Chapter 2.4 : Physical Agents

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Objectives

Knowledge objectives:

The student

- Gives international accepted definitions of the following concepts: noise, vibration, radiation, electromagnetic field, lighting, and temperature
- Identifies physical hazards as risk factors in the work and work environment
- Explains the main effects of physical hazards on health
- Knows roughly the threshold values of physical hazards
- Explains the specific role, tasks and responsibilities of the occupational health services and occupational physician at the workplaces with physical hazards exposure
- Recognizes the main occupational diseases due to physical hazards exposure and knows when to refer the patient to an occupational physician.

Skills/attitudes related objectives:

The student

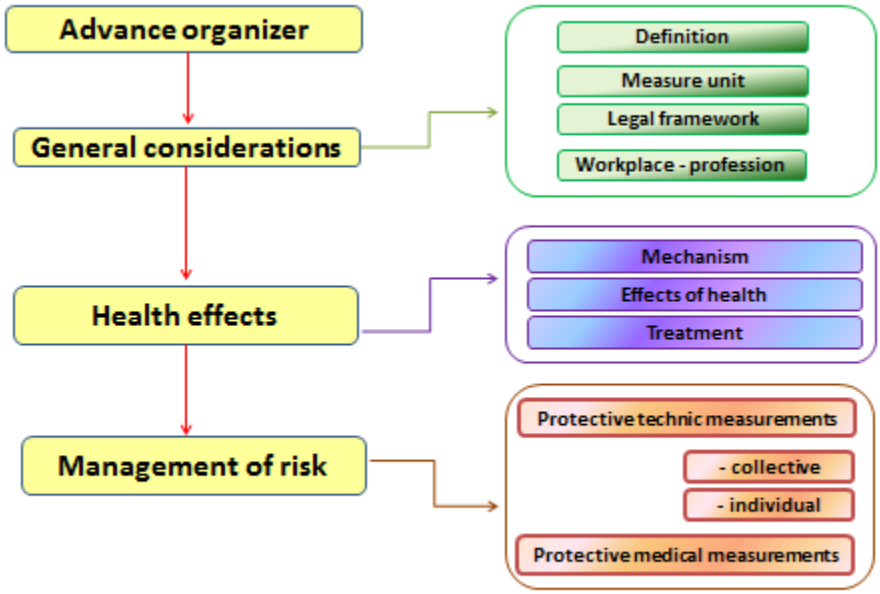
- Is attentive to the physical hazards at the workplace
- Takes an occupational history on the level of the physical hazard, time of exposure, use of protective equipment, general effects of physical hazards on health
- Adopts a preventive attitude when considering work and health issues.
- Shows an ethical and deontological attitude when considering work and health issues.
- Finds reliable sources (e.g. Pubmed) with information and evidence about physical hazards (threshold values, health effects and preventive measures).

Physical agents are sources of energy that may cause injury or diseases

1. Noise
2. Vibration
3. Radiation
4. Temperature
5. Lighting
6. Pressure

Concept Map

Framework



Advance organizer

John P is a 50-year old man who works as a carpenter. John P is sent by the occupational physician from his workplace to the Ear Nose Throat (ENT) clinic with the presumptive diagnosis of bilateral neuro-sensorial hypoacusia/ Noise induce hearing loss (NIHL). At the periodical medical examination the audiogram showed this aspect. J.P is 48 years old and he works as a carpenter for the past 17 years at the same workplace. In the past 3 years he has worked at the new wood working machine, but even if the working conditions have improved, the noise level still exceeds the thresholds values. In the first 7 years he worked as a guardian at a household warehouse. He lives in a house in a quiet area. He is married, he has two healthy children. He was diagnosed with increased blood pressure two years ago and he is under treatment with ACE-Inhibitors. He is overweight and he does not drink alcohol. At the workplace, he works mainly in a standing position, at many	**W**ork: -17 years at the same workplace -he works in a noisy workplace -he does not wear the protective equipment **A**ctivities: -tiredness -irritability -communication problems

wood working machines, such as wood cutting machine, drill press, grinder and sander. The noise levels measured at the workplace indicate 97 - 105 dB(A). He is a bit confused that he is sent to the ENT clinic with this diagnosis because he considers that he hears well for his age. He did not wear his protective equipment (ear muffs) much, because he preferred to hear the sound of the functioning machines. He remembers that two other colleagues had to change their workplace because of some communication difficulties. But he says that he does not have such problems, he hears the television sound and he can communicate on the telephone, although lately, he has raised a little the level of his voice. Only at the workplace he has to talk a little bit louder in order to be able to communicate with his colleagues. After the day work he feels more tired, sometimes he gets a headache or he is more irritable and lately has had some difficulties in understanding a conversation involving more people. "Are these symptoms linked to the noise at the workplace?". J was wondering while waiting to see the ENT doctor. Finally, he entered the ENT office. The doctor asked him about ear sufferance, infectious or traumatic, if he ever had taken antibiotics such as Streptomycin, Kanamicin, Gentamicin. J's answer was negative. When asked whether he was working or had worked in a noisy workplace, the answer was of course affirmative. His ear was examined with the otoscope, the aspect being normal. Then an audiogram is performed in the soundproof room. The audiogram confirms the diagnosis of NIHL. Is his pathology professional? Which treatment can he follow? Is he able to continue his professional activity?	**R**eferral: - for diagnosis (ENT specialist) - for work-relatedness (occupational physician, occupational clinic) - for treatment (?) - for prevention (occupational physician) - for compensation (occupational physician, insurance doctor,…) **P**revention: - machines - protective ear equipment

1. Noise

1.1. What do you know about noise?

1.1.1. Definition

Noise is probably the most frequent physical hazard, present in the working environment as well as in our everyday life. Daily, in Europe and throughout the world, millions of workers are exposed to noise. According to the data furnished by OSHA, in Europe, one out of five workers has to speak louder in order to be heard, at least half of the working time.

Noise is as a group of unwanted or/and wanted sounds which produce an unpleasant hearing sensation, sometimes disturbing, which impede communication. Usually, noise is an annoying sound. The perception depends on the listener and the circumstances. For example, rock music can be pleasant for a person, but uncomfortable in a surgery room.

The occupational noise is a complex of sounds, of variable intensities and pitches, having different characteristics, rhythmic or rhythm less, produced continuously or discontinuously by machines, tools, devices, means of transportation, human voice, etc during the performance of the professional activity.

The simple sound or pure tone is a mechanical oscillatory movement capable to produce hearing sensation. It is an acoustic wave that results when a vibrating source, such as machinery, disturbs an elastic medium, such as air.

The audibility of the sound is determined by two parameters: the frequency and the intensity of the sound.

The *frequency* expresses the pitch of the sound; is measured in Hertz (Hz) and means the number of vibrations per second. The normal human ear is sensitive to frequencies between 20 and 20.000 Hz. There are high pitch (>3000Hz) and low pitch (<500 Hz); for example, the women's voice and the man's voice. Frequencies around 2.000 Hz are the most important for understanding speech, while frequencies between 3.000 Hz and 4.000 Hz are the earliest to be affected by noise.

The *intensity* expresses the level of the sound or the sound pressure; is measured in decibel (dB) and means the relative value of the acoustic intensity in a logarithmic form. "0" dB does not mean any sound; it means a sound level where the sound pressure is equal to that of the reference level which corresponds to 0.02 mPa (milliPascal). For example, if the noise produced by a machinery is 92 dB (A), when doubling the source of noise (if we have 2 identical machineries), the noise will increase with 3 dB, will not be doubled!

The *loudness* is the subjective human response to sound. It is dependent by sound pressure (primarily) and frequency.

1.1.2. How do we measure noise?

The level of noise is measured in decibel with sound meters or dosimeters.

The human ear does not respond equally to all frequencies: we are much more sensitive to sounds in the frequency range about 1000Hz to 4000Hz than to very low or high frequency sounds. For this

reason, when we measure the level of sound by sound meters we use a filter (A) which records a selection of sounds similar with the human ear. In this situation the unit will be **dB (A)**.
The noise measured at a workplace is expressed in Leq, which means the equivalent continue weekly acoustic level. If the workplace noise levels are different during the day, it will be useful to measure noise by the dosimeter.

1.1.3. What is the Threshold Limit Value?

Threshold Limit Value (TLV): depends of the work specificity (International Standard, ISO 1999-1990.)
Law: Directive 2003/10/EC of the European Parliament and of the European Council. This directive is to be transposed into the national legislation of all Member States. In the European countries the maximum admitted values (Leq-weekly equivalent acoustic level) in the workplaces with normal neuro-sensorial solicitation are in between 85 and 90 dB (A).

1.1.4. Which are the workplaces with noise?

We can find it in heavy industry, in manufacturing and mining, in construction, agriculture, transport and communications, service sectors - education and healthcare, bars and restaurants. For example, in kindergartens > 85dB (A), truck traffic - 95 dB (A), power saw - 95 dB (A), chainsaw, night clubs - 100 dB (A), pig farms < 115dB (A), rock concert - 120 dB (A), gunshot - 140 dB (A).
In offices the noise generated by the air conditioner and the PCs does not exceed 70 dB (A) and does not affect the hearing, but it can cause irritability, decrease of attention, concentration and occurrences of errors.

Figure : Noise thermometer

1.2. Which are the health effects?

1.2.1. Pathogenic mechanism

The health effects are determined by the source of noise and could be favored by individual factors (pre-existent ear diseases, alcoholism, smoking, ototoxic drugs). Regarding the source of noise, it is important to know: the intensity (>80 dB (A)), the distance of the source, the high frequency noises (>3000Hz) and the impact noises are the most aggressive for the human internal ear compared to the low frequencies (500Hz). Also, the effects of noise exposure depend on the time of exposure (5-15 years).

In acute exposure to noise, the tympanic membrane, middle ear and cochlea are affected.

In chronic exposure to noise the neural-sensorial cells in the Corti organ are affected.

http://www.hse.gov.uk/noise/video/hearingvideo.htm

In our case, J. has a significant workplace exposure to noise, as intensity (97-105 dB (A)), as well as a characteristic of noise, that is, the impact noise (e.g. cutting wood machine), the short distance between the source and the worker, and also the long time of exposure (17 years). The individual factors are absent.

1.2.2. Health effects

Noise exposure can cause two types of health effects: auditory effects and non-auditory effects.

According to Eurostat data, 7% of European workers suffer from work-related hearing difficulties, and noise-induced hearing loss is the most common reported occupational disease in Europe (European Agency of Safety and Health of Work).

Auditory effects could be acute and chronic. These are the result of excessive noise exposure.

Acute effects include hearing impairment (auditory fatigue, tinnitus), acoustic trauma which can lead to total deafness. The time of exposure is brief.

Tinnitus: Ringing or buzzing in the ear

Acoustic trauma: Sudden hearing damage caused by short burst of very high intensity noise (>140 dB (A)) such as an explosion or gun shot. The auditory deficit in acute acoustic trauma is neuro-sensorial or mixed (both conductive and neuro-sensorial), symmetric or asymmetric depending of exposure, and generally partially reversible, depending on the level of noise and the duration of exposure.

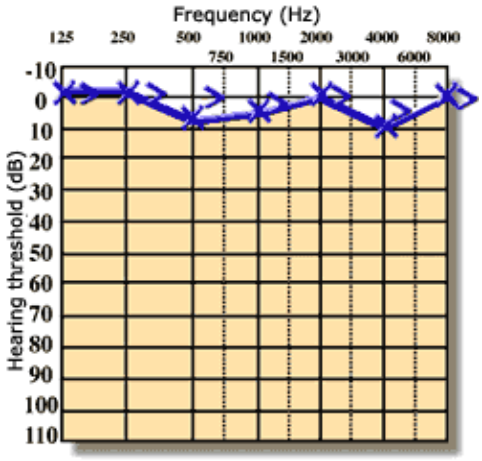
Chronic effects including ***Noise induced hearing loss*** develop slowly and insidiously. The period of exposure is between months and years. Six months with 93 dB (A) daily exposure for the most susceptible individuals. Every 3 dB increase in noise exposure halves the time of onset of adverse effects.

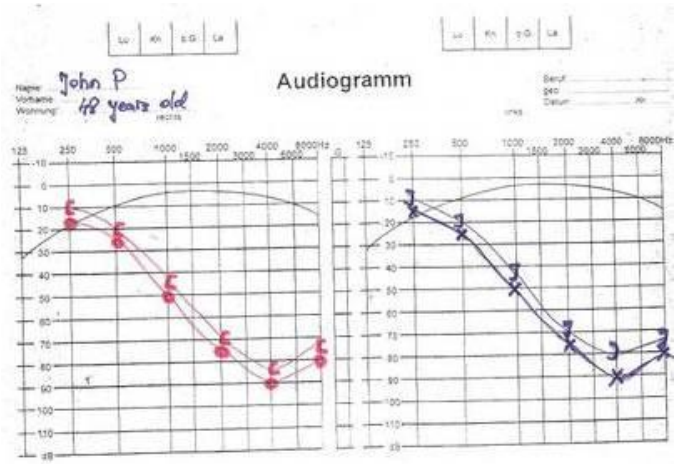
Hypoacusia / Noise induce hearing loss (NHIL): the hearing damage of internal ear is permanent and irreversible and it is approximately the same for both ears, more pronounced on the frequencies 3 to 6 kHz and especially for 4 kHz. It is neuro-sensorial, bilateral and generally symmetrical, irreversible but usually not progressive once exposure to noise ceased. When noise exposure stops, the person does not regain the lost hearing sensitivity. As the employee ages, hearing may worsen as "age-related hearing loss" adds to the existing noise-induced hearing loss.

Non-auditory effects can be:

- sleep disturbances, such are: difficulty of falling asleep, modifications of the sleep phases, decreasing of the profound sleep duration. These can affect the psycho-metric performances, can cause fatigue and can affect the mood of the person.
- general effects, especially cardiovascular (increase arterial blood pressure and cardiac frequency), increase respiratory rate, metabolic changes (catecholamine, cortisol)
- behavioral effects, such are concentration difficulties, aggressive behavior, especially in people prone to this.

Laboratory investigations involve the performing of an audiogram. The audiogram records both ways of sound transmission: air and bone conduction.





Normal audiogram J's audiogram

In our case, J.'s audiogram diagnosis is NIHL.
Corroborating the occupational exposure, history and audiogram we can establish the diagnosis: occupational NIHL.

1.2.3. Treatment

Noise-induced hearing loss cannot be cured with medical treatment and worsens as noise exposure continues. The first step is ceasing the exposure to noise and other toxic substances for the ear (Hg, SC_2, CO, toluene, Gentamycin, Kanamycin, etc). The experimental study shows that the administration of a certain diuretic and antioxidants N Acetyl-L-Cysteine, vitamins A, C, E with the vasodilator magnesium, each one alone and in combination led to similar reductions in NIHL. In severe cases hearing aids are needed.

In our case, J. has to change the workplace. BUT, attention should be given so that in the new workplace there will not be exposure to noise nor ototoxic substances (Hg, SC_2, CCl_4, CO etc)! Also, the new activity should not imply any risk regarding verbal communication.

1.3. How can we protect us from noise?

To avoid the health effects on the exposure of noise some technical and medical measures has to be taken.

1.3.1. Technical and organizational measures to reduce the level of noise imply

- elimination/reduction of the noise level at the source (isolation of the source)
- increase the distance between source and worker (it is known that the sound pressure level decreases with 6 dB for each time the distance from the point source is doubled)
- appropriate maintenance programs for work equipment, the workplace and workplace systems;
- (re)organization of work in order to reduce noise: limitation of the duration and intensity of the exposure; adequate resting periods.

If these measures are applied and the noise reaching the worker is still more than 80 dB (A), the employer is obliged to give his workers individual protection equipment, and if the noise is more than 85 dB (A), the worker is obliged to wear it. The individual protection equipment can be : ear plugs or ear muffs.

1.3.2. Medical measures

These imply a good pre-employment examination, periodical medical examinations and proper risk assessment and risk management. Audiometric testing should be performed at pre-employment and periodical examinations.

http://summaries.cochrane.org/CD005234/the-effectiveness-of-interventions-to-promote-the-wearing-of-hearing-protection-to-reduce-exposure-to-noise-among-workers

In our case, for the carpentry shop where J. worked, because the machines were renewed, the employer must see that the workers wear the individual protective equipment, especially the ear muffs because these also protect the bone conduction.

1.4. Infrasound and ultrasound

Ultrasounds are high-frequency (>20000Hz) sounds which are inaudible, or cannot be heard by the human ear.
We can find ultrasounds in industry (used in detecting defects, cleaning of pieces etc), medicine (ultrasounds, dental scaling, therapy), devices against thieves, pests etc.

Infrasound is a low-frequency sound (1-20 Hz) that is not audible.
Many of the sources of infrasound are natural, resulting from geological (earthquakes, landslides, avalanches) or meteorological events (storms, tornadoes), but there are also artificial sources, such as industrial machines, ventilation systems, air conditioning, aircraft, rail traffic. For example, in the industrial sector, low frequency vibrations of machines can cause infrasound, especially in association with air compressors and ventilation systems. In environment, infrasound may be produced, especially when trains travel at high speed through tunnels. Wind turbines, the movement of tall buildings during windy conditions emit infrasound.

Which are the health effects of ultrasounds and infrasound?
For the ultrasounds which go through liquids, the studies show that repeated exposure can lead to muscle contractions and can alter the thyroid function, decrease the weight of the fetus in pregnant women.
For the ultrasounds which go through air, the studies show there are no negative effects up to the level of 120 dB, but at 140 dB they slightly increase the skin temperature, and >180 dB they lead to death through hyperthermia.
Acute effects occur at exposure to 18-30 kHz such as: headache, fatigue at the end of the day, sleepiness during day time, the feeling of pressure inside the ear, walking disturbances, numbness, and sensitivity disturbances.
Chronic effects can be: vascular disturbances, increase of the central and skin temperatures, hyperglycemia, increased number of eosinophil. Association with noise exposure can lead to hearing loss and vestibular disturbances.
For the infrasound the hearing pain and damage can occur at exposure above 140dB. The studies show that for acute exposures to intensities high enough to be heard, they can determine a decrease in vigilance. In chronic exposures to normal levels present in the environment, there is not enough evidence in order to formulate a clear conclusion regarding the effects on health.

How do we protect from ultrasound and infrasound?
Protection is achieved by respecting the technical prophylactic measurements concerning noise exposure. For ultrasound, wearing rubber cotton gloves may be of help.

2. Vibration

The 5th European Working Conditions Survey shows that the physical hazards remain a problem for the European workers for the last few years.

2.1. What do you know about vibration?

2.1.1. Definition

Vibration is the mechanical oscillations of an object about an equilibrium point.
Vibration enters the body from the organ in contact with vibrating equipment. There are two situations:

- the hand-arm vibration exposure when a worker operates hand-held equipment such as a chain saw or jackhammer, vibration affects hands and arms.
- the whole-body vibration exposure when a worker sits or stands on a vibrating floor or seat, the vibration exposure affects almost the entire body.

2.1.2. How do we measure vibration?

The measurement of vibrations is made with special device similar to the sonometer and the established parameter according to legal standards is the acceleration.
http://www.occup-med.com/content/3/1/13

2.1.3. Legal framework

European Directive 2002/44/ CE

2.1.4. Which are the workplaces with vibration?

We can find vibrations in: mining, in construction, in forestry work, car driving (tractor, excavator, and bulldozer), helicopter, etc.
Sources of vibrations are: the pneumatic tools, chain saw and other vibrating tools.

2.2 Which are the health effects?

A. The hand-arm vibrations exposure

Tom is 62 years old and he is retired. He went to the plastic surgery practice in order to get help to be able to normally use his hands. Do you know what disease he is suffering from?

Yes, it is Dupuytren disease. It started 19 years ago (43 years old), initially affecting his right hand due to fibrosis and the flexion of the fourth finger. In time, his left hand was also affected and the fingers of right hand, as well. What might be the cause?
His weight is normal, he is not smoking (he has smoked for 15 years, 10 cigarettes per day, he quitted smoking 22 years ago), and his glycaemia and glycozylated haemoglobin has normal values. In his family he does not have any history of such a disease but his mother has been suffering of arterial hypertension. He started working at 21 as a mechanic. In the first7 years he worked in the forestry department, on heavy machinery with exposure at vibrations, improper climate conditions, physical effort. The following 26 years he worked in the road construction field using compaction equipment for 15 years. With each hand he was manipulating a lever of the machine. This was noisy vibrating equipment. He was working 8, even 10 hours per day. He was reaching his workplace by bicycle, even in the cold seasons. His workplace has been changed due to the apparition of the Dupuytren disease, and he was retired because of this illness 12 years later, as well as because of his cardio-vascular problems (arterial hypertension and atrial fibrillation). His son works in the same field, but using more modern equipment, which is not vibrating as much as the old models. (Clinic of Occupational Medicine, Timisoara, Romania).

2.2.1. How do vibrations act?

***Pathogenic Mechanism*:** the vibrations transmitted to the hand-arm system range between medium and high frequencies (20-5000Hz). The target organs of HAV exposure are: the blood vessels of the fingers, the sensitive nerves of the hand and some bone-muscle-articulation structures of the hand-arm system. The pathogenic mechanism is not yet fully explained, but the actual considerations refer to these modifications as being independent in between each other. The blood vessels are affected due to the increase of sympathic nervous system activity (through central and local reflex mechanisms) and due to primary lesions at vascular level that affect the endothelium, the receptors, or the presence of anatomical modifications. The sensitive neuropathy can be caused mainly by the mechanical action of the vibrations and by ergonomic causes as well. The carpal tunnel syndrome can be the consequence of mechanical aggression and the compression of the median nerve through synovitis and the tumefaction of the flexor muscle tendons. Osteoarthritis is caused by the lesion of the articulation cartilage through repetitive exposure of these surfaces to mechanical vibrations. To these we can add individual susceptibility and the presence of tensed postures, exaggerated and prolonged muscles contractions which will reduce the blood flow into these muscles and their consequences.

There are factors that can influence the health effects of hand-arm vibration.

Factors that influence the effect of vibration on the hand		
Physical Factors	**Biodynamic Factors**	**Individual Factors**
Acceleration of vibration	Grip forces - how hard the worker grasps the vibrating equipment	Operator's control of tool

Frequency of vibration	Surface area, location, and mass of parts of the hand in contact with the source of vibration	Machine work rate
Duration of exposure each workday	Hardness of the material being contacted by the hand-held tools, for example metal in grinding and chipping	Skill and productivity
Years of employment involving vibration exposure	Position of the hand and arm relative to the body	Individual susceptibility to vibration
State of tool maintenance	Texture of handle-soft and compliant versus rigid material	Smoking and use of drugs. Exposure to other physical and chemical agents.
Protective practices and equipment including gloves, boots, work-rest periods.	Medical history of injury to fingers and hands, particularly frostbite	Disease or prior injury to the fingers or hands

2.2.2. The health effects of hand-arm vibration are:

Vascular changes:

- Vibration-induced white finger (VWF) is the most common condition among the operators of hand-held vibrating tools. The symptoms of VWF are aggravated when the hands are exposed to cold. Also known as Raynaud's phenomenon/syndrome is manifested through whitening of the tip of the fingers crisis, consecutive to cold exposure. These can last from a few minutes up to a few hours, accompanied by pain, numbness and reduced thermal sensitivity. These are followed by reactive hyperemia, intense pain, finger cyanosis and local temperature getting back to normal. Usually the hand which manipulates the vibrating tool is affected
- Hand-Arm Vibration Syndrome (HAVS) appear when the vibration induce changes in tendons, muscles, bones and joints, and can affect the nervous system. HAVS is also known as Raynaud's phenomenon/syndrome. Workers affected by HAVS commonly report: attacks of whitening of one or more fingers when exposed to cold, tingling and loss of sensation in the fingers, loss of light touch, pain and cold sensations between periodic white finger attacks, loss of grip strength, bone cysts in fingers and wrists.

  If you want to see a case with Raynaud syndrome you can find it at this address www.networm.casus.net , the case is "Forestry worker with white finger"

- Carpal tunnel syndrome, consequence of the compression of the median nerve through the edema caused by the initial peripheral vasodilatation which occurs in case of vibration exposure.

Neurological changes consist of night numbness (when the blood circulation is physiologically slowed down), or during the use of the vibrating tool, numbness during the fingers whitening crisis, decrease of the tactile sensitivity, alteration of the superficial thermal-pain sensitivity. The stages of the vascular and neurological phenomena based on subjective criteria are shown separately for each component and for each hand in the Stochkolm classification realized in 1986.

Table 2(a)
The Stockholm Workshop classification scale for cold-induced vascular (blood flow) symptoms in fingers with hand-arm vibration syndrome

Stage	Grade	Description
0	(none)	No attacks
1	Mild	Occasional attacks affecting only the tips of one or more fingers
2	Moderate	Occasional attacks affecting finger tips and middle of the finger and rarely also the finger parts close to the palm
3	Severe	Frequent attacks affecting most fingers
4	Very Severe	Same symptoms as in stage 3 with degenerate skin changes in the finger tips.

Table 2(b)
The Stockholm Workshop classification scale for sensorineural changes in fingers due to hand-arm vibration syndrome

Stage	Symptoms
OSN	Exposed to vibration but no symptoms
1SN	Intermittent numbness, with or without tingling
2SN	Intermittent or persistent numbness, reduced sensory perception
3SN	Intermittent or persistent numbness, reduced tactile discrimination and/or manipulative dexterity

Source: Gemne, G., et al. Scandinavian Journal of Work, Environment and Health. Vol. 13, no. 4 (1987). p. 275-278.

Osteo-musculo-skeletal disorders: cysts at the level of the carpal bones, osteoarthritis of the metacarpal – trapez bone articulation, Kienbock disease (the aseptic necrosis of the semilunar bone), Dupuytren disease (the retraction of the superficial palmar aponevrosis). Clinically we have pain at the level of the wrist articulation, elbow articulation, muscle pain, decrease of muscle force at these levels
- Other manifestations: increased hearing losses in noisy places, headache, fatigue, sleep disturbances, memory losses, irritability, and increase of cardiac frequency.

Laboratory investigations: the specific test is the immersion of the hand in cold water (the cold provocation test), vascular Doppler test, infrared thermograph test, the vibration perception test.
Other investigations: the muscle force measurement, the sensitivity measurement, skin temperature measurement, bones X-ray (cervical vertebral column, hands), biological determinations of the cardio-vascular risk factors or other risk factors for Reynaud phenomenon (for e.g. colagenosis).

2.2.3. Treatment: the medication administrated targets the vasospasm and the platelet aggregation. In this sense we can administrate vasodilatation medication.

2.3. How can we protect from the vibrations?

2.3.1. Technical measures imply reducing the intensity of the vibrations, the exposure time, replacing or modification of the tools and the technological processes respecting the ergonomic rules, the use of special gloves, avoiding cold exposure.

2.3.2. Medical measures*:* medical pre-employment screening, periodical medical examinations. People suffering from collagen diseases, neuropathies, vascular diseases, blood cell disturbances are not allowed to work in workplaces with exposure at vibrations.

B. The whole-body vibration exposure

The level of the vibrations affecting the whole body is less than 20 Hz.
The pathological mechanism is not fully elucidated. Modifications of the blood flow, visual and vestibular systems disturbances, the increase release of biological factors are involved leading to the increase of the cardiac frequency and the oxygen consumption. In time the concentration capacity, the work performances and work safety decrease.
The health effects of whole-body vibration are:
- motion sickness when the vibration exposure occurs in the 0.1 to 2 Hz frequency range
- circulatory, gastro-intestinal and renal disorders can occurs at the 4-8 Hz
- visual disorders can occurs at the 5-20 Hz
- musculoskeletal disorders especial back pain, with disc modifications, arthrosis modifications, scoliosis.
Laboratory investigations: lumbar vertebral column X-ray or RMN for the MSD; biological investigations, gastric, renal, ENT examinations.

Treatment: ceasing the exposure is the most indicated. In case of vestibular disturbances anti-emetic or narcoleptic drugs are indicated; for MSD: pain killers, anti-inflammatory drugs, physiotherapy, vitamins.
Technical measures*:* wherever possible, reduction of vibration at the source is to be preferred. This may involve reducing the undulations of the terrain or reducing the speed of travel of vehicles. Ergonomic measures: seats can be designed to attenuate vibration.
Medical measures imply a good pre-employment examination, periodical medical examinations and proper risk assessment and risk management. We should pay special attention at people with cardio-vascular diseases and musculoskeletal disorders.

3. Radiation

"*The number of workers engaged in emergency work at the Fukushima Dai-ichi NPS as of May 23 was approximately 7800. Average accumulated dose for such personnel was approximately 7.7 mSv. Thirty people were recorded as receiving doses over 100mSv. By the end of June 2011, as a result of precise measurement by whole body counters, it was disclosed that accumulated dose exceeded 500mSv for several of them. There were also cases of acute exposure to highly contaminated water. On March 24, it was confirmed that two out of three workers involved in work for laying electric cables on the 1st of June stepped into puddles of radioactive water wearing low-cut shoes. After decontamination of their exposed skin the workers were transported to the National Institute of Radiological Sciences. Detailed checkups revealed neither specific signs nor symptoms suggestive of acute radiation syndrome. The workers were re-examined on April 11, and it was confirmed that they were not suffering any health problems. From the results of evaluations of skin doses, exposure was estimated to be between 2 and 3 Sv*. **"**
(Interim Report on working conditions after the nuclear accident at the Fukushima Nuclear Power Station, Toshiteru Okubo, ICOH Newsletter, vol.9, no.2)

3.1. What do we know about radiation?

Radiation is a complex process through which the energy emitted by a source is transmitted through different media and then absorbed by a support. According to the ionizing capacity of the matter we have **ionizing and non-ionizing radiation.**

a) Ionizing radiation

3.1.1. Definition

This is radiation that has enough energy to remove electrons from atoms or molecules (groups of atoms) when it passes through or collides with some material. When ionizing radiation interacts with the human body, it gives its energy to the body tissues.
Ionizing radiation includes two forms: **corpuscular**-Alpha particles, Beta particles, Neutron, and **electromagnetic-** Gamma rays, X rays.
Alpha particles are helium nuclei which are emitted from naturally-occurring heavy elements such as uranium and radium, as well as from some man-made transuranic elements. They are intensely

ionizing but cannot penetrate the skin (because of their big dimension), so are dangerous only if emitted inside the body.

Beta particles are fast-moving electrons emitted by many radioactive elements. They are more penetrating than alpha particles, but easily shielded – they can be stopped by a few millimeters of wood or aluminum.

Neutrons are mostly released by nuclear fission in the core of the nuclear reactor, and the probability to find them outside the nuclear reactor is very low. Fast neutrons can be very destructive to human tissue.

Electromagnetic rays (X and Gamma rays) are a flux of electromagnetic particles with short wave lengths (6-10 and 10-12cm), without weight or electric charge. The X, gamma rays and neutrons are very penetrating, representing a real danger for the internal organs, so require more substantial shielding.

3.1.2. How can we measure radiation?

For ionizing radiation we can measure some parameters, such are:

- the radioactivity of the radiation source,
- the energy of the radiation,
- the amount of radiation in the environment,
- the amount of radiation energy absorbed by the human body (the radiation dose).

The radiation dose is the most important measure, from the medical point of view. The radiation dose can be expressed by:

-*Absorbed dose* - the amount of energy absorbed per unit weight of the organ or tissue

- measured by **Gray (Gy)**

-*Equivalent dose* - Absorbed Dose in Gy x radiation weighting factor (WR)

- measured in **Sievert (Sv)**

The equivalent dose takes in consideration the radiation type, because the equal doses of all types of ionizing radiation are not equally harmful.

E.g. W_R =1 for X, gamma radiation and W_R =20 for alfa particle, W_R = 5-20 for neutrons

- *Effective dose (E)-* $\boldsymbol{E = \Sigma_T w_T.H_T}$ where $\boldsymbol{w_T}$ *= weighing tissue/organ factor* and $\boldsymbol{H_T}$ *= equivalent dose in tissue/organ*

3.1.3. What are the limits of exposure to radiation?

The Threshold Limit Values (TLVs) published by the ACGIH (American Conference of Governmental Industrial Hygienists) are:

20 mSv - TLV for average annual dose for radiation workers, averaged over five years

1 mSv - annual dose limit recommended for general public (ICRP - International Commission on Radiological Protection).

The risk of radiation-induced diseases depends on the total radiation dose that a person receives over time.

One Sievert is a large dose. The recommended TLV is average annual dose of 0.05 Sv (50 mSv).

The effects of acute exposure depend of the dose. For example:
10 Sv - Risk of death within days or weeks
1 Sv - Risk of cancer later in life (5 in 100)
100 mSv - Risk of cancer later in life (5 in 1000)
50 mSv - TLV for annual dose for radiation workers in any one year

Legal framework: there are specific standards for each type of radiation

3.1.4. Where we can find ionizing radiation?

Sources of radiation:

-natural (85%): cosmic, the natural radioactivity of the earth, the natural radioactivity of the air (radon), the natural radioactivity of the water, vegetation, and food

-artificial (15%): medical, occupational, and other sources such as industrial, nuclear research, nuclear accident (Chernobyl, Fukushima).

Workplaces where we can find exposure to ionizing radiation are: medical sector (X-ray examinations ~ 1mSv/year, nuclear medicine~1-2 mSv/year), research (operating accelerators ~4-5 mSv/year), industry (industrial X-ray examination, radioisotopes production, manufacturing of luminescent products), nuclear industry, natural sources (radon in the uranium mining activity, the cosmic radiation during plain flights).

3.2. Which are the health effects?

3.2.1. How do the ionizing radiations act?

Pathogenic mechanism: There are two categories of health effects: stochastic and non-stochastic (deterministic).

Stochastic Health Effects are associated with long-term, low-level (chronic) exposure to radiation. ("Stochastic" refers to the likelihood that something will happen.) Increased levels of exposure make these health effects more likely to occur, but do not influence the type or severity of the effect. Ex: cancer, mutations (teratogenous or genetic effects).

Non-Stochastic Health Effects appear in cases of exposure to high levels of radiation, and become more severe as the exposure increases. Short-term, high-level exposure is referred to as 'acute' exposure (burns and radiation sickness).

3.2.2. Health effects

The effects of the ionizing radiations are the consequence of their biological effects and manifest through: hypoplasia, aplasia, dysphasia, functional insufficiencies, tissue fibrosis and necrosis. The tissues with a higher division rate are more **radiosensitive** (for e.g. the bone marrow, the spleen, the thymus, the lymphatic nodules, the gonads, the crystalline, and the lymphocytes) while the muscles, the bones and the nervous system are less radiosensitive. The manifestations can be acute, often reversible, the gravity depending on the absorbed dose, and chronic, mostly irreversible, the way of occurrences being liked with the dosage. Each of them can affect the whole body or can be localized.

The acute irradiation syndrome: for the whole body the value of the lethal dose D50/30 is ~3 Gy. The clinical manifestations include haematopoietic, gastro-intestinal and nervous-vascular syndromes. The bone marrow is the main target of the ionizing radiations. The early effects consist of lymfopenia, granulocitopenia, and thrombocytopenia. These occur at exposure between 1-5 Grays. Long term effects are: inefficient bone marrow repopulation and inefficient haematopoiesis. The gastro-intestinal syndrome occurs at exposure between 6-7 Grays, and manifests through malnutrition, malabsorbtion hydro-electrolyte changes, gastro-intestinal, bleeding, anaemia, ileus paraliticus, and perforations. Nervous-vascular syndrome occurs at exposure >20 Grays and death occurs in 10 days.
Acute exposure at the level of the skin has different aspects depending on the dosage and evolutes differently in time. The absorbed dose can be evaluated only after a few weeks. The lesion can be: erythematic lesion >3 Gy, hair loss >3 Gy, dry desquamation >8 Gy, wet desquamation >15 Gy, ulceration >20 Gy, necrosis >25 Gy.
Late effects at the level of the skin are severe and consist of functional insufficiencies, sensitivity disturbances, and radiodermitis with increased risk of malignization.
Effects at the level of the eye: at doses of 2 Gy the crystalline is affected at cataract occurs. The latent period is in between 2-35 years.
Effects at the level of the gonads: the threshold value for temporal sterility is 0.15 Gy for men and around 5 times bigger for women. The recovery period depends on the dosage and can last up to a few years. Permanent sterility occurs at 3.5 Gy for men and 2.5 Gy for women.
Effects on the embryo and the foetus depend on the dose and the age of the pregnancy, being much bigger in the first months of pregnancy. Effects can be lethal, congenital abnormalities and late effects may include cancer and hereditary effects.

3.2.3. Which is the treatment?

Treatment in case of overexposure: It is not a vital immediate emergency! It is important to reconstruct the accident through physical and biological measurements and clinical data. Proper protection of the personnel involved in the rescue and the research is very important. Symptomatic treatment (anti-vomitive, sedative drugs etc) and monitoring the body functions are to be taken into consideration. In local exposure the prognosis is better.

3.3. How can we protect against ionizing radiation?

3.3.1. Technical measures*:* There are three important rules when ionizing radiation exposure is involved: screening of the source of radiation, increasing the distance between the source of radiation and the people exposed, reducing the time of exposure.

3.3.2. Medical measures imply a good pre-employment examination, periodical medical examinations and proper risk assessment and risk management. Blood count examination and nucleoli test must be performed at the pre-employment examination. Afterwards, both tests are performed periodically, but nucleoli test is done at larger periods of time.

b) Non-ionizing radiation

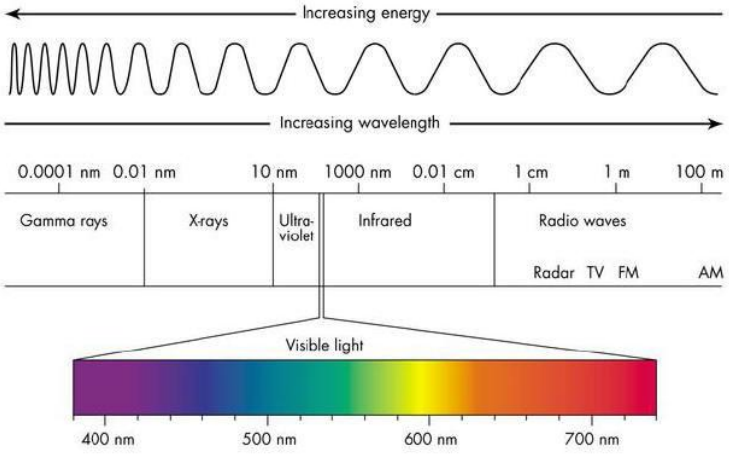
Background: *Ultraviolet radiation has been suspected as a possible cause of ocular melanoma. Because this association is controversial, we examine the role of occupational exposure to ultraviolet radiation on the occurrence of this rare cancer.*
Material and methods: A population-based case-control study was conducted in 10 French administrative areas (departments). Cases were 50 patients with uveal melanoma diagnosed in 1995-1996. Controls were selected at random from electoral rolls, after stratification for age, gender, and area. Among 630 selected persons, 479 (76%) were interviewed. Data on personal characteristics, occupational history, and detailed information on each job held were obtained from face-to-face interviews using a standardized questionnaire. Estimates of occupational exposure to solar and artificial ultraviolet light were made using a job exposure matrix.
Results: Results show elevated risks of ocular melanoma for people with light eye color, light skin color, and for subjects with several eye burns. The analysis based on the job exposure matrix showed a significantly increased risk of ocular melanoma in occupational groups exposed to artificial ultraviolet radiation, but not in outdoor occupational groups exposed to sunlight. An elevated risk of ocular melanoma was seen among welders (odds ratio = 7.3; 95% confidence interval = 2.6-20.1 for men), and a dose-response relationship with job duration was observed. The study also showed increased risk of ocular melanoma among male cooks, and among female metal workers and material handling operators.
Conclusion: Following the present study, the existence of an excess risk of ocular melanoma in welders may now be considered as established. Exposure to ultraviolet light is a likely causal agent, but a possible role of other exposures in the welding processes should not be overlooked. (http://www.jstor.org/pss/3553529, Occupational risk factors, ultraviolet radiation, and ocular-melanoma: a case-control study France, Pascal Guenel, Laurent Laforest, Diane Cyr, Joelle Fevotte, Svend Saloe, Cecile Dufore, Jean-Michel Lentz& Elsebet Lynge, Cancer Causes and Control 12, 451-459, 2001

3.4. What do you know about non-ionizing radiation?

3.4.1. Definition

Non-ionizing radiation include**:** electro-magnetic fields, Infrared, ultraviolet (UV), visual radiation laser, microwave.

Figure : EM spectrum



3.4.2. How do we measure?

Measure unit: frequency – Hz (cycle/second), wavelength – λ (m)

Ultraviolet (UV) radiation is that portion of the electromagnetic spectrum from 100-400 nm and don't reach the retina. UV radiation is made up of three types of rays : ultraviolet A (400-315nm)-"black light", ultraviolet B (280-315nm) - "erythematic region", and ultraviolet C (<280 nm) - "germicide region".
Sources: natural – the sun, artificial – welding activities, cutting with plasma, laser with UV, incandescence metals, lamp with Hg vapors, etc
Workplaces: the workers from agriculture, constructions, sailor, fisherman (outside exposure 10.00-15.00), welder, foundry, hospital, food conservation, etc

Visible radiation is the part of electromagnetic spectrum from 400-760nm which stimulates retina and produce light feeling. They are the only radiations which induce retinian photochemical reactions that are the base of the seeing.
Sources: natural- the sunlight, artificial- electric lamp, lamps with high intensity, flashs, laser, videoterminal, etc.

Infrared radiation (IR) is the part of electromagnetic spectrum over 760 nm, its reach the retina, but not induce the light feeling.
Sources: natural-sunlight, artificial- any object with temperature higher than 0 degrees absolute.
Workplaces: the workers from agriculture, constructions, sailor, fisherman, in industry – metallurgy, manufacture of glass, welding, in medicine - laser, and other devices of physiotherapy

Microwave radiation and radiofrequency wave is part of electromagnetic spectrum from 1mm-1m.
Sources: in radiocommunications, in industry- heating, drying, hardening of metals, wood etc., food sterilisation, in medicine- diathermy, display screen.

Laser – Light Amplification by Stimulated Emission of Radiation. It is monochromatic fascicle with the same frequency and wavelenght, they are parallel and have a same direction.
Workplaces: cutting the metals, plastics, in communications, in medicine (analyse, surgery, etc)

3.5. Which are the health effects?

3.5.1. How does the non-ionizing radiation act?

Pathogenic mechanism: there are two categories of health effects: thermal effect and non-thermal effect (genetic, phototoxic, and photo-allergic). The eyes and the skin are the main affects organs.

3.5.2. Health effects

In UV exposure effects at the eye can be: photo-kerato-conjunctivitis, cataract, retinal lesions, and malignant lesions. At the level of the skin we can have burning lesions as acute effects and premature aging and skin cancers in chronic exposure.

Visible radiation exposure has as main target the eye. In case of prolonged and repeated exposure at very strong light sources retinitis can occur. Light and medium exposure lead to the decrease of the visual acuity and eyestrain.

In IR exposure we have thermal effects at the eye (cataract) and the skin (brown spots).

Exposure at Microwave radiation and radiofrequency wave at high doses is followed by thermal effects at the eye (foreign body sensation in the eye, “red eye”, tearing) and the skin (as the solar burns), accompanied by headache, vertigo, irritability, abdominal cramps, increase of the blood pressure. The prognosis is good, with remission in 5-6 weeks. In chronic exposure at small doses cataract and non-thermal effects (fatigue, decrease of cardiac frequency and blood pressure, thyroid effects, decrease of the weight) can occur.

Laser exposure affects the eye.

Exposure at *very low frequency radiation (<200Hz, especially 50-60 Hz)* include the frequencies used for the high voltage electric lines and the domestic electric lines. The clinical effects are not yet fully known.

3.5.3. Treatment

In case of exposure at non-ionizing radiation includes limiting or ceasing the exposure and the specific treatment of the eye and skin lesions.

3.6. How can we protect from non-ionizing radiation?

3.6.1. Technical measurements

Proper clothing, special eye protection, protection cream. In case of IR exposure insulating partitions, special eye protection can be used. In case of visible radiation exposure it is important to respect the normal values for the exposure and to wear special protective glasses. In exposure to microwave radiofrequency wave radiation three rules must be respected: increase the distance from the source, use of protective shields, limited acces for the personnel.

3.6.2. Medical measurements

Proper risk assesments and risk managment, with special care at people having mechanical or cardiac implants when they are in the presence of electromagnetic fields. We can not employ people with eye sufferences, central nervous system sufferences, cardio-vascular or skin diseases. Pre-employment and periodical examinations are very important in the selection and the survey of workers exposed to non-ionizing radiation.

4. Lighting

4.1. What do you know about lighting?

4.1.1. Definition

Lighting is an essential aspect for any workplace. Light or visible light is electromagnetic radiation that is visible to the human eye, and is responsible for the sense of sight. It is necessary to have a uniform illumination over the entire workplace by combining both, natural and artificial lighting. Localized lighting improves illumination and may be required in certain cases to cut costs. Good lighting helps us to see and to recognize hazards and to do a good work to prevent the occupational fatigue, occupational visual diseases or work accidents.

4.2.2. How do we measure lighting?

The device for measuring lighting is luxmeter.
The measuring unit for lighting is “lux” (luminance) - the luminous flux per unit area at any point on a surface exposed to incident light.

4.2.3. Legal framework

According to the European legislation

4.2.4. Which are the sources and workplaces?

Sources: natural (the sunlight), artificial (lighting by incandescence, fluorescence, high- pressure sodium or mercury lamp, low-pressure sodium or tungsten lamp), mixed.
The sunlight is composed by: 40% visible radiation, 59% infrared visible radiation, 1% ultraviolet visible radiation.
Workplaces: agriculture, construction, sailor activity, foundry, office work.
Professions: workers of outdoor activities in summer and winter, inside activities with visual solicitation (jeweler, watchmaker, etc).

4.2. Which are the health effects?

Light is a key element in our capacity to see, and it is necessary to appreciate the form, the color and the perspective of the objects that surround us. Visual capacity and visual comfort are very important, because many accidents are due to lighting deficiencies or errors made by the worker because it hard to identify objects or the risks associated with machinery, conveyances, dangerous containers etc. Poor visibility increases the chances of errors being made. It also means that people work slower.
Poor lighting may affect the workers' performance and health too. The health aspects implies: the visual trouble (visual fatigue, tearing, and visual problems), fatigue, headache, musculoskeletal disorders.

Besides, natural working posture may not be possible under poor lighting, thus resulting in musculoskeletal strain, like cervical, thoracic, or lumbar pain, the changes the curvature of the back bone.

4.3. Which is the treatment?

Workplace: Solving the technical problem of inadequate lighting, such are: type of light, position, distance, color, no glare, etc; the organization of the work, with breaks of 10 min at 1 hour for relaxing the eyes (ex. fine, very fine work, computer work).
Worker: specific for visual disorder (ophthalmologic – eyewash, vitamins, protection or correction glasses), fatigue (vitamins, antioxidants), MSD (physiotherapy, swimming, NSAID gel, etc).

4.4. How can we prevent the effects of poor lighting?

4.4.1. Technical measures

The light and color affect the productivity and the psycho-physiological well-being of the worker. The good lighting implies: uniform illumination, optimal luminance, no glare, adequate contrast conditions, correct colors, absence of stroboscopic effect or intermittent light.
For a good lightning it is necessary to take into consideration: the precision required of the tasks performed, the amount of work, the mobility of the worker, and also the characteristic of the workplace (windows, type of lightning, the season). The following should be eliminated: the annoying reflections, excessive glare or deep shadows. The periodic maintenance of the lighting installation is very important, the cleaning of the windows as well. It is recommended to use the natural lighting.
The good lighting it is necessary to be sufficient (at least equal with the specific values).
It is necessary to have an ergonomic organization of the workplace in order to prevent the health effects.
A new study shows that the individual control was the best choice for a workplace environment.
“Manual controls give workers control over their individual work environments, increasing user satisfaction and acceptance. Because each person has different lighting-level requirements, glare tolerances, and task performance goals.” (Nancy Clanton)

4.4.2. Medical measures

From the medical point of view it is very important to monitor the visual capacity of employees before the employment and after that by periodical examination (usually once per year, screening examination).

5. Climate

The microclimate is characterized by: temperature (dry), relative humidity, air current speed, surfaces temperature and caloric radiation. From these parameters we will only study temperature.
Very cold and very hot temperatures can be dangerous to health.
A **cold environment** and **a warm /hot environment** challenges the worker in three ways: by air temperature, air movement (wind speed), and humidity (wetness). For the safely work, these challenges have to be counterbalanced by proper insulation (layered protective clothing), by physical activity and by controlled exposure to cold (work/rest schedule).

a) Cold environment

5.1. What do you know about cold environment?

Abstract
*Circumpolar areas are associated with prolonged cold exposure where wind, precipitation, and darkness further aggravate the environmental conditions and the associated risks. Despite the climate warming, cold climatic conditions will prevail in circumpolar areas and contribute to adverse health effects. Frostbite is a freezing injury where localized damage affects the skin and other tissues. It occurs during occupational or leisure-time activities and is common in the general population among men and women of various ages. Industries of the circumpolar areas where frostbite occurs frequently include transportation, mining, oil, and gas industry, construction, agriculture, and military operations. Cold injuries may also occur during leisure-time activities involving substantial cold exposure, such as mountaineering, skiing, and snowmobiling. Accidental situations (occupational, leisure time) often contribute to adverse cooling and cold injuries. Several environmental (temperature, wind, wetness, cold objects, and altitude) and individual (behavior, health, and physiology) predisposing factors are connected with frostbite injuries. Vulnerable populations include those having a chronic disease (cardiovascular, diabetes, and depression), children and the elderly or homeless people. Frostbite results in sequels causing different types of discomfort and functional limitations that may persist for years. A frostbite injury is preventable, and hence, unacceptable from a public health perspective. Appropriate cold risk management includes awareness of the adverse effects of cold, individual adjustment of cold exposure and clothing, or in occupational context different organizational and technical measures. In addition, vulnerable population groups need customized information and care for proper prevention of frostbites. (*Frostbites in circumpolar areas, *Ikäheimo TM*, *Hassi J.*, Glob Health Action. 2011;4.doi:10.3402/gha.v4i0.8456. Epub2011Oct10, http://www.ncbi.nlm.nih.gov/pubmed/2199448)

5.1.1. How we measure?

Measure unit: temperature in degrees Celsius or Fahrenheit.
Legal framework: according with European legislation.

5.1.2. Which are the workplaces with cold exposure?

This can be *outside*: road builders, construction workers, police officers, fire fighters, emergency response workers, military personnel, transport workers, bus and truck drivers, fishers, hunters and

trappers, divers; or *in inside*: workers in refrigerated warehouses, meat packaging and meat storage workers, etc

5.2. Which are the health effects?

5.2.1. Pathogenic mechanism

Heat loss can occur depending on the severity of cold conditions. The body maintains its heat balance by increasing production of the heat and activating heat retention mechanisms.

In the situation where more heat is lost than the combined heat production processes and heat retention mechanisms can generate, the core body temperature drops below +37°C. This decrease causes hypothermia which can impair normal muscular and mental functions.

5.2.2. Health effects

The clinic effects of cold exposure could be: local (frostbite) and systemic (hypothermia).

Frostbite is a common injury caused by exposure to extreme cold or by contact with extremely cold objects (especially those made of metal). Toes, fingers, ears and nose are at greatest risk because these areas do not have major muscles to produce heat. In addition, the body will preserve heat by favoring the internal organs and thus reducing the flow of blood to the extremities under cold conditions. If the eyes are not protected with goggles in high wind chill conditions, the corneas of the eyes may freeze.

Hypothermia is the most severe cold injury which occurs from excessive loss of body heat and the consequent lowering of the internal temperature of the body. Hypothermia can be fatal.

5.2.3. Which is the treatment?

The frostbite and hypothermia are emergencies and it is necessary to give the first aid.

First aid for frostbite implies: request medical attention, if possible, move the victim to a warm area, gently loosen or remove constricting clothing or jewelry that may restrict circulation, quickly transport the victim to an emergency care facility.

DO NOT attempt to warm the affected area on site, DO NOT rub area or apply dry heat, DO NOT allow the victim to drink alcohol or smoke.
First aid for hypothermia includes the following steps: request medical help immediately, ensure that wet clothing is removed, place the victim between blankets (or towels, newspaper, etc.) so the body temperature can rise **gradually**, body-to-body contact can help warm the victim's temperature slowly, be sure to cover the person's head, give warm, sweet (caffeine-free, nonalcoholic) drinks unless the victim is rapidly losing consciousness, unconscious, or convulsing, quickly transport the victim to an emergency medical facility, do not attempt to warm the victim on a site (e.g., do not use hot water bottles or electric blankets), perform CPR (cardiopulmonary resuscitation) if the victim stops breathing.

5.4. How can we prevent?

5.4.1. Technical measure

For continuous work in temperatures below the freezing point, heated warming shelters such as tents, cabins or rest rooms should be available. The work should be paced to avoid excessive sweating. If such work is necessary, proper rest periods in a warm area should be allowed and employees should change into dry clothes. New employees should be given enough time to get acclimatized to cold and protective clothing before assuming a full work load.
The risk of cold injury can be minimized by proper equipment design, safe work practices and appropriate clothing.
Balanced meals and adequate liquid intake are essential to maintain body heat and prevent dehydration. Alcohol should not be consumed because induce skin vasodilatation and impairs the body's ability to regulate temperature.
If workers are simultaneously exposed to vibration and/or toxic substances is necessary to reduce limits for cold exposure.

5.4.2. Medical measures

Proper pre-employment and periodical medical examinations, people with cardiovascular diseases, Raynaud syndrome, otitis, sinusitis, and nephropathy are not allowed to work in such environments.

b) Hot environment

"*To minimize dispersion of radioactive substances from the buildings, TEPCO made an effort to close and seal all doors and windows that had not been destroyed. As the reactors are still producing heat and plenty of water is used to cool them, workers have been beset by high humidity and high temperatures within the buildings. Some workers suffered heat stroke, and thus high temperatures and humidity have become a major concern with respect to the working environment. " (Interim Report on working conditions after the nuclear accident at the Fukushima Nuclear Power Station, Toshiteru Okubo, ICOH Newsletter, vol.9, no.2)*

5.5.1 How we measure?

Measure unit: WBGT index (Wet Bulb Globe Temperature).

Legal framework: according with European legislation.

5.5.2. Which are the workplaces with warm/hot exposure?

In *outdoor* occupations, such as construction, road repair, open-pit mining and agriculture, summer sunshine is the main source of heat. *Indoor* occupations such as: foundries, steel mills, bakeries, smelters, glass factories, and furnaces, extremely hot or molten material is the main source of heat; in laundries, restaurant kitchens, and canneries, high humidity adds to the heat burden.

5.5.3. What means Acclimatization?

The body's temporary adaptation to work in heat that occurs as a person is exposed to it over time. Complete heat acclimatization generally takes six to seven days, but some individuals may need longer. When a person gets acclimatized, the central temperature decreses with up to 1 degree Celsius and the cardiac frequency decreases with 10-14 beats/minute, compared to a non-acclimatized person in the same conditions. This is a consequence of the increased sweating process and a good vaso-motor control.

5.6. Which are the Health Effects?

5.6.1. How does heat act?

Pathogenic mechanism: "Heat stress" is the overall heat burden on the body from the combination of the body heat generated while working, environmental sources (air temperature, humidity, and air movement, radiation from the sun or hot surfaces/sources) and clothing requirements.

The healthy human body maintains its internal temperature around 37°C. Variations, usually of less than 1°C, occur with the time of the day, level of physical activity or emotional state. A change of body temperature exceeding 1°C occurs only during illness or when environmental conditions surpass the body's ability to cope with extreme temperatures.

As the environment warms-up, the body tends to warm-up as well. The body's internal "thermostat" maintains a constant inner body temperature by pumping more blood to the skin and by increasing sweat production. In this way, the body increases the rate of heat loss to balance the heat burden created by the environment. In a very hot environment, the rate of "heat gain" exceeds the rate of "heat loss" and the body temperature begins to rise. A rise in the body temperature results in heat illnesses.

Exposure to more heat stress can cause physical problems which impair workers' efficiency and may cause adverse health effects.

The risk of heat-related illness varies from person to person. Acclimatization depends on individual characteristics such are: the weigh (for the obese persons is more difficult), the age (>45), consumption of alcohol, medication (hypotensives, diuretics, antispasmodics, sedatives, tranquilizers, antidepressants and amphetamines decrease the body's ability to cope with heat).

5.6.2. Health effects

Heat exposure causes the following illnesses:

Heat edema is swelling which generally occurs among people who are not acclimatized. Swelling is often most noticeable in the ankles. Recovery occurs after a day or two in a cool environment.

Heat rashes are tiny red spots on the skin which cause a prickling sensation during heat exposure. The spots are the result of inflammation caused when the ducts of sweat glands become plugged.

Heat cramps are sharp pains in the muscles that may occur alone or be combined with one of the other heat stress disorders. The cause is salt imbalance resulting from the failure to replace salt lost with sweat. Cramps most often occur when people drink large amounts of water without sufficient salt.

Heat exhaustion is caused by loss of body water and salt through excessive sweating. Signs and symptoms of heat exhaustion include: heavy sweating, weakness, dizziness, visual disturbances, intense thirst, nausea, headache, vomiting, diarrhea, muscle cramps, breathlessness, palpitations, tingling and numbness of the hands and feet. Recovery occurs after resting in a cool area and consuming cool salted drinks.

Heat syncope is heat-induced giddiness and fainting induced by temporarily insufficient flow of blood to the brain while a person is standing. It occurs mostly among un-acclimatized people. It is caused by the loss of body fluids through sweating, and by lowered blood pressure due to pooling of blood in the legs. Recovery is rapid after rest in a cool area.

Heat stroke and hyperpyrexia (elevated body temperature) are the most serious types of heat illnesses. Signs of heat stroke include body temperature often greater than 41°C, and complete or partial loss of consciousness. The signs of heat hyperpyrexia are similar except that the skin remains moist. Sweating is not a good symptom of heat stress. There are two types of heat stroke – “classical” where there is little or no sweating (usually occurs in children, persons who are chronically ill, and the elderly), and “exceptional” where body temperature rises because of strenuous exercise or work and sweating is usually present.

Heat stroke and heat hyperpyrexia require immediate first aid and medical survey. Delayed treatment may result in damage to the brain, kidneys and heart. Treatment may involve removal of the victim's clothing and spraying the body with cold water. Fanning increases evaporation and further cools the body. Immersing the victim in cold water more efficiently cools the body but it can result in harmful overcooling which can interfere with vital brain functions so it must only be done under close medical supervision.

5.7. How can we prevent?

5.7.1. Technical measures

These are the most effective means of reducing excessive heat exposure and imply: reducing metabolic heat production**,** reducing the radiant heat emission from hot surfaces, insulating hot surfaces, shielding, ventilation and air conditioning, reducing the humidity.

Individual protection: Ordinary clothing provides some protection from heat radiated by surrounding hot surfaces. Eye protection which absorbs radiation is needed when the work involves very hot objects, such as molten metals and hot ovens.

5.7.2. Medical measures

These imply a good pre-employment examination, periodical medical examinations and proper risk assessment and risk management. We should pay special attention at the acclimatization.
However, a decrease in heat tolerance occurs even after a long weekend. This is the reason for which it is often not advisable for anyone to work under very hot conditions on the first day of the week. Also, the new employees should acclimatize before assuming a full workload.
People with some cardiovascular disease are not allowed to work in heat conditions.

6. Pressure

6.1. What do you know about the occupational exposure at air pressure?

The activities performed in conditions of abnormal pressure are grouped into two categories: activities performed at hyperbarism (atmosphere compression or decompression) and activities performed at hypobarism (pressure below that of ground level atmospheric pressure).

6.1.1. Which are workplaces with increased or decreased pressure?

Workplaces with hyperbarism : underwater activities, scuba divers (the pressure exceeds with at least 0.1 atmospheres, the normal value).
Workplaces with hypobarism: pilots, lift workers, modern fire protection systems in store-rooms working by reduction of the oxygen content of the air down to 13 % of oxygen.

6.2. Which are the health effects?

6.2.1. Hyperbarism. The appearance and the evolution of the pathological aspects are based on mechanical, biochemical and biophysical effects.
From the clinical point of view:
-the trauma of the ear, and the sinus during compression period
-the toxic effect of nitrogen and CO_2 while working in increased pressure
-caisson disease while decompression period
The treatment of the acute forms is very important being considered a medical emergency, consisting of oxygen administration and modifying the pressure.

6.2.2. **Hypobarism.** The problems that occur while working in decreased pressure depend on how quick is the transfer from normal pressure to decreased pressure, how trained the person is if it gets adapted to the pressure conditions. The organs most susceptible are the middle ear and sinuses.
From the clinical point of view we have:
- the decompression disease at high altitude (pilots, aircraft personnel)

- the altitude hypoxia (pilots, aircraft personnel)
- the lift workers disease
- the high altitude disease

Treatment consists of return to the level of the ground, specific treatment according to the condition of the patient.

6.3. How can we prevent?

6.3.1. Hyperbarism. *Medical measures*: proper pre-employment and periodical examinations, paying a special attention to the ENT (ear-nose-throat) examination, ophtalmological, neurological and cardiac examinations. Obese people, age>45, alchoolic persons, people suffering from otic, cardiac or respiratory diseases are not allowed to work in such conditions.

6.3.2. Hypobarism. *Technical measures* The problem was solved because of the pressurization of the planes. For mountain climbers, it is recommended climbing in stages.

Summary

For a good evaluation of the workplaces and workers' health condition it is necessary to have a good knowledge of the exposure at physical hazards, most of them being present in any workplace. This implies a risk assessment, measurement of the risk, comparing the level of the hazards with the threshold values, knowing the health effects, the preventive measurements, both technical and medical, the treatment, recognition and prevention of occupational diseases and occupational related diseases. Also, it is necessary to have knowledge about vulnerable groups, for example the young people or pregnant women and exposure to the ionizing radiation. The reference values for the Physical agents are found in the European Frame Directive, being transposed in the specific legislation for every country. These values are normalized for the specific professional activities in every country.

For the students it is very important to recognize the physical agents (special attention at radiation, both ionizing and non-ionizing, as these hazards cannot be perceived by normal sensorial means), as well as their effects on health, the treatments and the specific prophylactic means, both technical and mostly medical.

Key words

Acclimatization
Ionizing radiation
Lighting
Noise
Non-ionizing radiation
Occupational diseases
Physical agents
Pressure
Temperature (heat and cold)
Threshold limits
Vibration
Workplaces

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