinogens, etc.).
- Ensure that you dress appropriately and warmly! Be careful to keep your forehead and head warm. Adapt your clothing to accommodate significant temperature differences.
- Ensure that your work gloves are not too tight, as this impairs blood flow in the hands. The same applies to shoes and blood flow to the toes.
- Ensure that you are able to warm up and break attacks of white fingers as quickly as possible when they occur, as prolonged attacks worsen the damage.
- Avoid nicotine and tobacco, as nicotine increases the risk of white finger attacks and worsens the prognosis.
- Take care of your health through good diet, sleep, exercise and recovery – this also affects how you tolerate stress in the work environment.
- Severe sleep deprivation increases the risk of white finger attacks.
- Bear in mind that in the early morning (e.g. when scraping ice off your car windscreen on your way to work), there is an increased risk of getting an attack of white fingers. Therefore, adapt your clothing accordingly.

LINKS TO SECTIONS IN THE BOOK THAT YOU CAN PRINT SEPARATELY

- [Summary](#)
- [Checklist for new activities involving vibrations](#)
- [Checklist for activities where vibrations already occur](#)
- [Checklist for reducing exposure to hand-transmitted vibrations](#)
- [Checklist for reducing exposure to whole-body vibrations](#)
- [Checklist for supporting health factors in vibration exposure](#)
- [Checklist for early detection and treatment of injuries](#)
- [Information and training material for hand-transmitted vibrations](#)
- [Information and training material for whole-body vibrations](#)
- [Health surveillance questionnaire: Hand-transmitted vibrations](#)
- [Health surveillance questionnaire: Whole-body vibrations](#)
- [Example of documentation template.](#)

1. Working with vibrating machinery

Working with vibrating machinery is very common and a natural part of our everyday lives, both at work and during leisure time. Vibration refers to an object or surface moving back and forth. In the workplace, vibrations can occur when using machinery or vehicles that shake or vibrate. Sometimes there are also jolts or impacts. For example, a drill, a chainsaw or a lorry can cause vibrations.

Types of exposure

Vibrations can affect the body in different ways depending on which part of the body is exposed. Therefore, a distinction is made between two main types:

- **Hand-transmitted vibrations:** These occur when the hands are exposed to vibrations from hand-held machinery, such as screwdrivers, grinders and chipping hammers. Occupations that are particularly exposed include construction workers, fitters and electricians.
- **Whole-body vibrations:** These affect the entire body and occur when working in a vehicle or standing on a vibrating surface, such as in a car, tractor, forklift or lorry. Workers in industrial premises with vibrating floors may also be affected.

Vibrations are a common exposure in Swedish workplaces

Every day, around 500 000¹ employees in Sweden are affected by vibrations from hand-held machinery for more than a quarter of their working hours. In addition, around 450 000 people are affected by whole-body vibrations, for example from tractors or forklifts. The proportion affected has changed only marginally in recent decades. Men are affected more often than women, which can be partly explained by traditional gender roles in different industries.

Table 1.1 provides examples of different occupational groups where employees are at risk of exposure to hand-transmitted vibrations. Table 1.2 presents different types of sources that can cause whole-body vibrations.



Figure 1.1. Examples of work involving hand-transmitted vibrations (a) and whole-body vibrations (b).

¹ Swedish Work Environment Authority, Work Environment 2024, Work Environment Statistics Report 2025:01
<https://www.av.se/arbetsmiljoarbete-och-inspektioner/arbetsmiljostatistik-officiell-arbetskadestatistik/arbetsmiljon-2024/>

Table 1.1. Examples of occupations where employees are at risk of exposure to hand-transmitted vibrations.

HAND-TRANSMITTED VIBRATIONS
Construction workers
Rock and stone workers
Concrete workers
Construction workers
Electricians
Foundry workers
Mechanics
Fitters
Bricklayers
Park and property caretakers
Tinsmiths
Repairers
Plumbers
Carpenters
Welders
Dentists/dental technicians

Table 1.2. Examples of sources that can cause whole-body vibrations.

WHOLE-BODY VIBRATIONS
Construction machinery
Cars
Buses
Construction machinery
Aircraft
Excavators
Helicopters
Mills
Loaders
Trucks
Loading machinery
Forestry machinery
Stone crushers
Tractors
Forklift trucks

Vibration levels

Figure 1.2 shows the vibration levels for a selection of different types of hand-held machinery (regardless of manufacturer and year of manufacture).

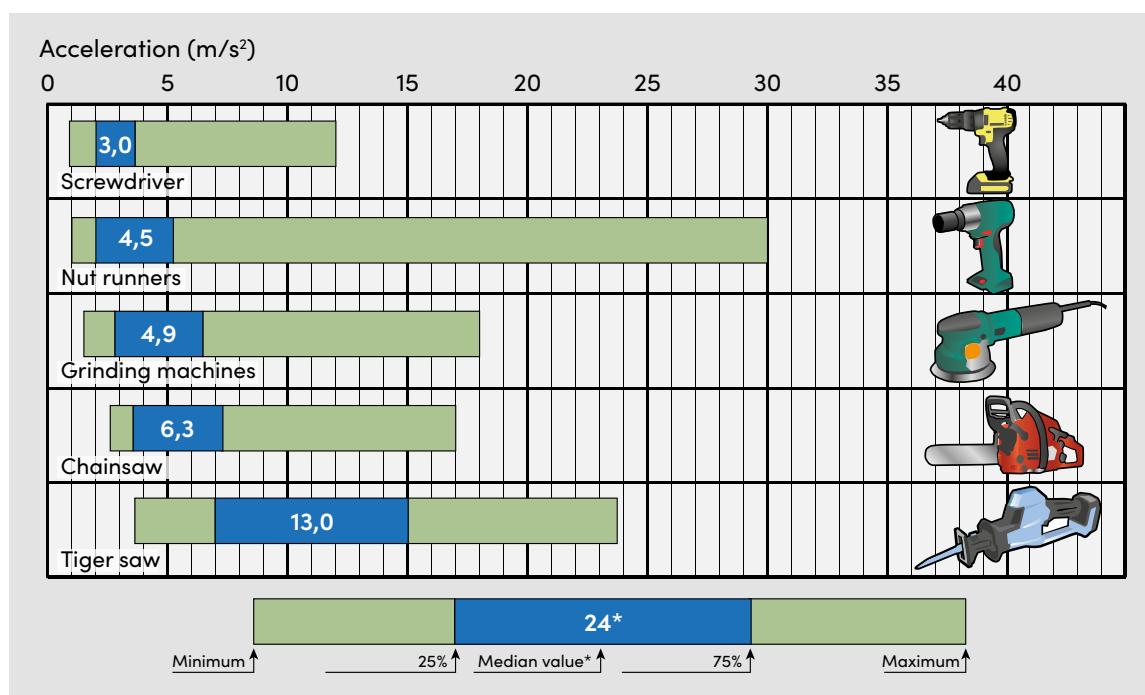


Figure 1.2. Examples of vibration values (m/s²) for a number of different and common hand-held machinery (data taken from the Vibration Database, Umeå University <http://www.vibration.db.umu.se/>).

Figure 1.3 shows the vibration levels for a selection of different types of vehicles and mobile work machinery.

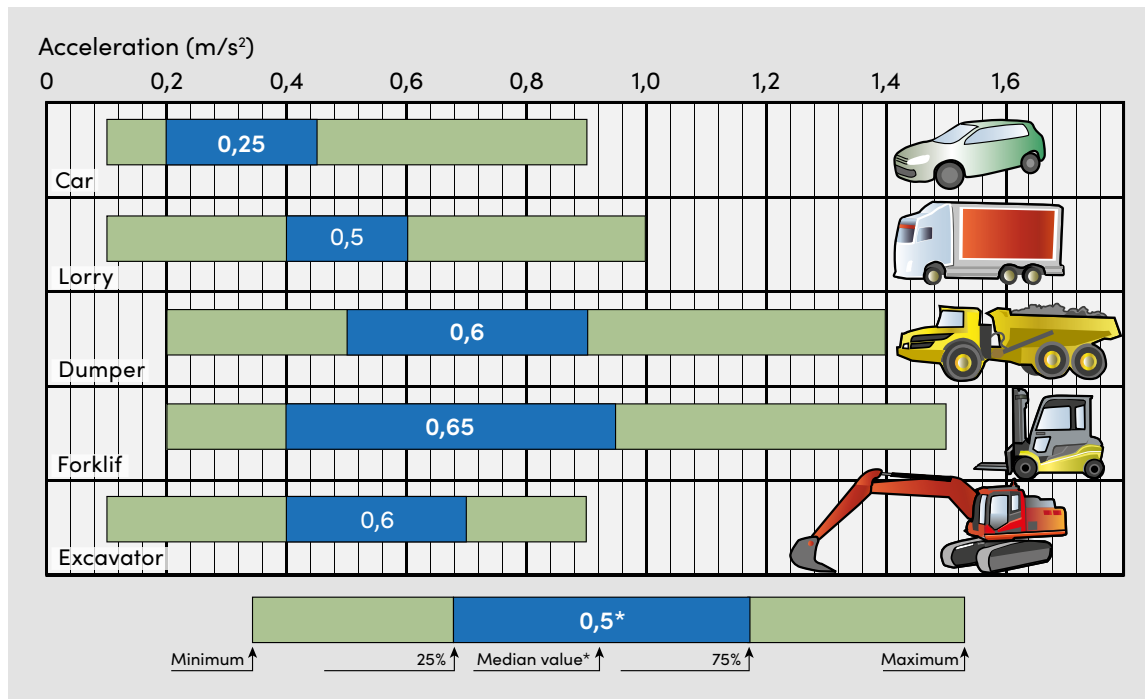


Figure 1.3. Examples of vibration values (m/s^2) for a number of different and common vehicles and mobile work machinery (data taken from the Vibration Database, Umeå University <http://www.vibration.db.umu.se/>).

As Figures 1.2 and 1.3 clearly illustrate, vibration levels can vary significantly even within the same category of machinery. This is due to a combination of factors.

For all vibrating machinery and vehicles, the design, age, power and any accessories of the machine or vehicle are of great importance. Working conditions and how the machine or vehicle is used also play a decisive role.

In the case of whole-body vibrations, the surface and speed also have significant impact on vibration levels. For hand-held machinery, the nature of the workpiece is a significant factor. The quality of accessories such as grinding discs and sanding paper is also crucial, as is the material being processed.

2. Injuries caused by working with vibrating machinery

Hand-transmitted and whole-body vibrations can damage the body. The damage is complex, variable and the mechanisms involved are not fully understood. Currently, disturbances in the blood supply are the best established cause of vibration damage to both nerves and blood vessels. Reduced blood flow and thus reduced oxygenation of the tissue over a longer period of time contribute to the damage. The extent of the damage caused by vibration exposure is greatly influenced by other individual and interacting factors. ([Appendix C](#)).

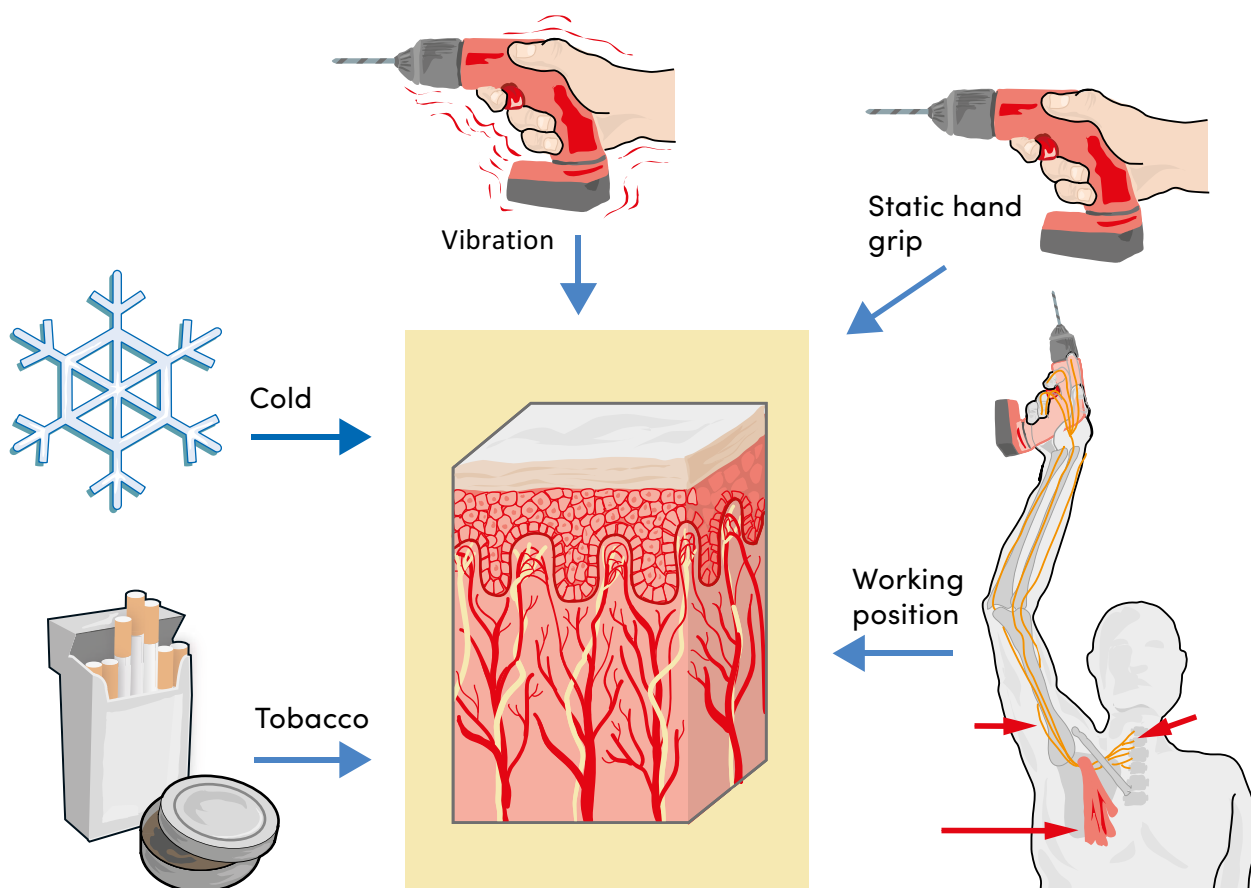


Figure 2.1. Blood flow to the tissue of the hand and fingers is affected by exposure to hand-transmitted vibrations, cold, nicotine and prolonged local pressure on the tissue, which disrupts blood and nerve flow. The effect is influenced by individual factors and other interacting factors.

Health effects of hand-transmitted vibrations

Acute effects of

Anyone holding a vibrating machine experiences the vibrations as a more or less distinct "tingling" sensation. We can feel if an object vibrates at a frequency of up to approximately 1200 Hz. If the vibrations have a higher frequency, we do not perceive the machine as vibrating (Appendix B).

Exposure to strong vibrations transmitted to the hand causes temporary impairment of blood circulation and overstimulation and fatigue of the sensory cells. This disrupts the fine motor skills and sensitivity of the hands. We often feel our fingers becoming cold and experience a "sugar drink sensation". This is completely normal. The symptoms may persist for a few minutes to an hour after exposure has ceased. Acute effects have mainly been demonstrated for machinery that vibrate at frequencies up to approximately 250 Hz.

There is no data on whether vibrations that we cannot feel (>1200 Hz) have acute effects.

Permanent damage

Temporary, recurring or prolonged exposure from working with vibrating machinery can cause a number of permanent injuries (Fig. 2:2). (In-depth section Appendix C Medical in-depth information) [16]. The injuries can occur after both short and long-term exposure. The risk of exposure to vibrations is cumulative with repeated exposure. When exposure to vibrations is intense, the damage can occur more quickly. Damage affects nerves (impaired nerve flow due to constriction in the carpal tunnel; carpal tunnel syndrome), the sense of touch (diffuse sensory impairment due to disturbances in the sensory organs), blood flow (increased vasoconstriction when exposed to cold, stress or vibrations, "white fingers" or "dead fingers") and the connective tissue of the hand (stretching defect of the fingers; Dupuytren's contracture, sometimes incorrectly referred to as "Viking disease") [10]. The injuries can also manifest themselves as increased sensitivity to cold and cold pain. When an injury is assessed to have been caused by vibrations, it can be specified as "vibration injury". The injury must then always be specified in terms of the type of injury and the degree of injury [6]. When several of these different injuries occur simultaneously and the injuries are related to vibration exposure, the injuries can collectively be referred to as vibration injury syndrome. The various injuries can occur separately or together.

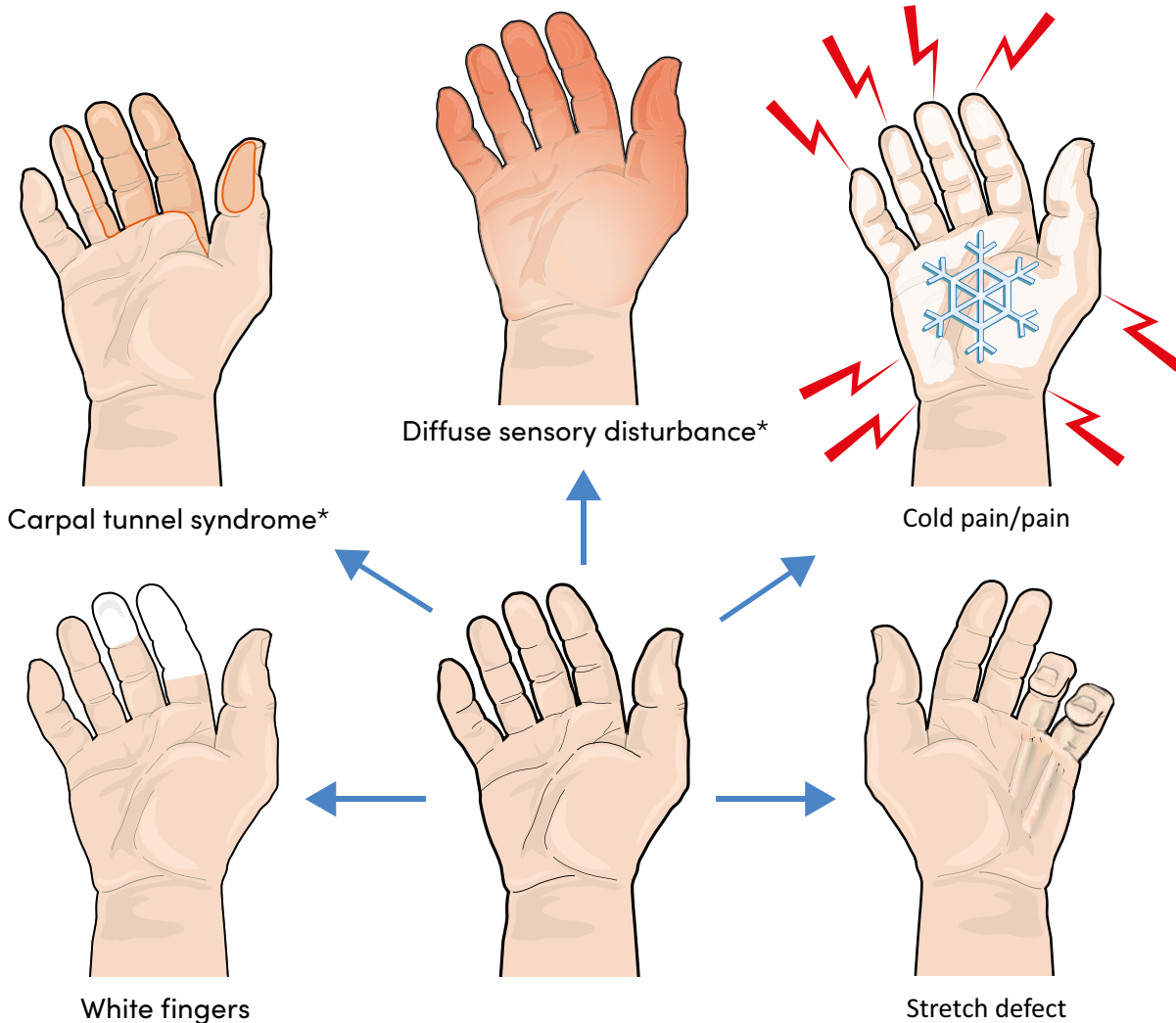


Figure 2.2. Working with hand-held vibrating machinery can lead to permanent nerve damage (nerve compression in the wrist, carpal tunnel syndrome), sensory impairment (diffuse sensory loss), blood circulation (white fingers), connective tissue defects that prevent the fingers from being stretched out (Dupuytren's contracture) and pain when exposed to cold. *Redness indicates areas with reduced sensation.

All injuries that we consider to be "vibration injuries" can also occur without any exposure to vibration. In such cases, the injury has another underlying cause. The doctor's assessment of the connection between the symptoms and exposure to vibration, as well as any other possible causes, determines when it can be classified as a vibration injury. There is a lack of knowledge about whether those who already have injuries from other causes also have increased sensitivity ([Appendix C Medical insight](#)) to vibrations. However, one can suspect common causal mechanisms that call for increased caution regarding further vibration exposure for these individuals.

It is not possible to predict who will suffer permanent damage from vibrations. Sensitivity and hand-transmitted exposure varies greatly between individuals. Some sensitive individuals are affected after only a short period of working with vibrating machinery, while for others it can take many years and sometimes no damage occurs at all.

The prognosis for damage from hand-transmitted vibrations is unfavourable. If serious damage from vibrations has occurred, there is currently very limited curative medical treatment available.

In addition to "vibration injuries", a single very powerful blow to the hand can damage the tissues in blood vessels, nerves, ligaments or joints.

Such injuries are classified as accidents in insurance medicine. Injury can also occur after striking oneself with the palm of the hand (hammer syndrome).

Repeated tissue-damaging impacts or blows can cause injuries in the form of crush injuries, pinching and pressure injuries, and if repeated, even fatigue damage to tissue. These injuries have causes other than vibration and should be named according to the exposure that primarily caused the injury. These injuries are not covered by the current risk assessment model for vibration.

Kraftergonomic overload on the musculoskeletal system can cause injuries that are often summarised as "strain injuries". These differ from vibration injuries in terms of the exposure that caused the injury and the tissues that were damaged (muscles, tendons, joints) (see separate regulations on hand-intensive work). Compression injuries to nerves (e.g. carpal tunnel syndrome) can be a vibration injury, a strain injury or a combination of these.

There are other exposures related to working with vibrating machinery that can also cause injury. These include, for example, noise exposure that causes "hearing damage" ([AFS 2023:10, see the chapter on noise](#)).

Health effects of whole-body vibration

Acute effects

Vibrations transmitted from the surface you are standing on (foot-transmitted vibrations) or sitting on (whole-body vibrations) also have acute effects. Foot-transmitted vibrations cause temporary effects with reduced general circulation. Whole-body vibrations (WBV), especially at low frequencies (below 5 Hz), have a tiring and soporific effect. Motion sickness (travel sickness) is another temporary discomfort that occurs in direct connection with exposure to WBV. It often manifests itself as nausea, dizziness, headache and fatigue.

Permanent damage

Exposure to foot-transmitted vibrations increases the risk of attacks of vasoconstriction in the blood vessels to the toes ("white toes").

Exposure to vibrations and shocks that affect the entire body can overload and damage muscles, bones, joints and ligaments, as well as disrupt the functioning of the body's nerves. The effects particularly affect the back and neck and mainly manifest themselves as pain [14], [17]. If the nerves in the back are affected, pain can radiate into the legs and arms (Fig. 2.3). Lower back and neck pain, with or without nerve radiation, can also occur without any exposure to whole-body vibrations.

Injuries are diagnosed based on medical history and examination findings, supported by X-rays (magnetic resonance imaging). X-ray findings do not always reflect the symptoms or the degree of discomfort. Pain, reduced ability to lift, twist, bend, stand, as well as weakness and sensory impairment are the dominant symptoms and can significantly reduce work ability.

Individual very powerful shocks or blows can damage the back and cause injury to the vertebral bodies (vertebral fracture). These injuries are classified as accidents in insurance medicine.

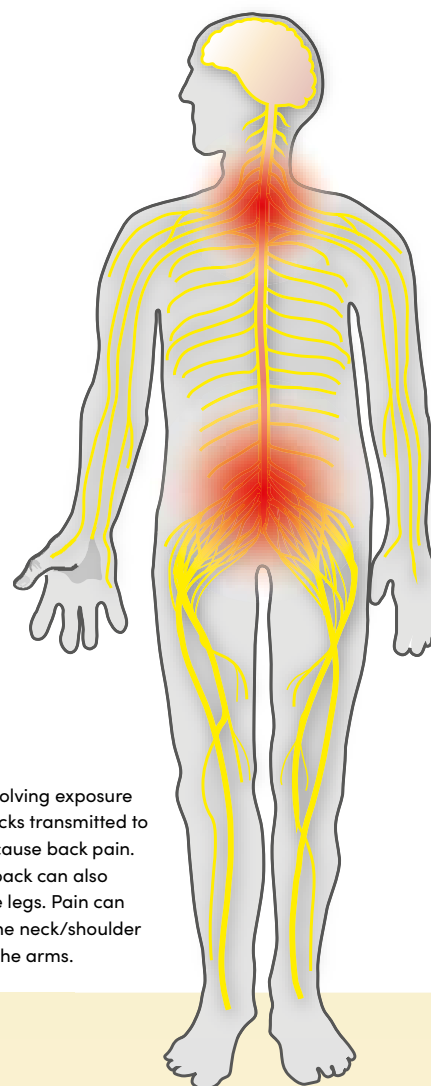


Figure 2.3. Work involving exposure to vibrations and shocks transmitted to the whole body can cause back pain. Pain from the lower back can also radiate down into the legs. Pain can also be localised to the neck/shoulder and radiate out into the arms.

3. Injury prevention measures

The following chapter provides an overview of how you, as an employer, can work systematically to reduce the risk of vibration injuries among your employees.

Focus on employee health

The employee and their health and well-being must always be the focus. We all have different conditions and vulnerabilities that require special consideration. Individual factors of particular importance include age, body type, education, physical condition, fitness, health or illness with any medication, as well as sensitivity to stress, fatigue and daily form. These factors are sometimes characterised as vulnerability factors, even though the same factors may constitute protective factors in other contexts.

The structure of the book is based on the Swedish Work Environment Authority's (AFS 2001:1) systematic work environment strategy for injury prevention (Fig. 3.1). The method is also clarified in Prevent's "Vibration Guide for Hand and Arm Vibrations" [11] and "Vibration Guide for Whole-Body Vibrations" [12].

The conceptual model is divided into four steps: 1. Injury prevention measures, 2. Monitoring or follow-up (referred to as control in the model), 3. Exposure review with identification of risk exposures (referred to as investigation in the model) and 4. Risk assessment where vibration exposure is compared with the regulatory exposure action value. The boundaries between these steps are not clear-cut, but fluid. The steps may overlap and the content of each step may vary between different users, professions and work environments. The important thing is that the various steps are carried out and followed up. Where you start arbitrary and depends, among other things, on whether work with vibrations already occurs at the workplace or whether the risk assessment applies to a new activity (Fig. 3.1).



Figure 3.1. Systematic work environment management is illustrated here as a continuous injury prevention effort that focuses on the health of the employee. The process includes an investigation to identify risk exposures, risk assessment, injury prevention measures, and follow-up with monitoring and control.



Figure 3.2. Example of a work environment where injury prevention measures are needed.

Strategy for injury prevention measures

The strategy can be divided into four areas of action (Fig. 3.3):

- Reducing and minimising exposures that cause harm,
- Early detection and treatment of injuries
- Reducing the effects of injuries that cannot be cured through work adaptation
- Supporting factors that contribute to maintaining health (supporting health factors).

The strategies often overlap and the boundaries between them can be fluid in practice. The injury prevention strategies differ mainly in that they address different stages in the development of an injury.

Reducing exposures that cause injury

Reducing or eliminating vibration exposure is the most important measure for preventing vibration injuries from occurring or worsening.

Early detection and treatment

Early diagnosis and treatment are important when injury is suspected. The aim is to detect and treat injuries early so that they can be healed. The preventive effect is reinforced by the employer simultaneously reviewing the work environment, renewing the risk assessment and implementing work environment measures (Medical Control AFS 2023:15) [2].

Reducing the consequences of injury

This preventive measure focuses on reducing the negative consequences of existing injuries that cannot be treated medically and on preventing further complications. This form of prevention includes work adaptation and functional preservation measures. This includes measures based on the employer's responsibility for work-oriented rehabilitation and possible redeployment or retraining.

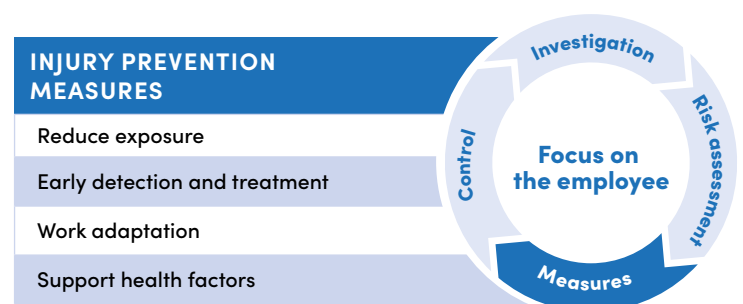


Figure 3.3. Injury prevention by minimising risk exposure, early detection and treatment of injuries, remedying untreatable injuries, through work adaptation and by supporting health factors.

Supporting health factors

Supporting health factors aims to reinforce factors that counteract the harmful effects of risk exposure. In many cases, health factors are the opposite of risk factors. Health factors include both organisational conditions such as the design of favourable wage systems, working hours, the balance between work and recovery, participation and influence, as well as the design of the working environment and individual factors. The latter includes supporting the individual's own abilities and behaviours that promote occupational health. The effect is often channelled by changing the direct exposure of the worker, strengthening resistance to the harmful effects, and modifying the influence of other interacting factors. Exposure risks are mainly managed by the worker acquiring and utilising abilities and developing skills that modify the transfer of vibrations from the machine to the worker. This may include, for example, education and training in how hard machinery should be gripped optimally, or machine operators learning to adjust the speed of the vehicle based on knowledge of the ground conditions.

4. Monitoring and control

Investigation of the working environment and risk assessment are justified by information about workers’ health, work ability, production, comfort, exposure and the costs of injuries. (Chapter 5). Monitoring also includes following up on whether measures have had the desired effect.

The information gathered from monitoring and control determines whether the working environment needs to be investigated further. Reasons for investigating the working environment may be based on information provided by employees, health and environmental surveys, or the results of targeted medical examinations. Vibration levels provide a basis for assessing exposure risks. The impetus for further injury prevention measures is also influenced by the severity of the consequences when someone is injured. Information about the severity of injuries, prognosis, impact on work ability and disability justifies injury prevention, regardless of the individual’s suffering. Deviations from the Swedish Work Environment Authority’s regulations can also lead to additional costs in the form of fines.

The need for a work environment investigation should be based on a balanced assessment of all of the following indicators, see Fig. 4.1 (see clarifications and explanations in the in-depth text in Appendix A):

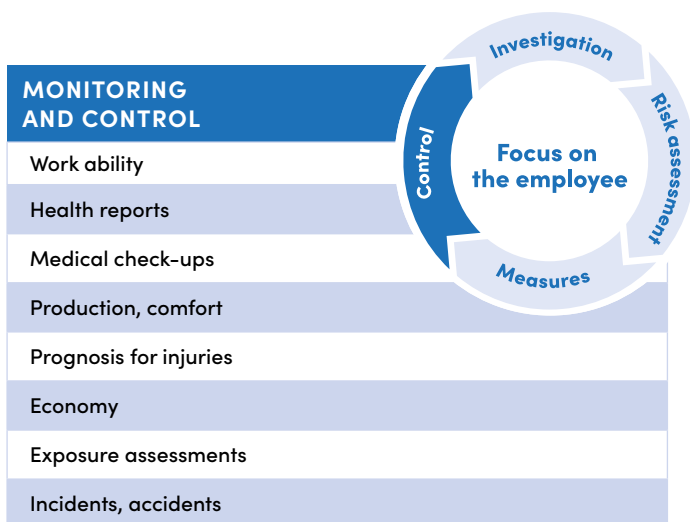


Figure 4.1. Sources of information that can be used for continuous monitoring and follow-up of injury prevention measures. The results may provide grounds for further investigation of the work environment.

- 1. Work ability:** Vibrations can lead to both acute and permanent impairments of work ability [7], including reduced fine motor skills, impaired blood circulation, nerve damage and difficulties in performing fine motor tasks and gripping with force.
- 2. Reported health:** Information from employees and safety representatives about perceived health problems can signal risks and justify a renewed risk assessment [13].
- 3. Medical checks:** Regular statutory medical checks can identify and prevent health problems linked to vibration exposure at work [2, 6].
- 4. Comfort, performance and production:** The impact of vibrations on work performance and comfort can indicate early signs of production disruptions and adverse vibration effects.
- 5. Prognosis of injuries:** The prognosis for injuries is often unfavourable, which particularly justifies active preventive work.
- 6. Economic consequences of injuries:** Exposure to vibration can lead to claims for financial compensation and significant occupational injury compensation, in addition to costs for sick leave and lost production. The Swedish Work Environment Authority may impose fines if the regulations are not complied with (Appendix A).
- 7. Exposure and risk assessment:** Risk assessment of vibration exposure involves comparing the estimated daily exposure with the Swedish Work Environment Authority’s regulations (AFS 2023:10 [1]) and taking action if the exposure action value is exceeded.
- 8. Incidents and accidents:** Vibration exposure can contribute to incidents and accidents due to changes in sensory perception, motor skills or balance.

5. Investigation of the work environment

The working environment is usually examined as a natural part of everyday work. Sometimes a supplementary review is required based on knowledge of known risk exposures. The investigations are motivated and guided by the information that has emerged during monitoring and control. A broad investigation of the working environment aims to identify all possible risk exposures (Fig. 5.1).

In practical terms, the investigation of the working environment can be carried out as a workplace investigation or by identifying risk exposures using checklists. The following factors are taken into account in a broad workplace analysis: the surrounding environment, the workplace, the workstation, work tasks and the transmission of vibrations to the worker. The extent of exposure in terms of exposure time and exposure level is measured or assessed.

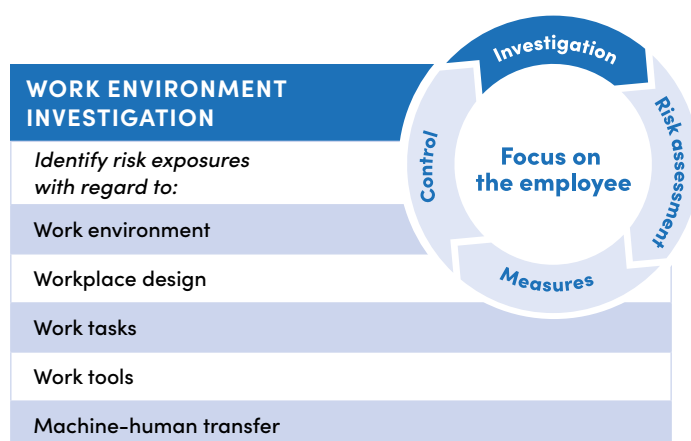


Figure 5.1. In addition to assessing vibration exposure, the working environment may also require a targeted systematic review to identify risk exposures in the surrounding environment, work premises, workplace, work tasks and the transmission of vibrations from machine to human.

6. Risk assessment

Risk describes the probability of an adverse effect. Here, risks are limited to health and work ability. Assessing risk exposure requires answers to the following questions:

1. How likely is it that exposure will cause harm?
2. How serious or severe will the consequences of the injury be?
3. How do society and the authorities accept the risk?

The probability of injury is based on statistics, theory, experimental results or summary assessments by experts. Knowledge of the relationship between exposure and injury makes it possible to identify risk exposures.

The consequences of a risk exposure are injuries. The consequences can be a more or less serious injury, mild to severe ill health or death. The consequences of a risk exposure can also be formulated as an economic cost.

Risk assessment involves three steps: an exposure assessment, which involves assessing whether identified exposures may pose a risk; an assessment of the extent of the exposure (dose) and thus the likelihood of harm; and finally, a risk evaluation. The risk evaluation involves assessing whether the exposure risk is acceptable or unacceptable. In some contexts, including the Swedish Work Environment Authority, the term risk assessment also refers to risk evaluation.

The risk assessment for vibrations is based on the results of workplace environment surveys (Fig. 6.1). In addition to vibrations, risk exposures also include cold, machine weight, feed force and gripping force (Fig. 2.1). The latter is important as these factors affect blood circulation. A prolonged reduction in blood supply due to continuous pressure from static hand grips increases the risk of injury. If it is not possible to take

micro-breaks ([Appendix C](#)) (relaxing for a few seconds), which allow the blood vessels to open and enable the blood to reoxygenate the tissue, the risk of injury increases.

Time spent in continuous vibration exposure becomes critical. Production and compensation models that affect the possibility of micro-breaks therefore indirectly influence the risk of injury. Piecework and piece rates in particular can influence whether workers take micro-breaks or experience increased stress. Vibration exposure under such wage systems, where the opportunity to take micro-breaks and breaks can be difficult, has repeatedly been shown to result in a higher incidence of white finger syndrome.

The assessment of risk exposure also includes an assessment of vibration levels and exposure time.

The final risk assessment also includes a risk evaluation. This involves an assessment of whether the exposure is acceptable based on societal norms and criteria. For vibrations, the result of the exposure assessment can be compared with the exposure action value. The current exposure action value is based solely on the risk of developing white finger syndrome ([Appendix C](#)), but is still considered to provide reasonable protection against all types of injury.

There are no criteria for assessing health risks from cold or prolonged blood flow disruption due to pressure on skin tissue. There is also a lack of specific consideration for individual vulnerability factors, such as stress, age, gender, other illnesses or medication. Currently, there are also no specific risk models for assessing the risk of nerve, sensory and connective tissue damage.

Regardless of knowledge gaps, the employer's risk assessment should always be based on whether the employee's exposure at work could pose a risk and whether risk exposure can be reduced. A risk assessment should always be carried out, even for factors for which there are currently no exposure limit or action values.

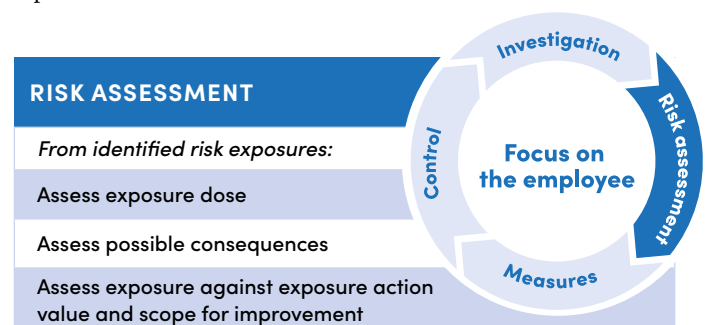


Figure 6.1. Risk assessment involves assessing the level of exposure based on identified risk exposures. At the same time, the possible consequences of the exposure are assessed. Finally, the exposures are evaluated against relevant guidelines in terms of exposure action value and exposure limit value – to identify any room for improvement.

7. How you as an employer can prevent injuries

This section provides a comprehensive overview of how you as an employer can work practically and systematically to reduce the risk of vibration-related injuries.

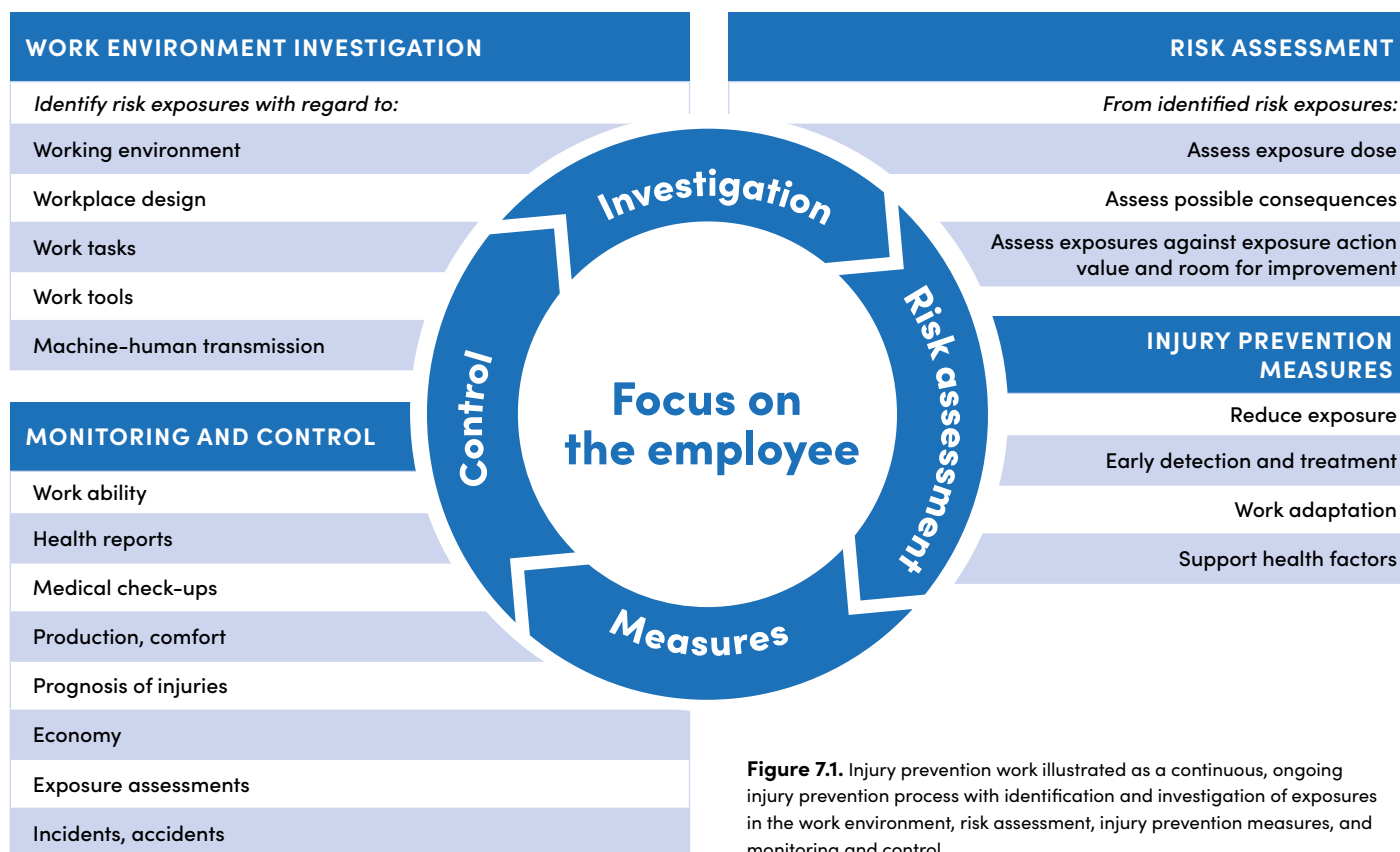


Figure 7.1. Injury prevention work illustrated as a continuous, ongoing injury prevention process with identification and investigation of exposures in the work environment, risk assessment, injury prevention measures, and monitoring and control.

General principles

Regardless of the situation, systematic work environment efforts are required, including regular inspections of the work environment, risk assessments, measures and follow-ups. Keep in mind that vibrations are rarely the only problem; take other factors into account, such as noise, cold, stress and ergonomics [5].

Always collaborate with employees, trade unions and safety representatives at work. Ensure that all concerned have sufficient knowledge of the risks associated with vibration and how to protect themselves. Document all measures and evaluate their effectiveness regularly.

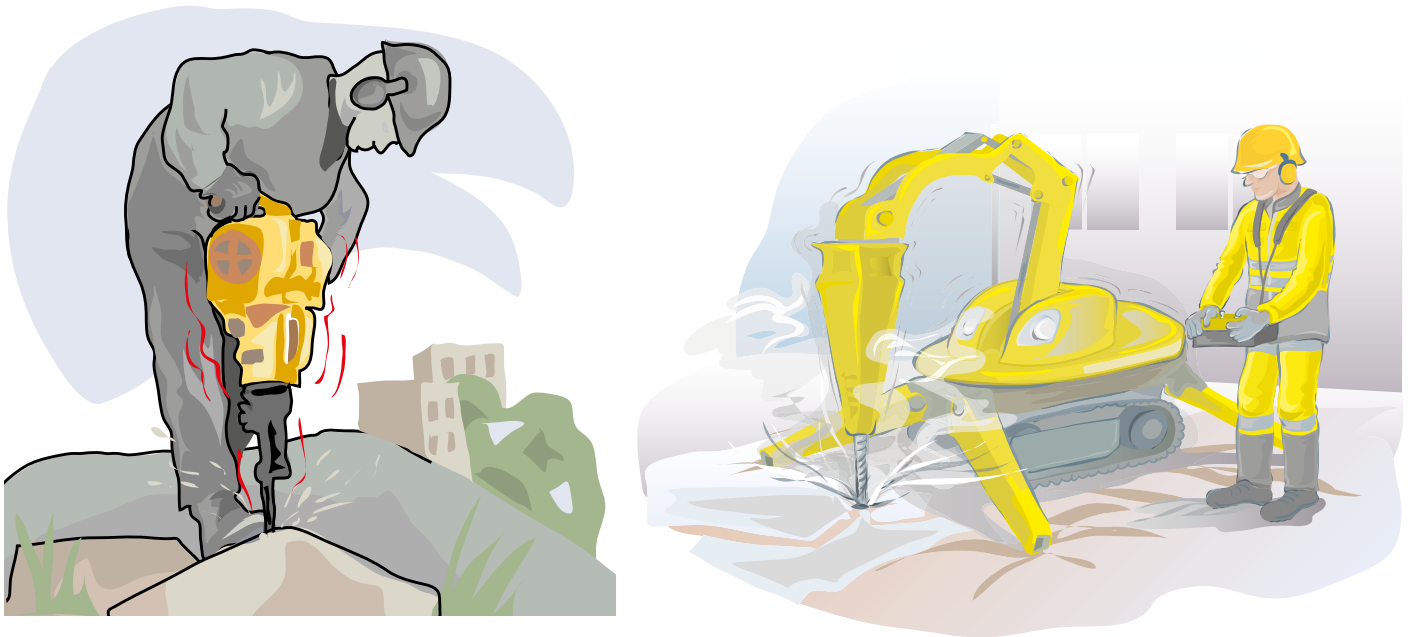


Figure 7.2. One example of an injury prevention measure is to replace manual chiselling work with remote-controlled chiselling robots.

When planning new or changed work

Even at the planning stage, you should strive for a working environment that is as vibration-free as possible. Incorporating strategies to minimise or eliminate vibrations at an early stage is not only an investment in the health of your employees, but also a financially beneficial measure. Adapt workplaces and equipment to avoid vibrations, and ensure that no one is exposed to vibrations for too long by using job rotation. Choose machinery with low vibration levels and ensure that the terms of employment are clear, and that vibration work is not linked to performance-based pay. Arrange [2] and offer medical check-ups before work commences.

In existing operations where vibrations already occur

Prioritise employee health by following the Swedish Work Environment Authority's regulations and actively working to reduce vibrations. Keep in mind that both the magnitude of the vibrations and the exposure time are important when it comes to the risk of adverse effects among employees. Therefore, replace heavily vibrating machinery and maintain existing ones regularly. Reduce exposure time by reducing the time employees are exposed to vibrations, use job rotation and ensure that employees take breaks. Prioritise the health and well-being of employees by ensuring that they have access to gloves, protective equipment and warm clothing. Remember that sensitivity to vibrations can vary between individuals, so be attentive and responsive to any problems. Create a pleasant working environment with well-maintained premises and heated break rooms for those who need them. Organise and offer [2] medical check-ups.

Dealing with discomfort

Ensure that procedures are in place to detect problems early on. Offer help and support to those who have experienced problems or injuries. Adapt work tasks to suit those who have been injured.

Health factors

Help employees develop the ability to recognise and manage their body's signals. Ensure that employees understand which symptoms are important to be aware of. Help employees develop the skills to perform their work safely. Create a good working environment with a good pay system and opportunities for co-determination. Encourage a healthy lifestyle.

Important!

Seek help from a health and safety expert if you need more detailed information and assistance with conducting a risk inventory and risk assessment. Remember that it is important to combine different measures to achieve the best results. By following these guidelines, you as an employer can create a workplace where the risk of vibration injuries is minimised and where everyone can work safely and efficiently.

Use checklists

Chapter 8, Materials for injury prevention measures, section "Checklists" contains a summary of various measures to facilitate the work. These checklists are designed to be adapted to the specific needs and industry of your business. It is important to involve all relevant parties in the work to ensure that all aspects are taken into account.

Remember that the checklists are a guide and that other measures may be more relevant to your workplace. The most important thing is to work systematically to identify and address risks associated with vibration exposure.

8. Materials for injury prevention measures

The following chapter offers practical material that can be used to prevent injuries caused by vibration.

Information and training materials

Knowledge is the single most important factor in preventing injuries. Here we provide suggestions for a simple training programme on working with hand-transmitted and whole-body vibrations. The study material contains a list of recommendations specifically for working with hand-transmitted and whole-body vibrations. The content can be used as discussion points for information, knowledge transfer and training.

Material for health monitoring

This section presents questionnaires that you, as an employer, can use for annual workrelated health monitoring. The questions are intended to complement the statutory medical examinations that are carried out every three years. Workers exposed to whole-body vibrations are also covered by medical examinations when the exposure action value is exceeded.

Here we propose a supplement to medical checks for whole-body vibrations in the form of health surveillance using a questionnaire aimed at those who work with whole-body vibrations. If the results show new problems or a deterioration, this justifies measures to reduce the risks. The questionnaire is accompanied by a proposal for interpreting the results and measures for further action.

Checklists for measures

The table of contents in the section on monitoring (Chapter 4) contains points that can be used as a checklist for monitoring. Similarly, the points in the section on investigating the working environment (Chapter 5) can be used as a checklist for investigating the working environment. Specific, detailed checklists are presented here for injury prevention measures in both new and ongoing activities involving exposure to vibration. The checklists provide suggestions for measures aimed at reducing exposure to hand-transmitted and whole-body vibrations, for early diagnosis and for supporting health factors.

Examples of how results can be documented

The results of surveys conducted on identified risk exposures, risk assessments and decisions on further planning shall be documented in writing. Here are some simplified suggestions for the content of such a documentation template. These documents should be shared with employees and with the occupational health service doctor prior to medical examinations, and with the Health and Safety Executive during inspections.

Information and training

The employer is responsible for informing and training all employees who are exposed to vibrations at work. The employer must also follow up and ensure that the information and training has led to understanding among the employees. This training can be done through self-study or led by an instructor. Suitable instructors may be health and safety specialists, production managers, occupational health services or representatives from machine manufacturers. Training and information should be carried out in dialogue and collaboration with trade union representatives and safety representatives.

Contents:

The following pages contain written information material, both for workers affected by vibrations transmitted from machinery and tools to the hands, and for workers affected by whole-body vibrations. The information material should be translated and adapted to the employee's language (use translators available via the internet).

Preparations

- Copy the relevant information material for all participants.
- Relevant health monitoring forms are copied for all participants.
- Also bring instruction manuals for the machinery/vehicles used.
- Bring a summary of the risk assessment carried out at the company and the action plan that has been drawn up.

Structure and implementation of oral teaching

- Go through the various sections of the information material orally.
- Discuss each part and explain the importance of paying attention to early signs of adverse health effects and how the employee can access medical check-ups.
- Present the risk assessment that has been carried out and highlight the particularly stressful work tasks.
- Present the action plan that has been developed to reduce adverse health effects.
- Explain the health monitoring form, its purpose and why employees should fill it in.
- Follow up on knowledge acquisition and answer questions.



Hand-transmitted vibrations

HAND-TRANSMITTED VIBRATIONS OCCUR WHEN WORKING WITH HANDHELD MACHINERY

Hazardous properties

Acute, temporary effects: Impaired blood circulation in the fingers, reduced sensitivity and effects on muscles. Risk of accidents.

Long-term effects: Vascular damage ("white fingers"), nerve damage (impaired sensation), connective tissue damage (Dupuytren's contracture), cold pain, and muscle and joint damage.

Safe working practices and personal protection

- **Instructions for use:** Always read and follow the instructions for use for machinery and tools. Make sure you understand the content.
- **Avoid overloading** machinery.
- **Use additional handles**, if available, that are designed for the machine for better control and safety.
- **Never hold the tool part** (socket, chisel, drill) during operation.
- **Never run machinery at idle speed** more than necessary.
- **Replace worn accessories** (grinding discs, bits, chisels) regularly.
- **Accessories:** Only use accessories recommended by the manufacturer.
- **Maintenance:** Perform regular maintenance on machinery and tools.
- **Store machinery** in a dry and suitable place, protected from moisture and temperature fluctuations.
- **Working position:** Avoid working positions that strain the body, as well as prolonged static loads.
- **Protective equipment:** Always use personal protective equipment that is suitable for the work, e.g. work gloves to keep your hands warm, hearing protection and safety goggles.

Health and safety

- **Avoid smoking and using snuff** when working with vibrating machinery.
- **Learn to recognise early signs** of overexertion, pain or other discomfort.
- **Learn to hold and grip handles** with the least possible grip and feed force.
- **Learn to choose clothing** that keeps you warm and comfortable.
- **Take breaks** and micro-breaks if you feel tired or uncomfortable.

Report back

If you have difficulty working with your hands (white fingers, numbness, aching, pain), report this to your immediate supervisor as soon as possible.

Applicable regulations

The Swedish Work Environment Authority's regulations and general advice ([AFS 2023:10](#)) on risks in the work environment.



Whole-body vibrations

WHOLE-BODY VIBRATIONS OCCUR WHEN USING MOBILE MACHINERY SUCH AS FORKLIFTS AND CONSTRUCTION MACHINERY

Hazardous properties

Whole-body vibrations can cause unfavourable pressure on nerves, overload muscles and joints, and strain the supporting structures (ligaments) of the back.

Long-term effects: The strain increases the risk of permanent injury or illness, especially in the back and neck, with or without nerve radiation. Foottransmitted vibrations can cause "white toes".

Safe driving and working environment

- **Instructions for use:** Always read and follow the instructions for use for all vehicles and machinery. Make sure you understand the content.
- **Adjust the driver's seat:** Adjust the seat, backrest, armrests and seat belt to achieve a comfortable and safe working position. Avoid sitting in a bent or twisted position.
- **Drive calmly and carefully:** Adjust your speed to road conditions and visibility. Avoid sudden manoeuvres and braking.
- **Choose suitable roads:** Avoid driving on uneven/poor roads as far as possible.
- **Ensure a safe working temperature:** Make sure the temperature in the cab is suitable. Avoid cold, draughts and overheating.
- **Perform regular maintenance:** Follow the maintenance schedule to ensure that vehicles and machines are in good condition.
- **Take regular breaks:** Plan regular breaks to rest and move around. Get out of the vehicle/machinery and stretch your legs.

- **Avoid heavy manual lifting** when loading.
- **Use personal protective equipment:** Always use the protective equipment required for the job, for example:
 - Safety helmet:** When working outside the vehicle or when there is a risk of falling objects.
 - Hearing protection:** If the noise level is high.
 - Protective gloves:** When handling loads or tools.
 - Protective footwear:** To protect feet from sharp objects and slipping.
 - Safety glasses:** When there is a risk of splashes or particles.

Health and safety

- Avoid smoking and using snuff
- Learn to recognise early signs of overexertion, pain or other discomfort.
- Learn to anticipate where and when impacts may occur.
- Learn how to adjust your chair and seat cushion for optimal ergonomics and shock absorption.
- Learn to adapt clothing that keeps you warm and comfortable.
- Take breaks if you feel tired or uncomfortable.

Report back

If you experience pain in your back or neck, report it to your immediate supervisor as soon as possible. Also report any pregnancy.

Health surveillance questionnaire*

HAND-TRANSMITTED VIBRATIONS

Name: _____

Date: _____

Year-month-day: _____

Workplace: _____

DO YOU EXPERIENCE:	NO	SOMEWHAT	YES, QUITE A LOT	IF "QUITE A LOT" IS A NEW DISTURBANCE OR A DETERIORATION OVER THE PAST YEAR?
A. Reduced ability to work due to one or more fingers turning white in damp or cold conditions?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
B. Reduced ability to sleep at night due to pain or numbness in the fingers at least once a week?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
C. Reduced ability to feel touch in your fingers?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
D. Reduced ability to feel warmth in your fingers?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
E. Reduced ability to feel cold in your fingers?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
F. Reduced ability to feel vibrations in your fingers?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
G. Reduced strength in fingers?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
H. Reduced work ability due to numbness or tingling in fingers?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
I. Reduced work ability due to pain when your fingers get cold?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
J. Reduced ability to fasten buttons?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
K. Reduced work ability due to clumsiness in your fingers?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
L. Reduced work ability due to pain in fingers/hand/forearm/elbow?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES

* Questionnaire for employers to use in health monitoring.

Interpretation and measures:

HEALTH SURVEILLANCE FOR HAND-TRANSMITTED VIBRATIONS

– EXAMPLE OF COMPLETED FORM WITH SUGGESTIONS FOR INTERPRETATION AND ACTION

DO YOU EXPERIENCE:	NO	SOMEWHAT	YES, QUITE A LOT	IF "QUITE A LOT" IS A NEW DISTURBANCE OR A DETERIORATION OVER THE PAST YEAR?
A. Reduced ability to work due to one or more fingers turning white in damp or cold conditions?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
B. Reduced ability to sleep at night due to pain or numbness in the fingers at least once a week?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
C. Reduced ability to feel touch in your fingers?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> YES
D. Reduced ability to feel warmth in your fingers?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
E. Reduced ability to feel cold in your fingers?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
F. Reduced ability to feel vibrations in your fingers?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> YES
G. Reduced strength in fingers?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
H. Reduced work ability due to numbness or tingling in fingers?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
I. Reduced work ability due to pain when your fingers get cold?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> YES
J. Reduced ability to fasten buttons?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> YES
K. Reduced work ability due to clumsiness in your fingers?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
L. Reduced work ability due to pain in fingers/hand/forearm/elbow?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES

Interpretation and action

If any of the questions A to L are answered with "Yes, quite a lot", arrange a medical examination ([AFS 2023:15](#)) in accordance with the Swedish Occupational Health Service's guide [6]. If the answer is also "yes" to the question of whether the symptoms are "a new disorder or a deterioration" over the past year:

- Conduct an investigation of the work environment with a renewed assessment of risk exposures, especially if several employees have reported similar new problems or deterioration, and
 - Take measures to reduce risk exposure. Coordinate preventive work using checklists ([Checklists, p. 32](#)).
 - Consider further investigation with MEBA diagnostics [15].
 - If there are indications of illness or suspected illness, refer the employee to healthcare services with the support of occupational health.
 - In this example, the employer must arrange [2] a medical examination and conduct a review of the work environment with a renewed risk assessment and measures.

Health surveillance questionnaire*

WHOLE-BODY VIBRATIONS

Name: _____

Date: _____

Year-month-day: _____

Workplace: _____

DO YOU EXPERIENCE:	NO	SOMEWHAT	YES, QUITE A LOT	IF "QUITE A LOT" IS A NEW DISTURBANCE OR A DETERIORATION OVER THE PAST YEAR?
A. Reduced ability to sleep at night, at least once a week due to pain?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
B. Reduced ability to lift heavy objects?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
C. Reduced ability to walk?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
D. Reduced ability to sit?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
E. Reduced ability to stand?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
F. Reduced ability to turn your neck?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
G. Reduced ability to turn the whole body?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
H. Reduced ability to bend down towards the floor?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
I. Reduced ability to work with arms above shoulder height?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
J. Reduced work ability due to pain, numbness, tingling in the arm, fingers/hand?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
K. Reduced work ability due to pain, numbness or tingling in legs and feet?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES

* Questionnaire for employers to use in health monitoring.

Interpretation and measures

HEALTH SURVEILLANCE FOR WHOLE-BODY VIBRATIONS

– EXAMPLE OF A COMPLETED FORM WITH SUGGESTIONS FOR INTERPRETATION AND ACTION

DO YOU EXPERIENCE:	NO	SOMEWHAT	YES, QUITE A LOT	IF "QUITE A LOT" IS A NEW DISTURBANCE OR A DETERIORATION OVER THE PAST YEAR?
A. Reduced ability to sleep at night, at least once a week due to pain?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> YES
B. Reduced ability to lift heavy objects?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> YES
C. Reduced ability to walk?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> YES
D. Reduced ability to sit?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> YES
E. Reduced ability to stand?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
F. Reduced ability to turn your neck?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> YES
G. Reduced ability to turn the whole body?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
H. Reduced ability to bend down towards the floor?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/> YES
I. Reduced ability to work with arms above shoulder height?	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
J. Reduced work ability due to pain, numbness, tingling in the arm, fingers/hand?	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/> YES
K. Reduced work ability due to pain, numbness or tingling in legs and feet?	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> YES

Interpretation and action

If any of questions A to K are answered with "Yes, quite a lot" and if the answer is also "yes" to the question of whether it is "a new disorder or deterioration" in the last year:

- Update the assessment of the working environment with an assessment of risk exposures, especially if several employees have reported similar new problems or deterioration, and
- Take measures to reduce risk exposure. Coordinate preventive work using checklists ([Checklists, p. 32](#)).

- Consider further investigation with MEBA diagnostics (MEBA [15] and/or a medical examination.
- If there are indications of illness or suspected illness, refer the employee to healthcare services with the support of occupational health.

In this example, it is recommended that the work environment be reviewed (renewed assessment of risk exposures and risk assessment) and remedied, and that the employee's problems be referred to healthcare services for investigation and treatment with the support of occupational health services.



Employer's checklists for managing vibration risks

These checklists are designed as a flexible basis that you can easily adapt to your specific business and industry-specific challenges. To ensure that all relevant aspects are covered, it is crucial to involve all relevant employees in this work.

Remember that these checklists are only a support for your systematic work environment efforts. Depending on your specific situation, there may be additional measures that can be even more effective in managing risks associated with vibration exposure. The key is to work in a structured manner to identify, assess and address these risks on an ongoing basis.

In this material, you will find checklists for the following areas:

- **New start:** Before starting a new business involving vibration risks, ensure you have a solid foundation from the outset.
- **Existing activities involving vibrations:** Assess and improve your current situation.
- **Reduce exposure to hand-transmitted vibrations:** Practical measures to protect your employees.
- **Reducing exposure to whole-body vibrations:** Strategies to minimise the impact on the whole body.
- **Early detection and management of vibration-related injuries:** Measures to protect health.
- **Promoting health factors during vibration exposure:** Measures to enhance well-being.

Checklist for new activities involving vibrations

CHECKLIST FOR MEASURES IN NEW ACTIVITIES INVOLVING BOTH HAND-TRANSMITTED AND WHOLE-BODY VIBRATIONS.

Working environment and premises

Design:

- Are the working environment and premises designed to promote a good working environment?
- For outdoor work, are there shelters from wind and rain, heated break rooms, and work clothes that are right for the job?
- Are the temperature, noise level, ventilation and lighting optimised for employees?

Division of labour:

- Are tasks distributed efficiently between employees and machinery?
- Are tasks designed to minimise physical strain and vibration exposure?

Ergonomics:

- Is the number of employees adapted to the tasks to ensure good ergonomics?
- Are workplaces and equipment adapted to employees to minimise adverse strain?

Personnel and Organisation

Terms of employment:

- Are terms of employment clearly defined and communicated to employees?
- Do the terms include individualised work schedules, pay and other benefits?

Training:

- Has the staff received basic training on vibration injuries, working techniques and methods, and safety for a safe and efficient work process?
- Has the staff received training on the requirements for medical examinations?

Equipment and Materials

Procurement:

- Are the machinery, personal protective equipment and work aids selected and procured to minimise the impact of vibration?
- Is the machinery and the personal protective equipment CE-marked?

Additions for maintaining efficiency

Process optimisation:

- Have all processes been evaluated to ensure optimal efficiency?
- Are there opportunities to automate or simplify work tasks?

Communication:

- Are there clear communication channels and regular meetings to ensure that everyone is informed and working towards the same goals?

Monitoring and control:

- Are there systems in place to measure and follow up on results, identify areas for improvement, and have the measures been sufficient?

Checklist for activities where vibrations already occur

CHECKLIST FOR MEASURES IN ONGOING ACTIVITIES FOR BOTH HAND-TRANSMITTED AND WHOLE-BODY VIBRATIONS.

Legislation and monitoring

- Control:** Are the Swedish Work Environment Authority's regulations on vibrations (AFS 2023:10) being complied with?
- Compliance:** Are regular checks carried out to ensure that all guidelines are being followed?
- Documentation:** Is there clear documentation of checks carried out and any deviations, including analysis of incidents and accidents?

Reduce vibration exposure

- Machine replacement:** Has an inventory been made of machinery that cause high vibration levels? Is it possible to replace these with better machinery with lower vibration values? Have low-vibration machinery been requested when purchasing or renting?
- Working methods:** Have working methods and techniques been analysed to identify opportunities to reduce vibration exposure?
- Maintenance:** Is regular maintenance carried out on work equipment to minimise vibrations?

Reduce other unfavourable occupational exposures

- Environmental climate:** Have factors such as cold, humidity and noise been evaluated to see how they affect vibration exposure and the overall working environment?
- Working positions:** Have working positions been analysed to ensure that they are ergonomic and minimise strain on the body?
- Breaks:** Are there sufficient opportunities for employees to take breaks and rest during work?

Aspects to consider

- Sensitivity:** Has consideration been given to workers with sensitivities that may adversely affect the effects of vibration?
- Adaptations:** Have special measures been taken to adapt the work for these employees?
- Follow-up:** Is the health status of these employees monitored regularly?

Training

- Knowledge:** Have all employees received training on the risks of vibration exposure?

Have all employees received training on the requirements for medical examinations?

- Protective measures:** Have employees received training on how to use personal protective equipment and other protective measures?
- Working techniques:** Have employees received training in correct working techniques to minimise vibration exposure?

Checklist for reducing exposure to hand-transmitted vibrations

THE ACTION LIST IS INTENDED TO ENSURE THAT THE COMPANY HAS A PLAN TO REDUCE EXPOSURE TO HAND-TRANSMITTED VIBRATIONS.

Machinery selection and maintenance

Machinery selection:

- Have machinery been selected with the lowest possible vibration levels?
- Are the manufacturers' declared vibration data compared when purchasing or renting?
- Is priority given to machinery with high quality, ergonomic design, low weight and robust construction?
- Is machinery stored in heated areas?
- Are machines with vibrations above 10 m/s^2 only used in exceptional cases?

Accessories and tools:

- Are only the manufacturer's recommended tools and accessories used?
- Have high-quality tools and accessories been selected to minimise imbalance and vibration?

Service and maintenance:

- Is regular servicing and maintenance carried out in accordance with the manufacturer's instructions?
- Are employees informed about the importance of reporting machinery faults?

Replacement of machinery:

- Are there plans to regularly replace machinery that are more than 5 years old?
- Is technological development being utilised to obtain machinery with lower vibration levels and maintained performance?

Working environment and work routines

Work premises:

- Are the work premises designed to promote a good working environment?
- For outdoor work, are there heated break rooms and work clothes suitable for the task?
- Are the temperature, noise level and lighting optimised to minimise stress on employees?

Breaks and rest periods:

- Are regular breaks and rest periods planned, and is there room for micro-breaks?
- Are work tasks varied to reduce continuous exposure to vibration?

Personal protective equipment:

- Are suitable work gloves, hearing protection and eye protection provided and encouraged?
- Are work gloves chosen that keep hands warm?
- Bear in mind that vibration-damping gloves are not a universal solution.

Training and information:

- Are employees trained in the correct use and maintenance of machinery?
- Are employees informed about the link between vibrations and health?
- Is information provided about the conditions for medical examinations?
- Is information provided on health promotion measures?

Checklist for reducing exposure to whole-body vibrations

THE CHECKLIST CAN BE USED AS A LIST OF MEASURES AIMED AT ENSURING THAT THE COMPANY HAS A PLAN TO REDUCE EXPOSURE TO WHOLE-BODY VIBRATIONS.

Machinery selection and maintenance

- Machinery selection:** Are vehicles and mobile machinery selected with the lowest possible vibration levels and that are adapted to the surface on which they will be used. Is the opportunity taken to test drive the machinery under conditions similar to those in which they will be used?
- Driver's seat and suspension:** Is a driver's seat selected that is adapted to the work tasks and provides good vibration damping?
- Driver environment:** Is the driver environment ergonomic and comfortable, with the option of individual settings?
- Service and maintenance:** Is regular service and maintenance performed on machinery, including driver's seats, shock absorbers and springs, and tyre pressure checks?

Working environment and working procedures

- Maintenance:** Are roads and surfaces maintained to minimise vibrations?
- Breaks and rest periods:** Are regular breaks and rest periods away from the machine included in the work schedule?
- Working techniques:** Are employees trained in correct working techniques to minimise vibration exposure?
- Speed:** Is speed limited and idling avoided to reduce vibrations?
- Health promotion measures:** Are employees informed about the link between vibrations and health, as well as the importance of exercise and healthy habits?

Checklist to support health factors in vibration exposure

THE CHECKLIST AIMS TO SUPPORT EMPLOYEES' ABILITIES AND SKILLS TO MASTER THE RISKS ASSOCIATED WITH WORKING WITH VIBRATIONS THROUGH LEARNING AND UNDERSTANDING.

Measures to support skills that promote health

- Has the employee been given knowledge about early signs and symptoms and knows what measures to take?
- Has the employee been given knowledge about how acute temporary symptoms manifest themselves and how they can be managed?
- Has the employee been given knowledge about the importance of correct grip strength and feed force, as well as the importance of micro-breaks and short recovery breaks?
- Has the employee been given knowledge about the risks of working in cold environments and the need for appropriate clothing?

Health promotion measures

- Tobacco habits:** Has the employee been given support for measures aimed at reducing tobacco use?

Organisational measures

- Training:** Have employees received training and acquired the ability to recognise early signs of injuries related to working with vibrating machinery?
- Pay system:** Has the pay system been designed so that employees who have the ability to recognise signs of overload are given the opportunity to master this? Has the pay system been designed so that employees who are exposed to long periods of continuous vibration are allowed to take breaks?
- Co-determination:** Are employees given the opportunity to influence their work situation and take micro-breaks and breaks when they feel the need?

Checklist for early detection and treatment of injuries

THE ACTION LIST AIMS TO EARLY DETECT AND TREAT INJURIES AND THUS REDUCE THE INCIDENCE OF INJURIES AMONG EMPLOYEES AND ENSURE THAT THE COMPANY HAS A PLAN TO REDUCE EXPOSURE TO VIBRATIONS.

Early detection and investigation

Suspicion: Suspect harmful effects of vibrations based on information about health, production and comfort:

- from individual employees,
- from the results of systematic health and environmental surveys of groups of workers administered by employers.
- From other indicators of adverse effects.

Medical checks:

- Are medical checks procured in accordance with current guidelines?
- Are medical examinations organised in accordance with the Swedish Work Environment Authority's regulations (AFS 2023:15) [2] and the Swedish Occupational Health Services' Vibration Guide [6]?
- Does the agreement with the occupational health service ensure that feedback on results and exposures is included [6]?
- Is compliance with participation monitored?

Measures in case of suspected ill health

Investigation and handling:

- Does the employer provide the conditions for a supplementary medical investigation?
- Does the employer provide the conditions for supplementary medical treatment?

Medical and work-related rehabilitation:

- Does the employer provide the conditions for supplementary medical rehabilitation?
- Does the employer provide the conditions for supplementary work rehabilitation?
- Are the possibilities for redeployment that suits the remaining work ability investigated?
- Are vocational rehabilitation programmes offered?

Follow-up of medical check-ups:

- Are there procedures in place to follow up on completed and missed medical examinations and to ensure that necessary measures are taken?

Renewed risk assessment:

- Are there procedures in place to follow up and investigate exposures that may have contributed to injuries?

Work changes:

- Are there procedures in place to follow up on exposures that adapt work tasks for employees with problems?

Insurance issues:

- Are employees supported in their contact with the Swedish Social Insurance Agency, AFA occupational injury insurance and other relevant authorities?

Goals of the checklist

- Early detection: Identify ill health at an early stage so that it can be treated and remedied.
- Individual adaptation: Adapt work to the individual employee's abilities.
- Rehabilitation: Support employees in returning to work or taking on new tasks.
- Prevent long-term sick leave: Reduce the risk of prolonged absence from work.

Example of documentation template

Company: _____

Date: _____

Department/Workplace: Responsible: _____

Person (name, position): _____

Participants (name, position): _____

1. REASONS FOR INVESTIGATING THE WORK ENVIRONMENT (see Chapter 4 and Appendix A)	YES	NO
Based on impaired work ability?	<input type="checkbox"/>	<input type="checkbox"/>
Based on impaired health?	<input type="checkbox"/>	<input type="checkbox"/>
Based on the results of a medical examination?	<input type="checkbox"/>	<input type="checkbox"/>
Based on affected comfort, performance and production?	<input type="checkbox"/>	<input type="checkbox"/>
Based on the prognosis for the injuries sustained?	<input type="checkbox"/>	<input type="checkbox"/>
Based on the financial consequences of the injuries?	<input type="checkbox"/>	<input type="checkbox"/>
Based on requirements for exposure assessment for vibrations?	<input type="checkbox"/>	<input type="checkbox"/>
Based on reported incidents and accidents?	<input type="checkbox"/>	<input type="checkbox"/>

2. INVESTIGATION OF EXPOSURE IN THE WORK ENVIRONMENT (according to Chapter 5)	YES	NO
Has the identification of risk exposures been carried out?	<input type="checkbox"/>	<input type="checkbox"/>
Specify identified risk exposures:		

3. RISK ASSESSMENT (according to Chapter 6)	YES	NO
Has an assessment of identified risk exposures (High, Low, Acceptable) been carried out in terms of exposure level?	<input type="checkbox"/>	<input type="checkbox"/>
Has an assessment of identified risk exposures as (High, Low, Acceptable) been carried out with regard to exposure time?	<input type="checkbox"/>	<input type="checkbox"/>
For vibrations. Is the exposure action value considered to have been exceeded?	<input type="checkbox"/>	<input type="checkbox"/>
For vibrations. Is the exposure limit value considered to have been exceeded?	<input type="checkbox"/>	<input type="checkbox"/>
How can risk exposure be reduced:		

4. MEASURES (according to Chapter 3)	YES	NO
Has an action plan been drawn up?	<input type="checkbox"/>	<input type="checkbox"/>
Specify identified risk exposures:		
How will they be addressed?		
Who will address them?		
Timeframe?		






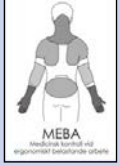


Signature of responsible person (name, position)

Date:

Place:

9. Sources of information

[1]		The Swedish Work Environment Authority's regulations and general guidelines (AFS 2023:10) on risks in the work environment (2025) https://www.av.se/arbetsmiljoarbete-och-inspektioner/publikationer/foreskrifter/afs-202310/
[2]		The Swedish Work Environment Authority's regulations and general guidelines (AFS 2023:15) on medical examinations in the workplace (2025) https://www.av.se/arbetsmiljoarbete-och-inspektioner/publikationer/foreskrifter/afs-202315/
[3]		Non-binding guide to good practice for the implementation of Directive 2002/44/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) at work (2007) https://op.europa.eu/sv/publication-detail/-/publication/3f9392ff-8975-4139-9ea2-5b168a334664
[4]		Vibration database; Umeå University https://www.vibration.db.umu.se/app/
[5]		Power Tool Ergonomics. Evaluation of power tools. Revised digital revision. (2022). Graf, F., p.174, ISBN: 978-91-527-0284-0 https://www.atlascopco.com/content/dam/atlas-copco/industrial-technique/ergonomics/documents/PowerToolErgonomics.pdf
[6]		Occupational Health Guide for Medical Examination of Hand & Arm Vibrations, 3rd edition, 2024:1 https://www.foretagshalsor.se/sites/default/files/2024-09/Vibrationsguide_upplaga3_inkl.Handledning-2024.pdf
[7]		Occupational Health Services Guide to Work Capacity – Concepts, Discussions and Investigations. 2021:1, https://www.foretagshalsor.se/sites/default/files/2021-11/Arbetsfo%CC%88rma%CC%8Ageguide_2021.pdf
[8]		Occupational Health Services Guide for Procurement of Occupational Health Services – Public Sector; 2019:1 https://www.foretagshalsor.se/sites/default/files/2020-04/Guide_Offentlig_upphandling_av%20FHVtjanster%202019-1.pdf
[9]		Occupational health services guide to purchasing services from Occupational health services – Private sector. 2019:1 https://www.foretagshalsor.se/sites/default/files/2020-02/guide_kop_av_fhvtjanster_privat_2019.1_1.pdf

[10]		<p>Diagnostic and exposure criteria for occupational diseases - Guidance notes for diagnosis and prevention of the diseases in the ILO List of Occupational Diseases (revised 2010); ILO; (2022) https://www.ilo.org/sites/default/files/2024-07/wcms_836362.pdf</p>
[11]		<p>VIBRATION GUIDE Hand and arm vibrations https://www.prevent.se/globalassets/prevent.se/jobba-med-arbetsmiljon/fysisk-arbetsmiljo/vibrationer/vibrations-guiden--hand--och-armvibrationer.pdf</p>
[12]		<p>VIBRATION GUIDE Whole-body vibrations https://www.prevent.se/globalassets/prevent.se/jobba-med-arbetsmiljon/fysisk-arbetsmiljo/vibrationer/vibrations-guiden--helkroppsvibrationer.pdf</p>
[13]		<p>Guidelines for workplace health examinations with a focus on lifestyle habits. Swedish Environmental Protection Agency (2024). https://www.av.se/arbetsmiljoarbete-och-inspektioner/publikationer/riktlinjer-for-foretagshalsovarden/riktlinjer-for-halsundersokningar-via-arbetsplatsen-med-fokus-pa-levnadsvanor/</p>
[14]		<p>Work and whole-body vibrations – health risks. Knowledge overviews. Swedish Work Environment Authority. Report 2011:8 https://www.av.se/globalassets/filer/publikationer/kunskapssammanstallningar/arbete-med-helkroppsvibrationer-halsorisker-kunskapssammanstallningar-rap-2011-8.pdf</p>
[15]		<p>Medical checks for ergonomically demanding work (MEBA) https://fhvmetodik.se/kontroller-halsobedomningar/annan-lagstadgad-medicinsk-kontroll-i-arbetslivet/meba/</p>
[16]		<p>Hand and arm vibrations. Centre for Occupational and Environmental Medicine, Stockholm Region. https://www.camm.regionstockholm.se/4a8e25/siteassets/camm-dokument/faktablad/hand_och_armvibrationer_2013rev-20220920_tg_slutv.pdf</p>
[17]		<p>Whole-body vibrations. Centre for Occupational and Environmental Medicine, Stockholm Region. https://www.camm.regionstockholm.se/4a3c04/siteassets/camm-dokument/faktablad/helkroppsvibrationer_2013rev202208_tg.pdf</p>

Appendices

Appendix A. Reasons for reviewing risk exposures – in depth:

Based on work ability

Acute temporary effects on work ability

Work ability may be temporarily impaired when exposed to vibrations. During and immediately after exposure, the ability to feel touch may be temporarily impaired. This, in turn, may cause temporary difficulties in performing fine motor tasks.

Vibration exposure can also temporarily impair blood circulation. The hands become colder and the worker has more difficulty keeping their hands warm, which can lead to difficulties in handling cold work objects or working in cold, damp environments. The acute effect on blood circulation increases the risk of frostbite ([see the section on acute effects of hand-transmitted vibrations in Appendix C](#)).

Permanent effect on work ability

The immediate but temporary effects on blood circulation and sensation can cause permanent damage if exposure to vibration continues. Blood vessels affected by vibration become more sensitive and react more strongly than normal to cold, stress or vibration.

When fingers become cold, the blood vessels react by excessively constricting the small blood vessels that supply the skin. The fingertips or fingers then turn white. When the fingers are white, they also become stiff, motor skills deteriorate and the ability to feel touch and temperatures deteriorates. In severe cases of "white fingers" ([see section on Effects on blood vessels and blood circulation, Appendix C](#)), it is not possible to perform fine motor tasks. When the blood returns, severe, debilitating pain is often experienced.

The effect of vibrations can also lead to impaired nerve function, which causes difficulties in feeling touch, heat or cold. These changes in sensory abilities can occur without simultaneous "white fingers". The extent to which impaired sensory perception (see the section on effects on nerves in Appendix C) affects working ability depends on the task at hand. Difficulties in feeling or perceiving temperature mean that tasks requiring this cannot be performed.

An additional effect of nerve damage is that temperatures that are normally perceived as cold may be perceived as painfully cold. Nerve disorders can cause difficulties with tasks that require fine motor skills and where you must not drop objects or be clumsy ([In-depth section, Impact on nerves Appendix C](#)).

Damage from vibration exposure can also lead to difficulties in clasping the hands together or stretching out the fingers ([In-depth section Dupuytren's contracture Appendix C](#)).

Nerve disorders with pain at night, which make it difficult to sleep, can impair work performance in tasks that require high levels of attention and alertness. The ability to perform forceful grips may then be reduced, as may the ability to work with the wrists bent sharply ([In-depth section Carpal Tunnel Syndrome Appendix C](#)).

As an employer, you can ask about nerve disorders (changes in sensation, motor function, cold intolerance and pain) and their impact on work ability ([Chapter 6, Health surveillance questions](#)) [7, 13]. If the results of the questionnaire indicate significant difficulties or impairments in ability ("quite a lot"), there is reason to initiate a medical examination (Occupational Health Service Guide for Medical Examination for Hand & Arm Vibrations, 3rd ed., 2024:1 [6]) and perform a renewed risk assessment.

For workers exposed to whole-body vibrations, the main complaints are pain in the back and neck and difficulty performing certain tasks. These include reduced ability to stand, walk, sit, lift, carry or turn. If the results of health monitoring questionnaires indicate significant difficulties ("quite a lot") for new disorders or deterioration, there is reason to investigate the work environment and possibly refer the injuries for medical treatment.

Based on reported health

Individual employees' reports of perceived health

As an employer, you may be informed about health problems and adverse effects from vibrations by an individual employee or a safety representative. This allows you, as an employer, to identify which jobs, exposures and work tasks may pose risks to health and well-being.

Information about individual employees' problems and health gives you the opportunity to tailor support to each individual, initiate a review of the work and put them in touch with the occupational health service. If employees have training in the risks associated with working with vibration exposure, you as an employer can obtain information about early signs of injury.

Systematic, general health examinations of groups of employees

Companies' regular, work-related health and work environment surveys can also provide guidance on disorders that may be caused by working with vibrating machinery.

Health and environmental surveys often include a questionnaire survey of health, health markers, and an examination of lifestyle and sleep habits and stress [13]. This is often followed by feedback to the individual employee and is also reported back at workplace, group and organisational level. Occupational health services offer services for general mapping and investigation of how employees perceive their working environment and health. Such general surveys can be supplemented with questions specifically concerning vibration problems for both hand-transmitted and whole-body exposure. Examples of questions that can be asked repeatedly in targeted surveys can be found in Chapter 8. (Chapter 8) Questions for health surveillance, for hand-transmitted vibrations and whole-body vibrations respectively.

Based on the results of medical examinations

The Swedish Work Environment Authority's regulation AFS 2023:10 [1, 2, 6] (Appendix AFS 2023:10) describes the employer's obligations when planning work that involves vibration exposure, conducting risk assessments, taking corrective measures and under what conditions a medical examination should be arranged.

The Swedish Work Environment Authority's requirements on employers include arranging and paying for medical examinations. The term "medical examination" in relation to vibration exposure refers to an examination that includes a medical examination (AFS 2023:15) [2]. The purpose of the medical examination is to identify and prevent any health problems that may arise in connection with vibration work. The medical assessment will be more reliable if the request for a medical examination also includes information about other identified risk exposures in addition to vibration, which may constitute contributing or competing causal factors. The results of the medical examination form the basis for a renewed risk assessment. As an employer, you must ensure that the person performing the medical examination for vibrations is a licensed doctor with good knowledge of occupational health and safety, good knowledge of the employee's exposure and working conditions, and clinical competence to examine and investigate vibration-related complaints and work ability disorders.

The Swedish Occupational Health Services' guide to medical examinations for "Hand and arm vibrations in the workplace". (Chapter 9) "Vibration Guide, Third Edition Version 2024:1" [6] provides occupational health services with detailed guidance on how to carry out medical investigations and simplified health examinations.

Occupational health services report the final assessment of the medical examination to the individual employee, as well as to you as the employer, subject to the consent of the person examined and taking into account the doctor's duty of confidentiality.

The results of medical examinations for a group of employees should indicate whether there are any risks of vibration injury. This is particularly important if several employees report that certain work tasks are unfavourable and suggest measures to be taken. As an employer, you should ensure that the procurement of medical examinations includes feedback to employees and employers.

Based on comfort, performance and production

The complex exposure to vibrations, the various health effects, the uncertainty about damage mechanisms and the impact of other interacting factors have made it difficult to define a simple risk relationship between vibration exposure, damage or disturbance.

The impact of vibrations on work ability and work performance gives you, as an employer, the opportunity to monitor production and identify early signs of potential production disruption. Production results can therefore sometimes indicate an adverse vibration impact. Requirements to maintain production despite a negative vibration impact can lead to discomfort. Information about comfort and production can, together or separately, indicate adverse vibration disruption that warrants a renewed risk assessment.

Based on the damage forecast

The motivation to prevent damage also increases if the prognosis for the damage is poor. Clinical and epidemiological studies suggest a possible, albeit insignificant, improvement in "white fingers" if exposure to vibrations ceases. The improvement appears to be inversely related to the degree of injury, exposure time and age. Tobacco use has an adverse effect on the prognosis.

Mild symptoms of nerve damage have been reported to decrease if vibration exposure is limited. For example, night-time numbness has been reported to decrease when vibration exposure is reduced or after treatment for carpal tunnel syndrome. Few studies report a favourable prognosis for severe nerve damage. Most studies show that nerve changes are permanent.

Increased sensitivity to cold may be due to vascular damage, but also to nerve damage. Studies have shown that cold sensitivity is a dominant residual condition after nerve damage and that such increased sensitivity to cold (cold intolerance) often becomes permanent. Severe cold intolerance with pain, without signs of white fingers, is described in several studies of vibration-damaged individuals. The unfavourable prognosis for vibration injuries should motivate more active prevention. Vibration injuries often affect young workers. Injuries that occur at a young age are often permanent and lack treatment, which motivates active prevention efforts.

Based on the economic consequences of the injuries

Studies show that extensive and prolonged exposure to manual work using vibrating machinery can cause permanent impairment of the musculoskeletal system, hand function and work ability. Those affected by vibration injury syndrome are therefore entitled to financial compensation and occupational injury compensation under both previous and current occupational injury legislation.

There is currently a lack of evidence-based knowledge about vibration exposure doses in relation to disease effects in individual workers, which explains why it is not currently possible to make individual risk predictions. However, there is epidemiological support for a group-level correlation between vibration exposure and injuries. Vibration exposure may constitute a predominant cause of occupational disease in insurance

law. In the latest updated version of the ILO's list of occupational diseases (ILO 2022) [10] (Information sources, Chapter 9, p. 40), vibration exposure is classified as an exposure risk for vibration injury, specified as disorders of peripheral blood vessels, peripheral nerves, ligaments and tendons (Raynaud's phenomenon, small fibre peripheral neuropathy, carpal tunnel syndrome, radial tenosynovitis, tenosynovitis of the hand and wrist, (Medical Deepening, p. 52). Results from recent research also support a link with an increased risk of Dupuytren's contracture (Medical Deepening Appendix C, p. 52) when working with handtransmitted vibrations.

Society pays compensation for occupational injuries through, for example, the Social Insurance Agency and work injury insurance. The Insurance Fund compensates for occupational injuries for, among other things, the diagnoses approved by the ILO [10].

The employer currently pays sick pay (80% of monthly salary) for the first 14 days an employee is sick, except for the first sick day (waiting period deduction). From day 15 onwards, the employee receives sickness benefit from the Swedish Social Insurance Agency. According to several collective agreements, the employer also pays 10% of the salary between days 15 and 90. Indirectly, the employer is also financially burdened by loss of income as a result of lost production. The employer's total costs for injuries incurred can be significant. In addition, there are costs for possible new recruitment and training.

In addition to suffering, the affected person also suffers significant financial losses. The costs for the affected person can be devastating if the vibration injury means a change of job, retraining and, in the worst case, even a change of residence, etc.

The Swedish Work Environment Authority can impose fines if the regulations are not followed. Orders to take action can then be combined with financial penalties. The financial cost is determined by the severity of the deviation and the number of employees in the organisation. This means that the financial costs can be significant.

Based on exposure assessment

Assessing the risks of exposure to vibrations involves comparing estimated daily exposure with the Swedish Work Environment Authority's regulations AFS 2023: 10 [1].

There are two limits to ensure that employees are not exposed to the harmful effects of vibrations. One limit is called the exposure action value and the other is called the exposure limit value. These limits are shown in Table A.1.



Figure A-1. Swedish Work Environment Authority regulation AFS 2023: 10 [1].

Table A-1. Exposure action and limit values for daily exposure to vibrations according to AFS 2023: 10.

	EXPOSURE ACTION VALUE	EXPOSURE LIMIT VALUE
Hand-transmitted vibrations	2,5 m/s ²	5,0 m/s ²
Whole-body vibrations	0,5 m/s ²	1,1 m/s ²

If the exposure limit is exceeded, employers must take measures to reduce the risk from vibration exposure. This applies to both hand-transmitted and whole-body vibrations. In addition, employees exposed to hand-transmitted vibrations above the exposure limit must be offered regular medical examinations arranged by their employer. The limit value must not be exceeded.

It is important to remember that the action value does not represent a safe level for injury. For hand-transmitted vibrations, 10% of employees can be expected to develop white fingers within 10 years of exposure at the action value. It is important to note that problems can arise even at lower exposure levels. Risk assessments are often based on estimates and contain a degree of uncertainty. Daily vibration exposure above 2 m/s² for hand-transmitted vibrations and 0.4 m/s² for whole-body vibrations should be considered a clear indication that measures are needed to reduce the risk of health problems.

The need to prevent the risks associated with exposure to vibrations and shocks remains crucial, even though scientific understanding of specific exposure limits in relation to the various injuries caused by vibration-related disorders is still limited.

The Swedish Work Environment Authority's website on vibrations provides practical tools for conducting risk assessments based on vibration levels and exposure times (<https://www.av.se/halsa-och-sakerhet/vibrationer/>).

Based on incidents and accidents

Vibration exposure can cause changes in sensory function, motor skills and balance, as well as increased fatigue. Under unfavourable conditions, the risk of errors, accidents and incidents may increase. It is therefore advisable to analyse whether vibrations may have contributed to any incidents or accidents. This applies to work involving both hand-transmitted vibrations and whole-body vibrations.

Appendix B. Technical details - in depth

General information about vibrations

Vibration level

Vibration refers to an object or surface oscillating back and forth around a resting position, see Figure B-1.

When a surface is still, it is in equilibrium position B, and when it oscillates back and forth, this occurs between the extreme positions A and C. Two important measurements are needed to describe this movement. Firstly, the magnitude of the oscillation (strength, level, amplitude) and secondly, how often these oscillations occur (frequency). Other important characteristics are the total time during which the oscillation occurs, the direction of vibration and the type of vibration.

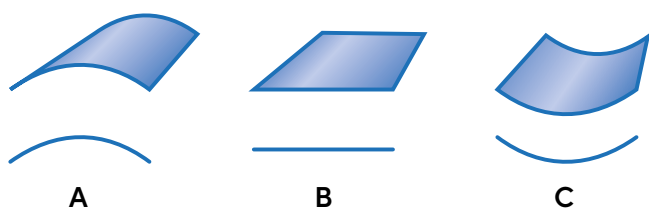


Figure B-1. A surface oscillating around its equilibrium position.

The magnitude (strength, level) of vibrations can be described using three different measures:

- displacement,
- velocity, or
- acceleration.

Displacement refers to the movement of an object in relation to its resting position, measured in metres (m). **Velocity** indicates the displacement of an object per unit of time, measured in m/s. **Acceleration** describes how the velocity of an object changes over time, measured in m/s². Acceleration is the quantity used to describe the effect of vibrations on humans.

The oscillation can be described as a movement in which the surface moves from its resting position (B) over a certain distance, turns at the end position (A) and then moves in the opposite direction past the resting position again. The movement then continues to the other end position (C), stops and moves in the opposite direction back to the resting position or past it. Figure B-2 illustrates the displacement of the surface over time. It is also possible to describe its acceleration over time.

The period (T) describes the time it takes for the surface to complete this entire movement back to its original position. During this oscillation, the position of the surface varies continuously. It is therefore important to be able to describe the oscillation in a simple way. One way is to specify the value that is constantly recorded, which is usually called the instantaneous value (momentary value). The highest instantaneous value during a given time period is called the peak value.

However, we want to specify some kind of average value for the current oscillation. The most common way is to specify the effective value of the vibration (the effective average value), also known as the RMS value (Root Mean Square). The effective value corresponds to the energy content of the vibration per unit of time.

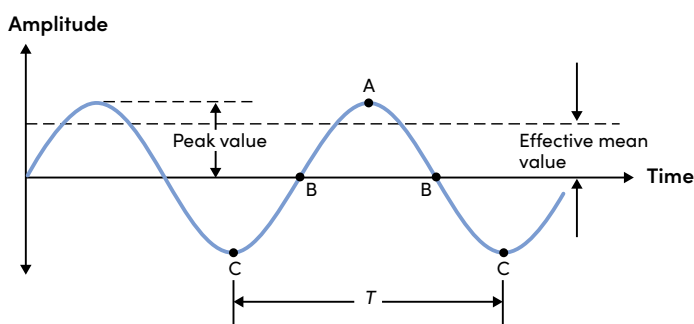


Figure B-2. Surface displacement over time and peak and effective mean values for this movement.

The effective value (RMS value), a_{eff} , for the acceleration is defined as:

$$a_{eff} = \sqrt{\frac{1}{T} \int a^2(t) dt} \quad \text{[Formula 1]}$$

where

$a(t)$ is the instantaneous value of the acceleration at time t and T indicates the total time for which the effective value of the acceleration (a_{eff}) is to be calculated.

The peak value of acceleration (a_{topp}) is defined as the largest instantaneous value of the vibration that has occurred over a specified period of time. Usually, no consideration is given to whether this instantaneous value is positive or negative; only the maximum value is specified.

The crest factor is used to describe the ratio between the peak value and the effective value. This value describes the impact content of vibrations. The crest factor (TF) for vibrations is therefore dimensionless and is defined as:

$$TF = Toppfaktor = \frac{a_{topp}}{a_{eff}} \quad \text{[Formula 2]}$$

where

a_{topp} is the peak value of the acceleration and a_{eff} is the effective value of the acceleration.

Vibration type

Vibrations can be divided into three main types: sinusoidal, noise and shock. Sinusoidal vibrations are a common form of periodic signal and are characterised by the vibration sequence repeating after a given time, see Figure B-3. Examples of sinusoidal vibrations include vibrations from a car engine or from the motor in a hand-held machine.

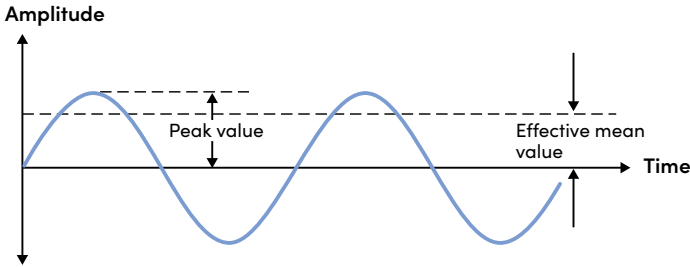


Figure B-3. Peak and effective mean value for a sinusoidal vibration.

A noise vibration varies randomly over time. A noise vibration can be driving a car on uneven ground or grinding with a hand-held machine, see Figure B-4.

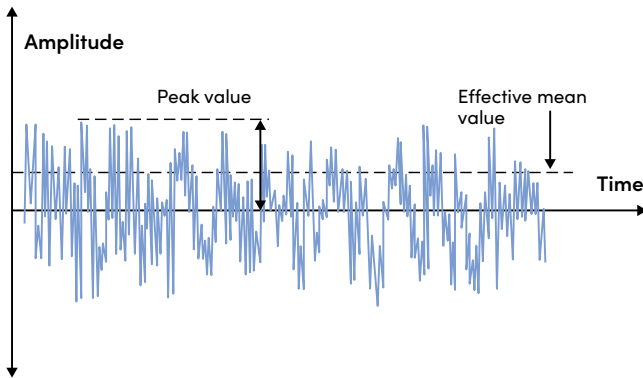


Figure B-4. Peak and effective mean value for a noise vibration.

A shock vibration occurs for a short period of time, often with a peak value that is much higher than the rest of the vibration curve, see Figure B-5. Shocks can occur on a single occasion or repeatedly. Examples of shock vibrations include when a car drives into a pothole with one of its wheels or when working with a hammer nut driver.

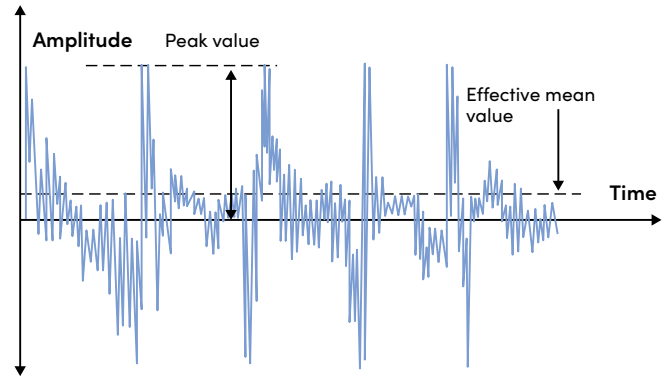


Figure B-5. Peak and effective mean values for a repeated shock vibration.

Most vibrations that occur in the workplace are combinations of different types of vibrations.

Frequency

The frequency of a vibration is a measure of how often the oscillations are repeated and is expressed in the number of oscillations per second. This unit is called Hertz, abbreviated Hz. The relationship between frequency (f) and period (T), i.e. the time for a complete oscillation, is defined as follows:

$$f = \frac{1}{T} \quad \text{[Formula 3]}$$

where f is the frequency and T period time for the current vibration.

For example: If a machine has a speed of 6 000 revolutions per minute, this means that the frequency is $f=6\,000\text{ revolutions}/60\text{ seconds} = 100\text{ Hz}$.

A breakdown of the vibration into different frequencies is called frequency analysis. It is not normally possible to calculate the frequency of, for example, noise vibrations using the above formula. Instead, more sophisticated mathematical methods must be used. A frequency analysis of vibrations involves obtaining the frequency spectrum of the vibration. Figure B-6 shows the relationship between the vibration waveform over time and the corresponding frequency spectrum.

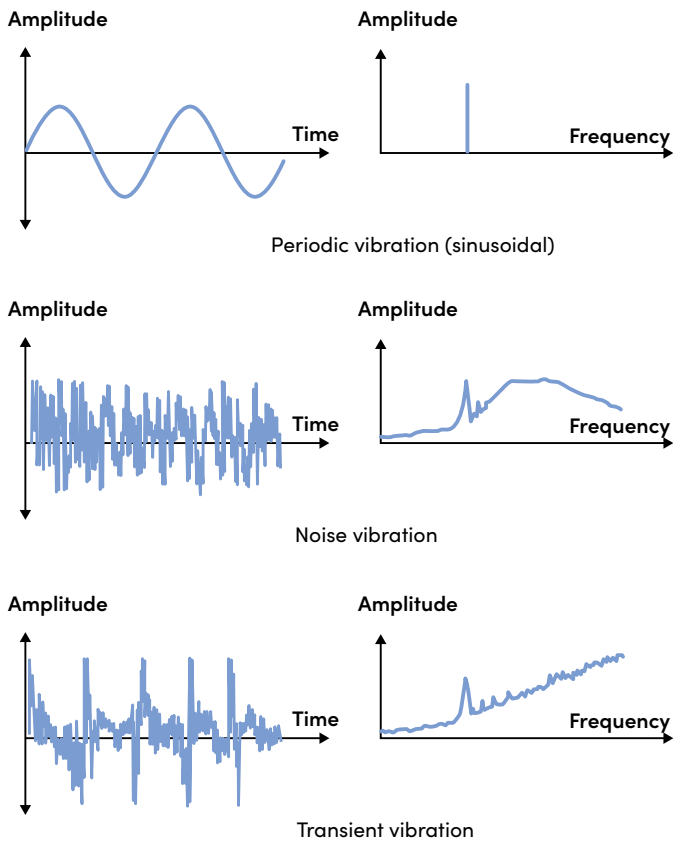


Figure B-6. The relationship between the oscillation of different vibrations over time and the corresponding frequency spectrum.

Frequency analysis

Information about vibration levels at different frequencies is often needed to determine the impact on exposed individuals. When the measurement results are to be used for assessing the risk of injury, 1/3-octave bands (terz bands) are used.

Instead of a frequency spectrum, the total acceleration can be calculated within a specific frequency range. This provides a single numerical value for the frequency section by summing the accelerations for each band according to:

$$a = \sqrt{\sum_{n=1}^i a_i^2} \quad \text{[Formula 4]}$$

where

a is the summed acceleration and

a_i is the acceleration in the different frequency bands.

Frequency weighting

Normally, different frequencies are assigned different weights in terms of their impact on humans. This means that the values for different frequency bands are weighted differently when added together, a process known as frequency weighting. The formula used is:

$$a = \sqrt{\sum_{n=1}^i (K_i \times a_i)^2} \quad \text{[Formula 5]}$$

where

a is the summed acceleration,

a_i is the acceleration in the different frequency bands, and

K_i is the weighting for the different frequency bands.

Vibration direction

Vibrations usually consist of movements in several directions at the same time. This means that, in addition to a specific magnitude, the vibrations also have a specific direction, i.e. the vibration can be described by a vector in space. To describe this vector in the various possible directions of movement, the values are usually specified in a coordinate system where the axes are designated x , y and z . These three directions are also perpendicular to each other

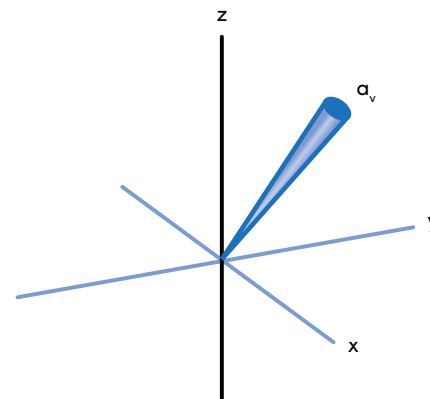


Figure B-7: Vibrations occur in three directions.

If the acceleration is known in the different directions, the vector sum of the vibration, a_v , can be calculated using the formula:

$$a_v = \sqrt{a_x^2 + a_y^2 + a_z^2} \quad \text{[Formula 6]}$$

where

a_x , a_y and a_z are the acceleration in the x , y and z directions, respectively.

These calculations are used to evaluate hand-transmitted vibrations. For whole-body vibrations, a different methodology is applied, based on measurement data in each direction only.

Determination of daily exposure time

Various methods are used to determine the daily exposure time to vibrations from individual sources, such as stopwatch timing, video analysis and time studies. Manufacturers also provide data on typical exposure times for various hand-held machinery (see SIS-CEN/TR 15350).

In some cases, such as repetitive work tasks, the exposure time can be estimated by measurements taken over a limited period, such as a work cycle or a typical 30-minute period. These measurements are then supplemented with information about the work pace, such as the number of work cycles per day or the length of the shift.

Alternative methods for determining exposure time include analysing material consumption or work performed. For example, time can be estimated based on how long it takes to wear out a grinding disc and how many discs are used daily. Another way is to count the number of screw joints tightened per day and multiply that by the time spent per joint.

Experience shows that users of hand-held vibrating machines often tend to overestimate their actual exposure time. This is because they tend to include the entire time spent operating the machinery, rather than just the active vibration exposure. For whole-body vibrations, the agreement between estimated and actual usage time is generally better, as exposure is often continuous during machine operation.

For mobile machinery, the machine's hour meter can in some cases be used to estimate the exposure time.

Finally, it is important to remember that the calculated daily vibration exposure should represent a typical working day. If exposure varies significantly between different working days, this must be taken into account in the assessment.

Determining the magnitude of vibrations

The vibration level for each work task can be determined either by using existing information or by performing your own measurements. Existing information can be found in the manufacturer's instructions, databases or publications. Your own measurements are performed in accordance with applicable standards to ensure accuracy and comparability.

Manufacturer's instructions

Hand-held and mobile machinery must be designed to minimise vibration risks. Within the EU, such machinery is required to be CE marked, which means that the manufacturer certifies that the product complies with EU health and safety requirements. A key part of this marking is that the manufacturer must declare the vibration level in the user manual and an uncertainty factor (*K*-factor).

These declared values can be used with caution to estimate the magnitude of the vibrations by adding the declared value and The *K* factor. However, it is important to remember that the declared values for handheld machinery are measured under simulated laboratory conditions, specifically adapted to the applicable standards for different machine types. This means that they may not cover all types of accessories or variations that may occur in practical use. If the work in question differs significantly from the manufacturer's measurement standard, the declared values are not always directly relevant for assessing the actual vibration level.

For users of mobile work machinery, workplace-related variables, such as the surface and speed, can also have a significant impact on the measured vibration levels. Declared values for mobile machinery are often incomplete because there are no standards for the nature of the surface, which means that each manufacturer defines its own surface for measurements.

From 2027 onwards, instruction manuals for hand-held machinery will also include a declaration of the shock content of the machinery's vibrations.

Databases or publications

There are various databases where vibration data has been collected. These show the results of measurements carried out and information on declared values for different machinery/vehicles (see section Supplementary sources of information).

There are also publications that contain information about the vibration levels of various machinery/vehicles. Some examples can be found in the section "Additional sources of information".

Vibration measurements

In order to meet the requirements for vibration measurements according to the Swedish Work Environment Authority's regulations, the person performing the measurement must have:

- Good knowledge of applicable measurement standards
- An in-depth understanding of the instruments used
- Experience of performing measurements under various conditions
- Ability to identify and manage potential sources of error
- Knowledge of how to interpret and present measurement results

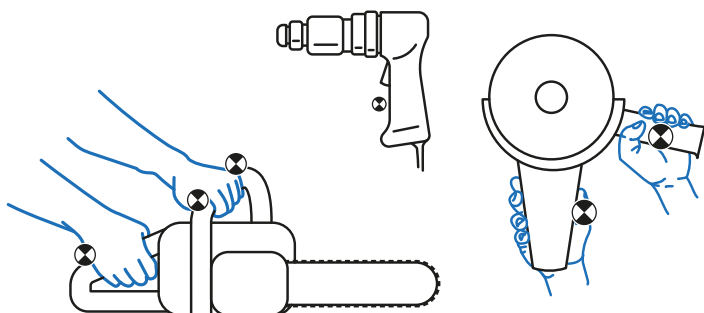
A small accelerometer is used to determine the magnitude of vibrations on a vibrating surface. When the accelerometer is subjected to movement, it emits a signal corresponding to the acceleration of the movement. This signal is usually transmitted to direct-reading instruments that have built-in functions for postprocessing the signal.

Sometimes vibration exposure occurs only for short periods that are repeated many times during a working day. The measurements should describe the average value over a period corresponding to the work in question. If possible, several measurements should be taken at different times during the day or during a week to take into account the variation in exposure.

Measurement of hand-transmitted vibrations

When measuring hand-transmitted vibrations, the accelerometer should preferably be placed in the centre of the surface that the user's hand grips. Normally, this is not possible because it greatly affects how the machine is used. Therefore, the accelerometer is placed in the immediate vicinity of the hand. Figure B-8 shows some recommended measurement positions for hand-held machinery. The standard SS-EN ISO 5349-2 contains more examples.

Figure B-8. Examples of measurement positions for some different types of handheld machinery.



The accelerometer should be mounted on the vibrating surface as stably as possible. This is best done with screws or glue. On cylindrical handles, it may be advantageous to use some form of hose clamp for mounting. This is particularly useful if the machine handle has a soft outer coating. Measurements using various types of hand-held adapters should be carried out with great care, as the measurement results may be affected by the user's grip and feed force.

Electronic monitoring systems for measuring hand-transmitted vibrations, for example on the back of the hand or wrist, should not be confused with standardised vibration measurements. Although these monitoring systems can provide an estimate of the vibration level, their vibration data is not reliable enough to be used for riskassessment.

The measurement time for determining hand-transmitted vibrations should not be less than 1 minute for each work operation. In addition, the measurements should be repeated at least three times for a more reliable result. Measurements are made in the three perpendicular directions, x, y and z, and simultaneous measurements in all three directions are preferable to separate measurements in each direction. The directions are defined in accordance with Figure B-9.

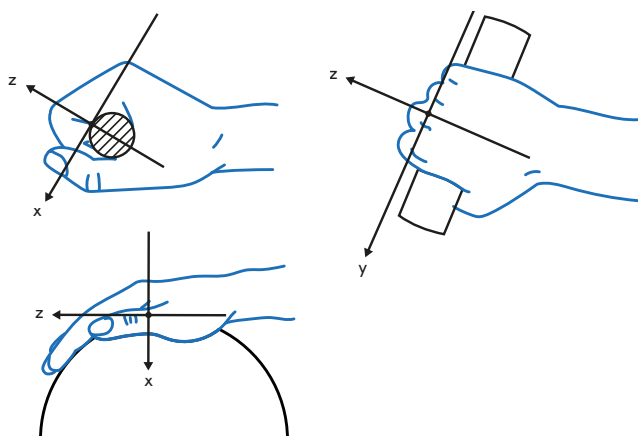


Figure B-9. Vibration directions for hand-transmitted vibrations.

When measuring hand-transmitted vibrations, it is appropriate for the frequency range to cover at least 5–1 500 Hz.

Measured values shall be frequency weighted in accordance with the applicable standard. For hand-transmitted vibrations, frequency weighting filters are the same in the three main directions, see Figure B-10. After frequency weighting, the values for the three main directions are added together in a so-called vector sum, i.e. the sum of the three main directions, according to formula 6.

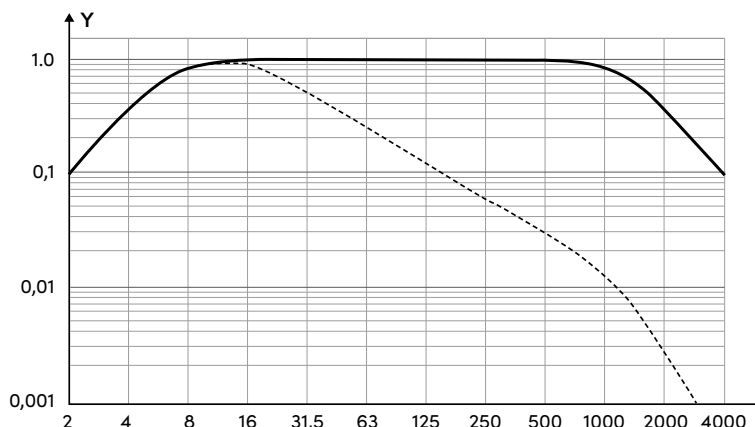


Figure B-10. Frequency weighting for hand-transmitted vibrations. The dotted line illustrates the frequency weighting according to standard ISO 5349-1, while the solid line illustrates the frequency weighting for quantifying the impact content of vibrations according to the ISO/FDIS 5349-3 standard.

In order to accurately quantify the impact content of vibrations from hand-held machinery, international guidelines specified in the ISO/FDIS 5349-3 standard are followed. A specific frequency weighting is used for this quantification (Figure B-10). Unlike the frequency weighting according to ISO 5349-1, which emphasises lower frequencies, this method is designed to give greater weight to the higher frequency ranges. This so-called flat frequency weighting is particularly effective because shocks are characterised by rapid energy peaks that often appear in the upper parts of the frequency spectrum.

By focusing on these higher frequencies, it is easier to capture and analyse the instantaneous, powerful variations in the vibrations – i.e. the shocks themselves.

To evaluate the total shock content, the average value of the vibration peak value is then calculated, which is referred to as Vibration Peak Magnitude (VPM). This average value is also given the special designation pF (which stands for peak Flat frequency weighting). A higher pF value is a direct indication of a more pronounced and potentially harmful impact content in the vibrations generated by the machine.

Measurement of whole-body vibrations

Vibrations in a vehicle’s driver’s seat are measured using a thin, soft rubber seat pad in which three accelerometers are mounted in the three main directions (x, y, z, Figure B-11). The pad is placed on the seat and secured by the driver sitting on the pad.

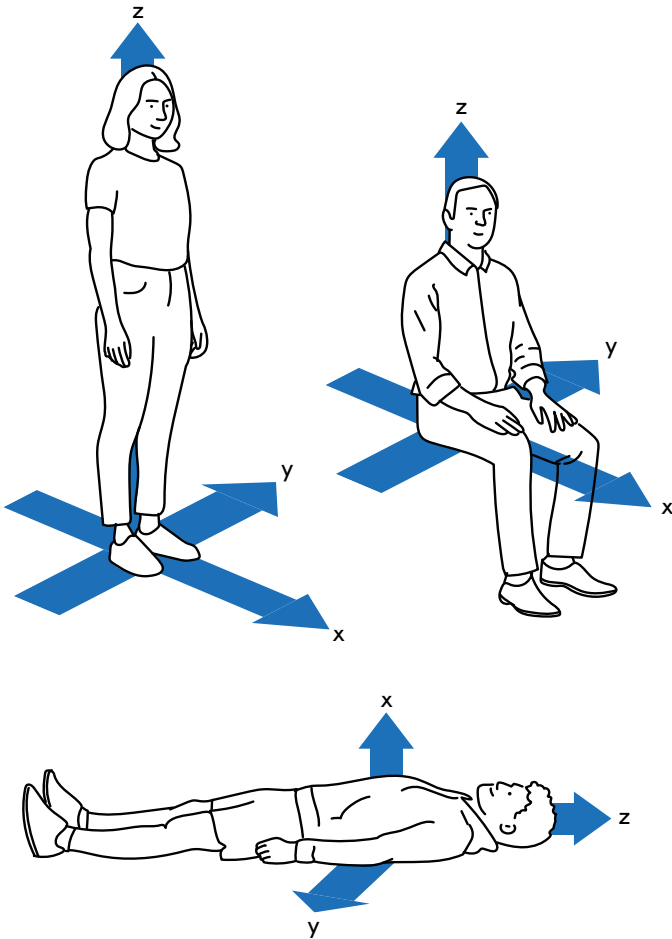


Figure B-11. Vibration directions for whole-body vibrations. The definition of measurement directions for whole-body vibrations applies to standing, sitting or lying working positions.

To determine whole-body vibrations, the measurement time should not be less than 3 minutes, which should also be repeated at least three times for a more reliable result. The measurements were taken within a frequency range of at least 1–80 Hz.

The measured values in the different main directions shall then be frequency weighted in accordance with the applicable standard. For whole-body vibrations in the horizontal directions (x and y), a different frequency weighting applies than for the vertical (z), see Figure B-12. Measured values in the x and y directions shall also be multiplied by 1.4. This is called the k-factor and takes into account that the body has different sensitivities in the x, y and z directions. The highest value in one of the three directions is then determined.

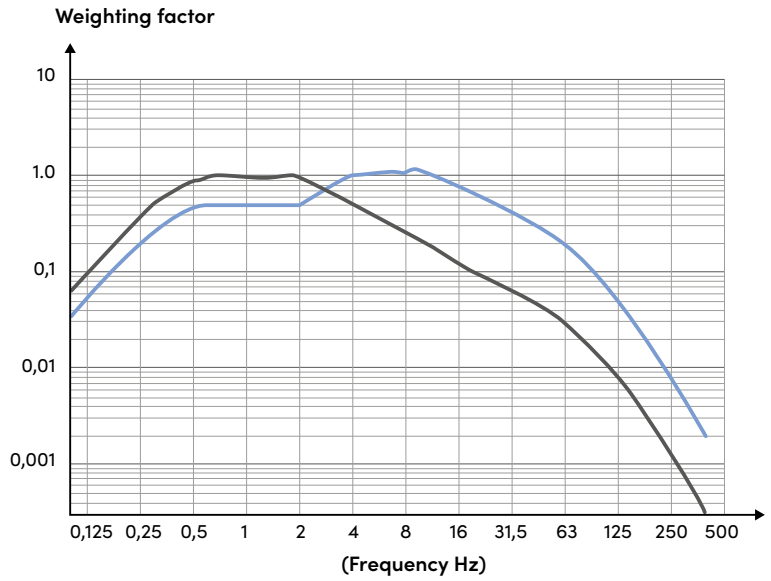


Figure B-12. Frequency weighting for whole-body vibrations in the different vibration directions. Grey line for x and y, blue line for z.

When exposed to whole-body vibrations that include shocks, the vibration level can be measured in several ways to assess the risk of health effects:

- 1. Maximum peak value:** This is the highest measured value of acceleration in any of the three vibration directions (x, y or z).
- 2. Crest factor:** The crest factor is the ratio between the maximum peak value of the acceleration and its effective value (RMS).
- 3. Vibration dose value:** This value is calculated by raising the acceleration-weighted vibration to the fourth power (VDV).
- 4. Compression pressure in the lumbar spine:** Impacts can cause high pressure on the lumbar spine, which can lead to damage over time. To assess this, the pressure to which the back is exposed during each impact in the vertical direction is calculated. The calculation includes factors such as the force of the impact, the number of impacts per time unit and how much of the impact energy is transferred to the lumbar spine. Based on this pressure, an "equivalent dose for static compression pressure" is then calculated, which can be used to assess the health risk.

Calculation of daily vibration exposure

Two pieces of information are used to assess workers' daily exposure to vibrations: the vibration value and the daily exposure time.

The vibration value, designated $a_{Arbete (work)}$, should provide a representative picture of how much the machine vibrates during the work in question. This value can either be estimated or measured.

The definition of $a_{Arbete (work)}$ varies depending on the type of vibration present:

- **Hand-transmitted vibrations:** $a_{Arbete (work)}$ is the frequency-weighted vector sum of the accelerations.
- **Whole-body vibrations:** $a_{Arbete (work)}$ is the highest frequency-weighted value of the acceleration in any of the three perpendicular directions (x, y and z). To take into account the sensitivity of the body, the values in the x and y directions are multiplied by a factor of 1.4 before the maximum value is determined.

The actual daily exposure time (T) is converted to correspond to a full working day of 8 hours. This is done to enable a standardised comparison of different vibration levels and exposure times. The load is thus expressed as the daily vibration exposure during an 8-hour working day, designated $A(8)$. This calculation is made using the following mathematical relationship:

$$A(8) = a_{Arbete} \times \sqrt{\frac{T}{8}} \quad [\text{Formula 7}]$$

where

$A(8)$ is the daily vibration exposure during 8 hours [m/s^2],

T is the actual exposure time [hours] and

$a_{Arbete (work)}$ is the estimated/measured vibration acceleration during the exposure time T [m/s^2]. When workers are exposed to vibrations from several different machinery or work tasks during the same working day, it is necessary to calculate the total daily vibration exposure. This is done by combining the individual exposure contributions. The total daily vibration exposure, designated $A(8)_{Total}$, is calculated by summing the individual contributions for each exposure according to formula 8:

$$A(8)_{Total} = \sqrt{A_1(8)^2 + A_2(8)^2 + \dots + A_n(8)^2} \quad [\text{Formula 8}]$$

where

$A(8)_{Total}$ is the total daily vibration exposure (8-hour equivalent acceleration) [m/s^2], $A_i(8)$ is the 8-hour equivalent vibration exposure for the i:th work task or the i:th machine [m/s^2] and n is the total number of individual work tasks or machinery that contribute to the daily exposure.

The estimated $A(8)$ values then form the basis for assessing the risk to the health and safety of workers, in accordance with the Swedish Work Environment Authority's regulations on vibrations ([AFS 2023:10](#)). These regulations establish specific exposure values in the form of exposure action values and exposure limit values that must not be exceeded.

References Annex B

EU Directive

Directive 2002/44/EC of the European Parliament and of the Council of 25 June 2002 [3] on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration) at work (sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC), as amended by Regulation (EU) (EU) 2019/1243 of 20 June 2019.

The Swedish Work Environment Authority's regulations

AFS 2023:10 [1], Swedish Work Environment Authority regulations and general advice on risks in the work environment, 2025.

Standards

Hand-transmitted vibrations

- SS-EN ISO 5349-1 Vibration and shock – Measurement and assessment of hand-transmitted vibration – Part 1: General guidelines, Edition 1, 2001.
- SS-EN ISO 5349-2 Vibration and shock – Measurement and assessment of handtransmitted vibration – Part 2: Practical guidelines for measurement at the workplace, Edition 1, 2001.
- ISO/FDIS 5349-3² Mechanical vibration – Measurement and evaluation of human exposure to hand-transmitted vibration - Part 3: Isolated and repeated shocks using the frequency range of ISO 5349-1, Draft.
- SIS-CEN/TR 15350 Mechanical vibration – Guideline for the assessment of exposure to hand-transmitted vibration using available information including that provided by manufacturers of machinery.

Whole-body vibrations

- SS-ISO 2631-1 Vibration and shock – Guidance for the assessment of the effects of whole-body vibration on humans – Part 1: General requirements, 1998/Amd 1:2010.
- SS-ISO 2631-5 Vibration and shock – Assessment of the effects of whole-body vibration on humans – Part 5: Method for assessing vibrations with many shocks, 2019.
- SS-EN 14253 Mechanical vibration – Measurement and calculation of occupational exposure to whole-body vibration with reference to health – Practical guidance, 2007.
- SIS-CEN/TR 15172-2 Whole-body vibration – Guidelines for vibration hazards reduction – Part 2: Management measures at the workplace.

² ISO/FDIS 5349-3 will become a Swedish standard in 2026 with the designation SS-EN ISO 5349-3.

Appendix C.

Medical text – in depth

Hand-transmitted vibrations

Acute effects

The immediate effect of holding a vibrating machine is the sensation that the object is vibrating. The sense of touch reacts to vibrations up to approximately 1200 Hz. If the frequency is higher, we do not perceive the machine as vibrating. Working with hand-held, vibrating machinery causes, if the exposure is significant and mainly in the frequency range up to 250 Hz a temporary deterioration in the blood circulation in the skin, fatigue of the sense of touch and an effect on the muscles. The change in blood flow manifests itself in the skin becoming pale or white and colder at the periphery. Vibrations also have a temporary effect on the nerves and sense of touch (Temporary Threshold Shift). The effect on the sense of touch can be experienced as a reduction in the ability to feel touch, heat or cold.

Alternatively, the effect may be experienced as tingling or numbness. The time it takes for normal sensation to return after the end of vibration exposure varies depending on individual sensitivity and the duration of exposure and the level of vibration to which one has been exposed. This acute, temporary sensory impairment usually lasts for a few minutes to less than an hour. Intermittent vibration exposure during an entire working day causes a gradual, temporary deterioration of the sense of touch during the course of the day. The time required for full recovery is affected by the strength, frequency and duration of the vibration exposure, as well as the individual sensitivity of the exposed person.

Working with impaired sensation may cause the worker to grip the handle of the vibrating machine more tightly. A firmer grip increases muscle strain but also increases the amount of vibration transmitted to the hand. The body may also react with a reflex-controlled contraction of the muscles exposed to vibrations (tonic muscle reflex), which further increases the strain on the musculoskeletal system and also the amount of vibration transmitted to the hand. It has not been proven whether the degree of acute impact can be used to assess the risk of permanent damage in the case of severe and prolonged exposure to vibration.

Permanent damage

Prolonged or intense exposure to hand-transmitted vibrations can lead to symptoms and damage to the blood vessels, nerves and muscles in the hands and arms. Vibrations from hand-held machinery can thus cause permanent functional and work ability impairments. The injuries are complex, variable and the mechanisms of origin are not fully understood. Currently, disturbances in the blood supply are the best-established cause of vibration damage to both nerves and blood vessels. Reduced blood flow and thus reduced oxygenation of the tissue over a longer period of time contributes to the damage. The extent of the effect of vibration exposure is greatly influenced by other individual and interacting factors.

Individual factors include: the body's stress level (physiological stress: sleep, circadian rhythm) physical stressors (e.g. noise), psychological stressors (e.g. time and work demands) hormones, nerve, vascular or other diseases, medication (certain drugs for ADHD, angina, high blood pressure, migraine and cytostatics), central stimulants (cocaine, amphetamines, cannabis).

In addition to vibrations, blood flow is also affected by cold temperatures, static hand grips with continuous pressure against tissue that prevents blood flow (local pressure from weight, gripping and feeding forces) and episodic exposure to nicotine from tobacco and snuff.

The symptoms of damage originate in the peripheral nerves, blood vessels, bones, joints and muscles. These various symptoms of damage were initially summarised as "vibration injury syndrome" (HAVS), but have recently been divided into the syndrome's various vascular, nerve and connective tissue components. Many of the symptoms and manifestations commonly associated with vibration exposure are also found in other contexts. They are then caused by other factors and may therefore have a completely different origin unrelated to vibration exposure.

It has proven difficult to demonstrate a clear exposure-response relationship between damage and the degree of vibration exposure for an individual. This difficulty is due, among other things, to the wide variation in the exposure transmitted to the hand and differences in vibration sensitivity between individuals. A number of physical factors related to exposure are also significant. In addition to the work itself, these include cold and cold effect, vibration frequency, intensity, duration, direction, energy transfer, point of attack, tissue pressure from gripping and feeding forces, time with impaired blood flow, human physique, body posture and the manual force applied by the operator to the vibrating machine.

Impact on blood vessels and blood circulation

"White fingers" (Raynaud's phenomenon, (Fig. C-1) is probably the best-known symptom of damage associated with vibration exposure. The medical term "Raynaud's phenomenon" describes a temporary attack of impaired circulation in the skin, where the skin feels "dead" and "cold" ("white fingers" or "dead fingers"). The "whiteness" is caused by increased spasm (vasospasm) in the small peripheral blood vessels of the skin, which stops blood circulation. People with an increased tendency to "white fingers" experience attacks when exposed to cold, stress or vibrations.

In mild cases, the spread of "paleness" is limited to the fingertips, but in more severe cases it covers a larger part of the fingers. In rare cases, the whiteness affects all fingers. It is unusual for the thumbs to be affected, but this does occur in severe cases. During an attack, the affected person experiences reduced sensation, feels stiff, loses muscle function and their fingers become cold. As a result, their ability to perform fine motor tasks is also severely impaired during such an attack. When a vasospasm attack subsides, which can happen after a few minutes or several hours, it is often experienced as very unpleasant and painful.



Figure C-1. Raynaud's phenomenon (white fingers) with severe discoloration of the outer phalanges of the fingers. The boundary between reddened skin with normal blood supply and whitened tissue with reduced blood supply is clear and has a sharp border. When "white fingers" regain normal blood supply, severe redness or a bluish tint often occurs.

An increased tendency to react to cold with "white fingers" is also common in the general population, even though they have not previously been exposed to vibrating machinery. Such "white fingers" with no known external cause were described as early as the 1860s by the Frenchman Maurice Raynaud and are therefore usually referred to as "Raynaud's phenomenon" or "primary Raynaud's". It can be difficult to distinguish between primary and secondary vibration-induced Raynaud's. Primary Raynaud's is often bilateral, i.e. both hands show symptoms, while Raynaud's phenomenon caused by vibration mainly manifests itself in areas with the most severe vibration exposure. However, both hands are usually exposed to vibration when one hand holds the machine's controls while the other hand guides or supports the tool. Compared to secondary Raynaud's phenomenon, primary Raynaud's phenomenon often has a more favourable course, milder symptoms and a better prognosis. The severity of white finger symptoms can be graded according to the Stockholm Workshops vascular scale or local modifications of this scale. The revisions reflect differences in the purpose for which the classification scale is used.

Latency time refers to the time from the first exposure to vibration until the first signs of damage appear. Although there is probably a relationship between exposure and the onset of symptoms of damage, the connection and thus the risk for an individual cannot be specified precisely. However, it is clear that the higher the vibration intensity, the shorter the time until damage occurs. The length of the latency period is also affected by the fact that there is considerable biological variation in sensitivity to vibrations and considerable variation in the transmission of vibrations to the hands between different individuals. There are examples where two people have stood side by side and performed identical tasks, but one has developed damage while the other has remained symptomfree.

"White fingers" can lead to a functional impairment that reduces work ability and significantly lowers quality of life. In severe cases of "white fingers" causes such a handicap that the person has great difficulty maintaining employment both at work and in their leisure time. If exposure to vibration is stopped, the symptoms often get better, but it can take years before you notice any real improvement. Symptoms that show up after exposure has stopped (> 2–3 years) are probably due to some other causal factor than vibration. The causal mechanisms behind this increased reactivity and vasoconstriction leading to "white fingers" are still unknown, but several theories have been put forward. These are mainly based on functional changes in peripheral blood vessels and/or nerves and blood flow capacity. Theoretically, several mechanisms may contribute to the symptoms. The effects of exposure to vibrations, cold, static hand grip that impedes blood flow, nicotine, stress, other illnesses, medication, and individual factors all contribute. In addition to congenital predisposition (primary Raynaud's) and secondary Raynaud's due to factors such as vibration exposure, vascular symptoms in the fingers can also be caused by other work-related exposures (e.g. polyvinyl chloride, arsenic, lead), inflammatory connective tissue diseases (e.g. scleroderma, rheumatoid arthritis, SLE), vascular diseases (e.g. atherosclerosis; thromboangiitis obliterans, embolisms), neurological diseases (e.g. thoracic outlet syndrome, carpal tunnel syndrome), changes in blood viscosity (e.g. cold agglutinins after infection), medications (e.g. drugs for ADHD, angina pectoris, high blood pressure, migraine and cytostatics) and exposure to cold.

Tobacco use in the form of smoking, snus or other forms of nicotine consumption is not considered to cause "white fingers" in itself, but nicotine can contribute to triggering attacks of vasoconstriction more easily in people who already have an increased tendency to vasoconstriction. Nicotine use is therefore significant for the occurrence of symptoms among people exposed to vibration who have white fingers. The prognosis for white fingers is worse among those who use nicotine.

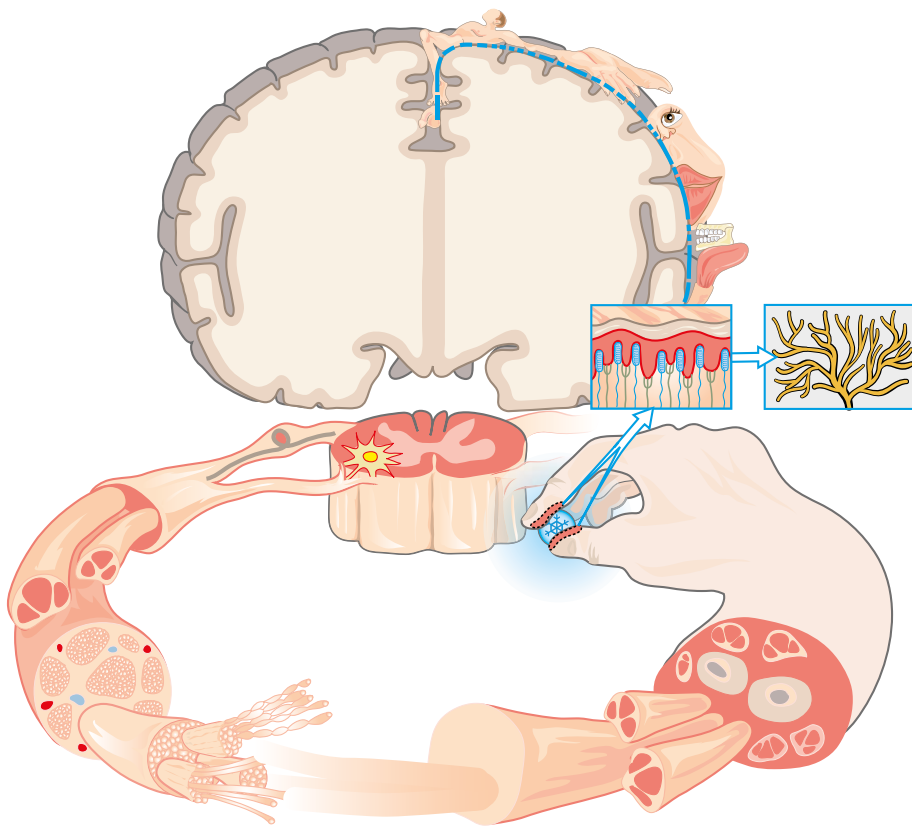


Figure C-2. Vibrations can affect sensation in the fingers (sensory disturbance), affect and constrict the median nerve in the wrist (carpal tunnel syndrome) and disrupt the interpretation of sensory signals in the central nervous system (cold pain).

Impact on nerves

Nerve damage in the hand can manifest itself in several different ways. When a hand is exposed to vibrations, sensitive nerve structures can be damaged at various levels (Fig. C-2). The damage can affect everything from the receptors in the skin of the fingers for touch, pain, cold and heat to the nerves that supply the sensory organs to the sensory representation in the brain (Fig. C-3). Pressure on the median nerve in the carpal tunnel affects several of the nerve’s functions, which are collectively referred to as carpal tunnel syndrome (CTS) (Fig. C-5). A similar effect also occurs for the ulnar nerve in the wrist (Guyon’s canal syndrome). Prolonged sensory vibration stimulation can disrupt information processing in the central nervous system and can lead to altered sensory perception (cf. cold allodynia with cold pain, or the fields for sensory representation of the fingers in the brain becoming blurred). Such changes in the central nervous system are still relatively unexplored.

Neurosensory effects

Early symptoms of sensory nerve effects are characterised by acute irritation symptoms in the form of tingling, paraesthesia, “sugar drink sensation”, “numbness” or sensory impairment. It is not uncommon for these individuals to be awakened at night as a result of the discomfort. In more severe cases, the symptoms become continuous and cause a higher degree of discomfort, including impaired tactile and fine motor skills. Nerve damage can also be associated with discomfort and pain.

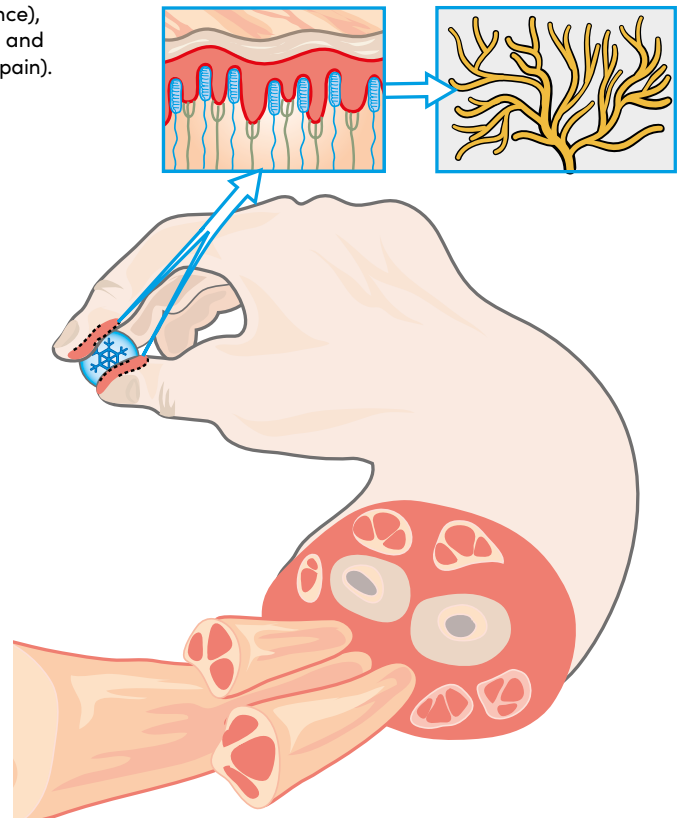


Figure C-3. Vibrations can affect the sense of touch, heat, cold and vibrations.



Figure C-4. Damage to the nerves in the hand caused by hand-transmitted vibrations is diagnosed on the basis of medical history, clinical examinations and laboratory tests. [6]

The perception threshold, i.e. the degree of stimulus intensity required for an individual to perceive touch, cold or heat, is often altered. The degree of sensitivity reduction depends on the strength and duration of vibration exposure. This nerve damage is summarised as sensory nerve damage. Nerve damage is a critical effect of vibration exposure. Other work-related factors, such as ergonomic stress and neurotoxic exposure, also play a significant aetiological role in neurosensory disorders.

The severity of diffuse neurosensory damage is classified according to the Stockholm Workshop's neurosensory scale or a local revision thereof (Fig. C-4). Those affected with only mild symptoms report periodically recurring numbness, while in more severe cases the symptoms increase and other symptoms appear. The classification scale is thus progressive. The classification scale has been criticised because the development of damage does not always seem to follow a regular pattern, cumulative stepwise pattern. Individuals with severely impaired vibration thresholds do not necessarily report symptoms such as numbness or tingling, either during the day or at night. It is therefore not always possible to strictly classify nerve damage based on the symptoms according to this symptom scale. The scale also does not take into account that neurosensory symptoms can be either loss symptoms (loss of sensation), additional symptoms (paresthesia, pain) or provoked symptoms (pain when pressing or pulling on the nerve). Another weakness is that changes in all different nerve types and modalities are not taken into account. Fine thread neuropathy, i.e. disturbances in temperature sensation, is not covered by the scale, for example. There is therefore both a need and strong reasons for a revision of the classification scale. Locally, individual countries have introduced clarifications additions to the scale. A group of experts consisting of researchers and clinically active physicians has used the Delphi method to develop an international consensus criteria document. Although several proposals have been put forward, these still do not cover symptoms such as increased sensitivity to cold or pain.

Current scales also do not take into account other harmful effects that have been noted recently, such as Dupuytren's contracture (Fig. C-7) and carpal tunnel syndrome (Fig. C-5).

It should be noted that even a relatively moderate neurosensory impairment can lead to a significant reduction in hand function, which can impair work ability. In the case of a neurosensory impairment, the central nervous system does not receive accurate and/or sufficient information from the receptors in the hands and fingers to be able to interpret sensory impressions adequately. The absence or lack of this information reduces the brain's ability to control the motor functions of the hand. If the impairment is too severe, even very simple, everyday tasks such as fastening buttons, picking up small objects, and so on. The hand becomes more or less functionally "blind". Experience has shown that in most cases, "blind fingers" constitute a greater disability and a greater reduction in quality of life for the affected person compared to "white fingers". An important reason for this is that people with "blind fingers" experience discomfort around the clock, unlike symptoms of "white fingers", where discomfort only occurs in connection with attacks triggered by cold or stress. Damaged nerves can lead to severe discomfort and pain (sensory cold intolerance) when exposed to cold or in environments with a strong cooling effect.

Carpal tunnel syndrome

Carpal tunnel syndrome (CTS) occurs due to intermittent or continuous compression or constriction of the median nerve as it passes through the carpal tunnel from the wrist to the hand (Fig. C-5). Increased pressure on the nerve in the tunnel can lead to progressive sensory and motor disturbances in parts of the hand that correspond to the distribution of the median nerve. This is often accompanied by pain and, in the most severe cases, impaired sensation and motor function.

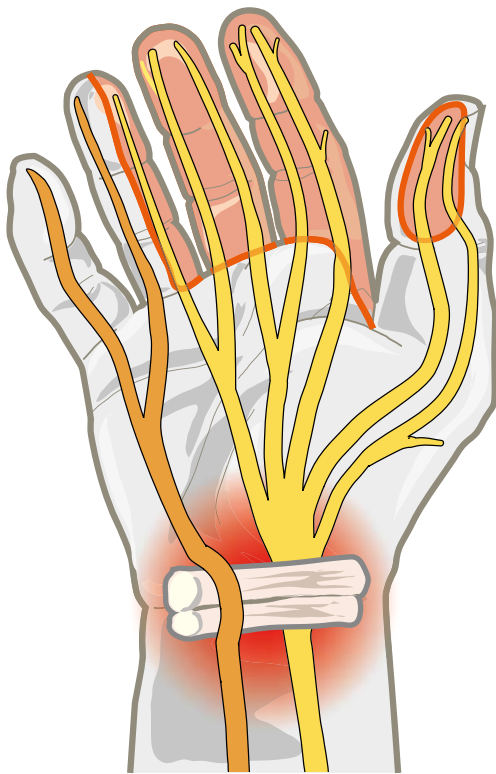


Figure C-5. Carpal tunnel syndrome. Compression of the median nerve in the carpal tunnel (marked in red) with sensory impairment/pain in the fingers (the extent of sensory impairment marked in blue).

CTS has a multifactorial aetiology, with a number of recognised risk factors, including non-occupational ones (cold, pregnancy, advanced age, female gender, family history, hypothyroidism, diabetes, autoimmune diseases, rheumatological diseases, arthritis, obesity, kidney disease, trauma and a possible predisposition related to the shape and structure of the carpal tunnel, bones and tissues in the wrists and hands). The main occupational risks for the disease are vigorous repetitive hand-intensive work, especially repetitive movements of the hands and wrists with forceful grips, hand-transmitted vibration, direct pressure and awkward wrist positions (i.e. pronation and supination of the forearm, deviation of the wrist and flexion of the metacarpophalangeal and fingers).

The diagnosis "carpal tunnel syndrome" (CTS) summarises the complex of symptoms and clinical findings that arise when pressure is exerted on the median nerve in the wrist (carpal tunnel). Pressure on the median nerve can occur when the nerve, together with several finger tendons, passes through the limited space of the carpal tunnel. Mechanical pressure from these tendons, increased tissue volume in the tunnel from, for example, oedema or fluid retention, swelling of the nerve due to disruption of the endoneurial flow, inflammation, muscle hypertrophy or ganglion cause reduced space for the nerve. Skeletal changes or deformities can also reduce the space in the canal.

Carpal tunnel syndrome (CTS) occurs more frequently in jobs that involve exposure to vibrations, as well as in occupational groups with repetitive, hand-intensive work. The injury is caused by pressure on the median nerve, which disrupts the nerve's metabolism as it passes through the carpal tunnel. This nerve transmits nerve impulses from the skin's sensory receptors distally on the thumb, index and middle fingers, and the radial half of the ring finger. The nerve also transmits motor impulses to the muscles of the thumb. The entrapment causes inward sensory and outward motor nerve impulses to be blocked as a result of pressure on the nerve.

The dominant symptoms of CTS are tingling, numbness, reduced sensation, reduced motor ability and sometimes even pain in the innervated area. The symptoms can be provoked by unfavourable flexion and extension hand positions. Mild discomfort is characterised by transient symptoms, mainly at night. Repeated impact on the nerve through direct pressure and strong shocks, static strain and extreme wrist positions can increase the risk of CTS. Exposure to vibrations in combination with forceful gripping is considered to increase the risk of injury. Women are more prone to developing CTS than men. The prognosis for surgical treatment is good, but for vibration patients, surgery often results in only a slight improvement.

General symptoms

When exposed to low-frequency vibrations in particular, these can be transmitted via the shoulder and neck up to the head. This could explain some subjective complaints, such as headaches, nausea, dizziness and abnormal sweating, symptoms that have been discussed in connection with vibration exposure but for which there is no clear scientific documentation. Vibration-related disabilities have been linked to reduced mental well-being.

Impact on the musculoskeletal system

The soft tissues of the upper extremities, as well as the skeleton and joints, can be affected by hand-transmitted vibrations. Degenerative changes in the finger and wrist bones among those exposed to vibrations were reported in X-ray examinations as early as the 1920s and 1930s. The changes observed were mainly in the epiphyses and joint surfaces (arthrosis) and decalcification of the hand and arm skeleton (osteoporosis, cysts, vacuoles). Several studies have shown a high prevalence of changes in bones and joints, but this cannot be said to be specific to vibration exposure. Exposure to low-frequency shocks from high-intensity percussive machinery may play a particularly important role in the development of damage to tendons and joint surfaces due to the need for joint stabilisation and high grip strength. In addition, the tonic muscle reflex increases muscle contraction, resulting in muscle fatigue. The same effect occurs when work continues if the temporary sensory impairment is not given the opportunity to recover. Exposure to high-frequency vibrations from, for example, grinding machines and chainsaws does not appear to be specifically associated with joint damage.

There is only one study on the effect of hand-transmitted vibrations on muscles. Vibrations can cause reduced muscle strength, even though muscle volume remains unchanged. Degenerative changes in muscle structure have been observed in animal experiments where extremities have been exposed to vibration loads, as well as among workers exposed to vibrations. It is not known whether vibrations can damage the motor unit's nerve end plate in such a way that nerve impulses cannot be transmitted to the muscle fibre, or whether the impaired muscle function is a result of nerve damage alone or damage to the muscle spindles alone. Direct mechanical impact on muscle fibres, changes in the biochemical environment of muscle cells, blood supply or neuropathies are other possible causes.

Musculoskeletal pain in the musculoskeletal system can cause referred pain but also distal sensory disturbance through centrally disturbed pain modulation.



Figure C-6. Illustration of finger osteoarthritis. Illustrated here with joint swelling, joint misalignment, joint cartilage growth and reduced joint space, all often accompanied by pain.

Osteoarthritis

Osteoarthritis (also known as osteoarthrosis or arthrosis deformans) is a collective term used to describe joint failure resulting from an imbalance between the breakdown and regeneration of the various tissues in the joint (bone, cartilage, ligaments, tendons).

Osteoarthritis has historically been considered a wear-and-tear disease. However, recent research shows that the disease has a complex background in which several different causal factors interact to cause the disease. Blood circulation, inflammatory and pro-inflammatory markers, mechanical stress and trauma, as well as age-related processes, interact over time with a hereditary predisposition to the breakdown and accumulation of bone and cartilage in joint structures. Osteoarthritis can occur after joint injury, joint disease, congenital malformations and deformities, as well as in cases of impaired neuromuscular function and abnormal mechanics, and spontaneously without any known cause.

Osteoarthritis is usually a slowly progressive disease that affects synovial joints ("true" joints) surrounded by a joint capsule containing synovial fluid and synovial membrane. Osteoarthritis occurs when there is damage or impaired repair in any of the joint tissues (joint cartilage, subchondral bone, ligaments, muscles or synovium). The result, in the form of cartilage degradation and bone deposits, is accompanied by pain, stiffness and functional impairment (Fig. C-6). Long-term Working with powerful pneumatic impact machinery can cause discomfort and pain in the elbow and wrist and, in rare cases, even lead to osteoarthritis. Joint damage is not specific to vibrations but can also be caused by other work-related stresses. Working with vibrating machinery usually involves high static and dynamic joint loads as well as repetitive, one-sided body movements. These high loads are often combined with poor working postures. Vibration exposure in itself is not supported in the literature as an individual risk factor for X-ray-diagnosed hand osteoarthritis.

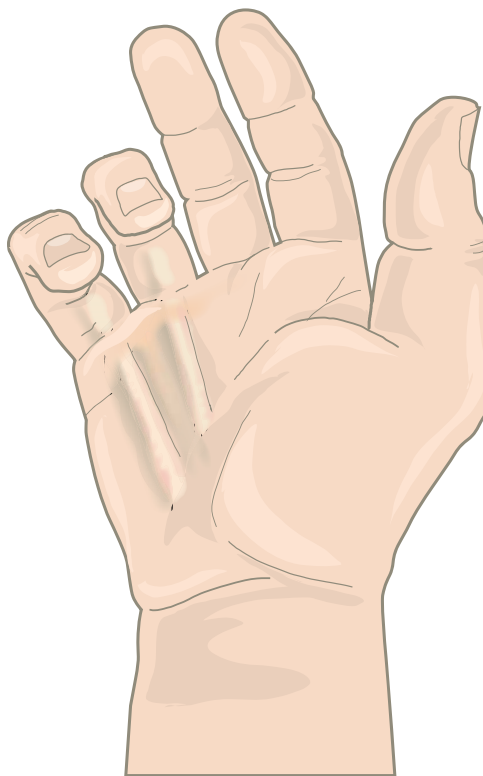


Figure C-7. Illustration av hand med Dupuytren's sjukdom där bindvävsplattan dragit ihop sig, vilket medför svårighet att sträcka ut fingrarna (sträckdefekt eller kontraktur). Här illustreras kontrakturer för ring- och lillfinger.

Dupuytren's contracture

A link between connective tissue changes in the fingers and heavy manual labour has been repeatedly reported since the 18th century. In 1831, Baron Dupuytren concluded that connective tissue changes were linked to chronic hand trauma at work. Surgeons who treated connective tissue shortening (contractures) in the palm of the hand long believed that the disease could be most easily explained by repeated trauma to the hand. They claimed that increased pressure on the palm of the hand during heavy manual labour and impacts were the cause of the disease.

Results from recent studies of workers exposed to manual work with vibrating machinery have raised the question of whether there may also be a link between vibration exposure and the contraction of the connective tissue plate in the palm and on the inside of the fingers. In other words, pathological changes corresponding to what we now call "Dupuytren's disease".

Dupuytren's disease with fibrosis, collagen deposition and possible contraction of the fingers has multifactorial causes that are largely unknown. Factors that increase the risk include heredity, male gender, the simultaneous occurrence of other fibrotic diseases, other comorbidities (diabetes, epilepsy), tobacco and alcohol use, and a number of environmental and occupational exposures. Among the occupational exposures now associated with Dupuytren's disease is working with vibrating machinery.

As the disease progresses, the elasticity of the palmar fascia decreases and it contracts. This prevents extension and flexion in the hand and finger joints, resulting in contracture (Fig. C-7).

The disease is usually noticed by the affected person themselves when signs of palpable hardening appear on the inside of the hand (nodules) as well as connective tissue thickening. The calluses can vary in size and may

increase in size over time, forming streaks of hardened tissue. Gradually, the elasticity of the skin and underlying tissue may decrease and the connective tissue plate in the palm may shrink, preventing the fingers from being extended and causing them to remain in a contracted position (contracture).

Pain and increased sensitivity to cold

Hand-transmitted vibrations can cause symptoms and functional impairment of the senses of touch, vibration and temperature, as well as reduced fine motor skills, weakened grip and, in some cases, pain and discomfort. Neurosensory damage can also manifest itself as increased sensitivity to cold, with pain and cold intolerance. One of the most common symptoms among workers exposed to hand-transmitted vibrations in temperate and colder climates is an inability to tolerate cold exposure due to painful cold sensitivity in the hands (Fig. C-8).

Such increased pain sensitivity to cold has been defined as a collection of symptoms resulting in an abnormal aversion to cold, with pain, sensory changes and stiffness. The symptoms may occur after traumatic nerve damage or exposure to vibration. The pathophysiological mechanism behind cold pain is not fully understood but may involve both neurosensory and vascular mechanisms. One reason for this lack of clarity is that the pain symptoms involve neural (possibly small fibre neuropathy) and vascular (possible endothelial micro vascular damage) mechanisms. The pain may originate from neurovascular damage affecting vascular function, or alternatively from vascular damage causing nerve damage, or be purely neural in some cases and vascular in others.

Increased sensitivity to cold and pain occur among all categories of machine users, i.e. from users of heavy and powerful vibrating machinery in the engineering industry to users of light and more high-frequency vibrating machinery in, for example, dental care. These neurological symptoms and problems can occur either in isolation or in combination with white fingers.

Other injuries related to working with vibrating machinery

In addition to "vibration injuries", a single very powerful blow to the hand can damage blood vessels, nerves, ligaments or joints. Such injuries are classified as accidents. Injuries can also occur after a single blow or repeated blows with the palm of the hand (hammer syndrome).

Repeated tissue-damaging shocks or blows can lead to crushing injuries, pinching and pressure injuries and, if repeated, even fatigue injuries. These injuries have a different cause than vibration injuries and should be named based on the exposure that primarily caused the injury. These injuries are not covered by the current risk assessment model for vibrations.

Kraftergonomic overload on the musculoskeletal system can cause injuries that are often summarised as "strain injuries". These differ from vibration injuries in terms of the exposure that caused the injury and the tissues that were damaged (muscles, tendons, joints) (see regulation on hand-intensive work). Compression injuries to nerves (e.g. carpal tunnel syndrome) can be a vibration injury, a strain injury or a combination of both.

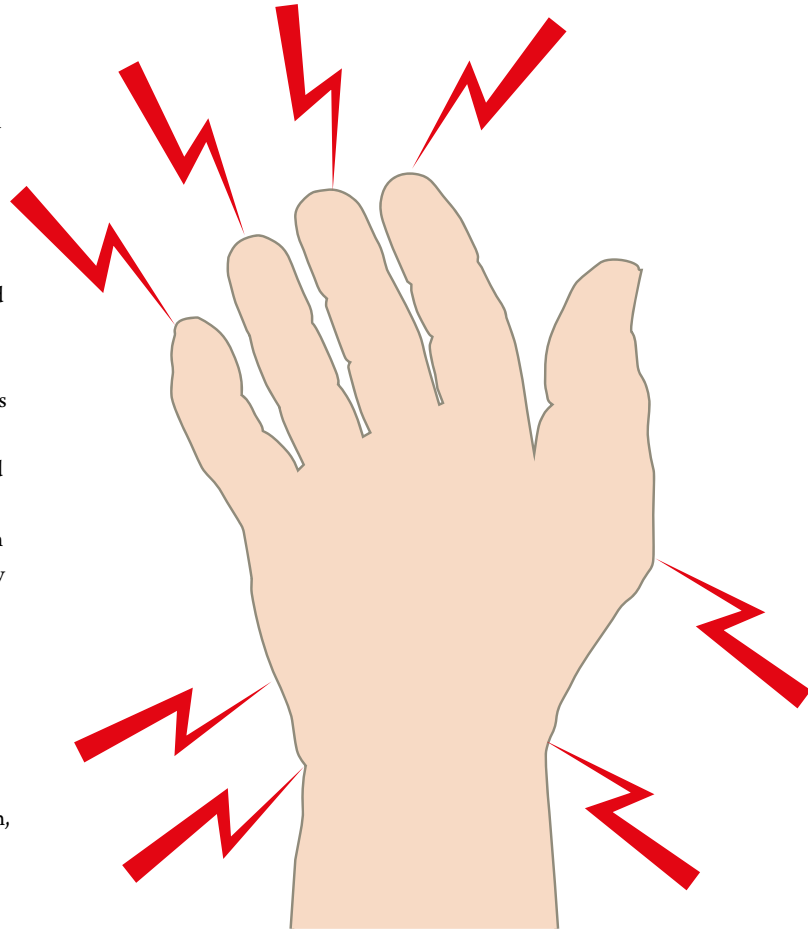


Figure C-8. Pain, cold pain as damage caused by vibrations.

There are additional exposures related to working with vibrating machinery, which can also cause injury. These include, for example, noise exposure that causes "hearing damage" (see regulations on noise).

Impact on the heart

An increased risk of heart attack and death from heart attack related to prolonged exposure to hand-transmitted and whole-body vibrations is supported by a few case-control and cohort studies. The reliability of the studies is negatively affected by the fact that confounding factors have only been partially controlled for. A Swedish thesis has shown that people who work with vibrating machinery, including hand-held powered tools, have an increased risk of heart attack, especially among younger professionals. Experimental studies have also shown that exposure to hand-transmitted vibrations can lead to an acute reduction in heart rate variability, which has an adverse effect on cardiac regulation and may be a possible mechanism behind the increased risk of cardiovascular disease.

Whole-body vibrations

Pain is common among people exposed to whole-body vibrations. The most common and well-documented effects of WBV exposure are discomfort, symptoms and damage to the lower back and neck, sometimes accompanied by radiating pain and weakness.

Strong shocks, including air or water-borne pressure waves, can cause both temporary discomfort and permanent damage. Other effects of WBV exposure, such as cardiovascular problems, gastrointestinal problems, urological problems, and general deterioration and fatigue, have some scientific support.

Headaches accompanied by functional impairment in the form of impaired balance and "shakiness" and nausea (motion sickness) shortly after or during exposure have been reported in particular from aviation and maritime transport, as well as from bus and truck drivers who have been exposed to WBV for long periods. Respiratory problems have also been observed in long-term studies of professional drivers, as well as intestinal disorders.

Acute effects

Vibrations transmitted from the surface on which one stands (foot-transmitted vibrations) to the surface on which one sits (whole-body vibrations) also have acute effects. Foot-transmitted vibrations cause temporary effects with impaired general circulation. Low-frequency whole-body vibrations have an acute sedative effect. This applies mainly to vibrations below 5 Hz. Such vibrations can make people tired, which can lead to serious consequences. The risk of accidents can increase when these vibrations occur in vehicles and aircraft. Vibrations with elements of shock usually have the opposite effect.

Vibrations that occur in the workplace often exceed the human sensory threshold, which means that our sense of touch is activated. Our brain receives a large amount of information from our sensory organs that must be processed and interpreted. This can be tiring and affect our ability to concentrate, our level of alertness and our reaction time. A person's experience depends, among other things, on the frequency, strength and duration of the vibration, as well as where and how it is transmitted to the body. In general, the higher the frequency, the more the experience is localised to the contact surface between the person and the vibrating surface. Frequencies below a few Hz are generally perceived throughout the body, while frequencies above approximately 30 Hz are largely felt by the parts of the body in contact with the vibrating surface.

Acute discomfort arising from WBV can be of a general nature, such as motion sickness, dizziness, discomfort and non-specific stress reactions such as headaches, fatigue, nausea, sweating and visual disturbances. The effects can also likely be caused by sensations transmitted to the brain via our sensory organs. The balance organ, vision and sense of touch are important factors in this context.

The eyeball and internal eye structures have resonance frequencies in the range of 30-90 Hz, depending on individual factors. Visual acuity can be severely impaired when exposed to the resonance frequency, which can be tiring but also increase the risk of accidents.

The vibrations can also have an acute effect on the vestibular system, resulting in dizziness and nausea. This effect is probably due to overstimulation of the receptors in the vestibular system, which normally register changes in the body's movement and position. It is not only impulses from

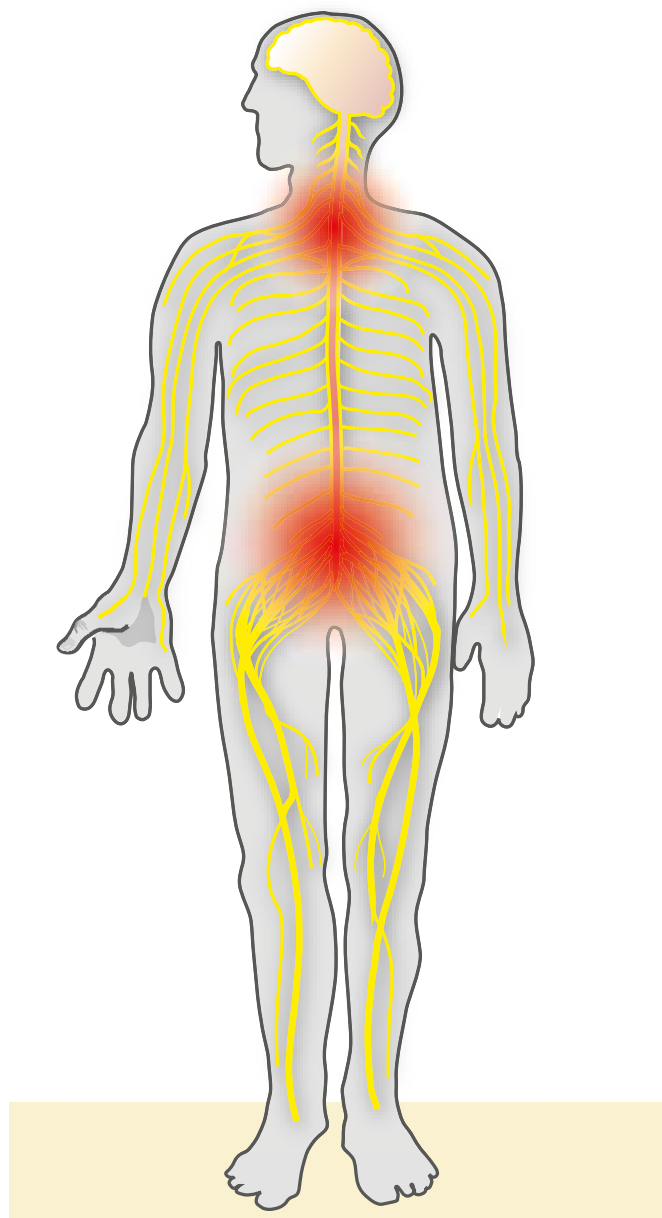


Figure C-9. Whole-body vibrations can cause pain originating in the lower back. The pain can also radiate into the legs. Similar pain can also occur in the neck/shoulders, radiating into the arms.

the balance organs that affect our sense of balance; other sensory impressions are also strongly involved. All sensory impressions are processed by the brain, and the effects of vibrations have been shown to trigger some form of coordination error. The impulses from the balance organ cannot then be coordinated with the corresponding visual impressions, sensory experiences and positional changes. Motion sickness (car sickness; seasickness) is one such effect of vibrations. The effect is most noticeable at very low vibration frequencies below 1 Hz.

WBV is also considered to affect heart muscle activity. Increased heart rate and blood pressure have been demonstrated in connection with relatively high vibration exposure. However, the research results are not entirely conclusive.

Permanent damage

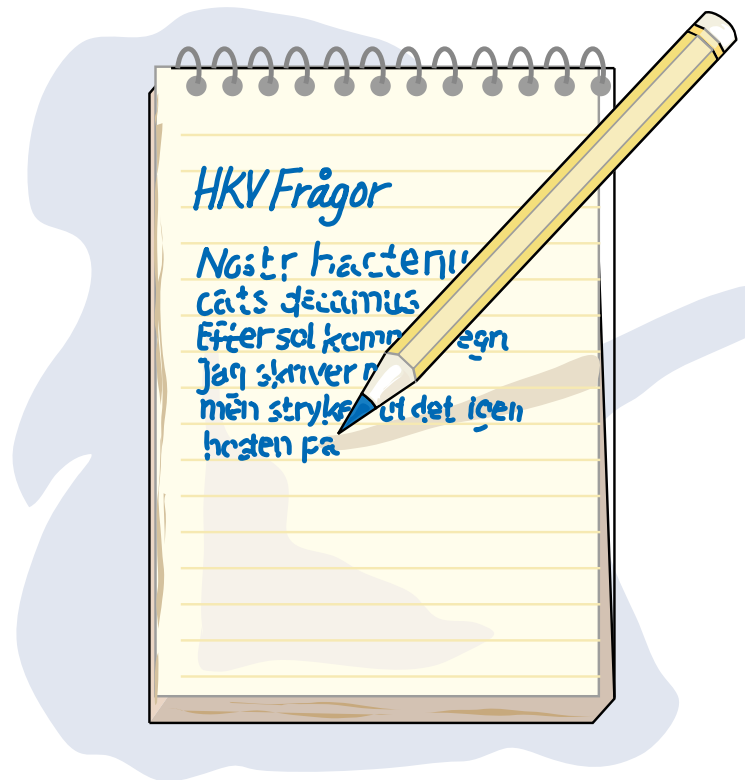
Our knowledge of the long-term effects of WBV on health is limited. Despite relatively extensive research, it is difficult to draw any firm conclusions. Several occupational health factors can co-vary with vibrations in such a way that it is impossible to separate any effect of vibrations from the effect of other factors. Shocks or sudden jolts in the vibration sequence can be particularly troublesome or harmful.

Stress and "wear and tear" injuries to bones, joints, muscles and ligaments, mainly in the back and lumbar regions, are the best documented effects of WBV. Recent studies also show an increased risk of neck-related problems. A number of epidemiological studies show an excess frequency of back disorders in groups of workers exposed to WBV. This may be an indication that there may be an "exposure-response relationship" and a causal link. The adverse effects of WBV also interact with the effects of awkward working positions, heavy lifting or a largely sedentary lifestyle.

During exposure to WBV, more or less intense local vibrations occur in muscles and muscle groups. The body interprets this as the muscles being stretched and shortened. Unconsciously, this can lead to reflexive muscle contractions and prolonged tension in the muscles, resulting in increased fatigue and discomfort. Exposure to seated WBV at a frequency of 5 Hz has been shown to accelerate the development of muscle fatigue and can also lead to more pronounced muscle fatigue. It is reasonable to assume that these increased muscle contractions in working life can damage the musculoskeletal system. However, the same effect is sought in medical rehabilitation or as reinforcement of muscle training in sports.

Other lasting problems caused by nerve damage include herniated discs, which can manifest as pain, muscle weakness and nerve irritation symptoms (tingling, crawling sensation) in the legs and arms. The problems are also accompanied by irritation and discomfort during rest. It is reasonable to believe that these problems may be due to WBV, especially if exposure occurs while standing on a vibrating surface.

A link between stomach problems and WBV has been suggested. Gastritis, ulcers and intestinal problems occur more frequently in people exposed to WBV. However, there is no clear evidence that it is the vibrations themselves that are the harmful factor. Shift work, irregular meals, poor eating habits and a sedentary lifestyle may also contribute to these symptoms. Urogenital problems have been explained in the same way.



Figur C-10. The consequences of whole-body vibrations can be noted based on the disturbances and pain caused by WBV.

Effects on the central nervous system and cognition

Cognitive impairment has been demonstrated in several studies where exposure consisted of very powerful shock impacts and concussions. Such powerful blows and impacts can occur when travelling in high-speed boats, for example, or be the result of shock waves from explosions. In both of these examples, the shock wave affects the central nervous system. The effect is attributed to a direct physical impact on the brain from the shock waves, or alternatively a secondary consequence of vascular impact and rotational force. These injuries are classified as "closed head trauma" or "mild traumatic brain injury" and "chronic traumatic encephalopathy" in the case of permanent damage. The injuries manifest themselves as impaired cognitive function with impaired attention, reduced vigilance, impaired memory and slower information processing, and in some cases also as neuropsychiatric affective symptoms.

Impact on the lumbar spine, sciatica, disc herniation, impact on the neck/shoulder

There is scientific support for the notion that exposure to WBV increases the risk of low back pain (Fig. C-9). The state of knowledge regarding the relationship between WBV and sciatica and disc herniation is less clear, and more high-quality studies are needed to assess this relationship.

The vast majority of studies reviewed show a link between work involving exposure to WBVs and low back pain. Most of the studies are cross-sectional studies, but there are also a small number of prospective cohort studies and case-control studies.

Unfavourable working positions and prolonged sitting correlate with WBV exposure and have only been controlled in a few exceptional cases. However, it is unlikely that the overall risk pattern can be explained solely by other covariates, but in future studies, great importance should be attached to trying to measure these exposures in a better way than has been done in previous studies. There is also some support for an exposure-response relationship between low back pain and WBV exposure. Studies that allow exposure-response relationships to be studied show a clearer relationship when cumulative exposure time is used rather than when WBV exposure levels are given greater weight in the analyses. Meta-analyses indicate an overall doubling of the risk of low back pain as an average value based on current data. In several studies, the authors discuss that WBV exposure involving blows and impacts leads to an increased risk of injury. There is currently no scientific support for drawing any such definitive conclusions.

Disc herniation in the neck

Several cross-sectional studies show an increased risk of neck pain (Fig. C-9) in individuals whose work involves exposure to WBV. In these studies, those exposed to WBV have usually been compared with white-collar workers or people with office jobs, which means that the significance of other modifying and confounding factors cannot be distinguished. This means that pain in the neck/shoulder can arise from working with the neck in an unfavourable position or static working positions for the arms and shoulders, and that it is not the vibrations themselves that lead to the development of pain.

The impact of WBV on pregnant women and fetuses

There is no reliable scientific evidence of a link between WBV exposure and most outcome parameters that reflect health risks for pregnant women. However, whole-body vibrations and shocks during pregnancy affect the mother both directly and indirectly. The direct effect of WBV on pregnant women can be increased pain and strain on muscles, ligaments and tendons, as well as effects on nerves. Direct effects of WBV are therefore back and pelvic pain, which occur more frequently among pregnant women exposed to WBV and shocks.

Indirectly, injuries or falls can occur more easily when pregnant women are on surfaces that move and vibrate. The increased risk of falling interacts with the clumsiness and shift in centre of gravity that a pregnant belly causes in late pregnancy, in combination with whole-body vibration.

There is some scientific support for the idea that whole-body vibrations can also pose a risk of foetal damage, miscarriage or premature birth, but the link is not clear and research is limited. However, several sources and authorities state that pregnant women should avoid exposure to whole-body vibrations. Therefore, pregnant women are advised to avoid such exposure, even though the scientific evidence for direct foetal damage is limited and mainly concerns pregnancy complications rather than specific foetal damage. Health risks to the child as a result of premature birth and miscarriage have been demonstrated in a few well-conducted studies. A few studies point to a specific link between whole-body vibration exposure and miscarriage, which also shows an exposure-response relationship.

Experimental studies have shown that foetal alertness can be affected by WBV exposure, but there is no scientific support for this posing a long-term health risk to the foetus.

Impact on the heart

An increased risk of heart attack and death from heart attack related to long-term exposure to WBV is supported by a few case-control and cohort studies. The reliability of the studies is negatively affected by the fact that confounding factors have only been partially controlled for. However, exposure-response relationships suggest a possible link between WBVs and an increased risk of heart attack. Further scientific studies are needed to confirm the risks.

References in Appendix C.

Hand-transmitted vibrations

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