

ERGONOMICS: Prevention and Protection of Workers' Health and Safety

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Abstract

Ergonomics studies how people interact with their physical work environment and is concerned with designing the workplace to optimize worker productivity while minimizing injuries and accidents. Ergonomics principles are increasingly important in the workplace because of the growing number of musculoskeletal disorders and lack of comfort that are directly attributed to poorly designed workstations, equipment, and work processes.

To eliminate or mitigate these disorders one must be able to design workstations, equipment, and tools that are comfortable, safe, and easy to use, and that can be adjusted to fit individual workers' needs.

Providing workers with the necessary training and education to understand ergonomics principles with safe work practices and conducting ergonomic assessments to identify potential hazards can be achieved via developing solutions to reduce or eliminate these threats.

We here account that implementing a system for reporting and investigating work-related injuries and illnesses to identify trends and programs that can improve worker health and safety is of countless importance. Ergonomics is therefore critical for ensuring the health and safety of workers.

KEYWORDS;- Ergonomics, Occupational Health, Safety

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I. INTRODUCTION

Work activity entails varying levels of exposure to potential causes of illness and/or accidents which, due to the frequency and/or impact with which they occur, justify taking preventive measures in order to reduce these risks to the minimum possible.

The occupational health nurse is one of the professionals qualified to identify, assess and manage the professional risks to which employees are subject and to propose appropriate measures to mitigate the possible consequences of exposure to these same risks.

Since ergonomics is the study of work and its relationship with the environment in which the function is performed and with those who perform it (employees), it is important to incorporate in this study the characteristics of the physical environment that interfere in this relationship.

It is, in fact, of capital importance for occupational nurses to know the possible impacts that vibrations, noise, lighting and temperature, among other environmental factors, can have on workers' health, on their productive capacity and on their satisfaction and well-being. Based on this premise, we will describe the main aspects related to these four environmental characteristics, the ways of evaluating them and the main measures to protect workers.

II. VIBRATIONS, WORK CONTEXT AND RISKS ASSOCIATED

Occupational vibrations are a special concern due to the dangers for the employee and the occupational diseases that are associated. Exposure to vibrations may vary depending on the operation to be carried out and the tools to be used.

Decree-Law No. 46/2006, of February 24th [1], establishes the minimum safety and health requirements regarding the exposure of employees to risks due to physical agents (vibrations). This law draws attention to the employer's responsibilities regarding exposure to vibrations in the workplace, as well as the limit values for exposure and action. The sources of unwanted vibrations in the workplace, especially in the industrial environment, are basically the following:

- Vibrations arising from the operating mode of the equipment – compressors, machines poorly adjusted to the floor, presses, etc.
- Vibrations from the production process – pneumatic hammers, jackhammers, etc.

- Vibrations as a result of equipment malfunction and poor maintenance.
- Vibrations that affect human health are included in a band that goes from values close to 0 Hz to ranges close to 1250 Hz.

The consequences of vibrations on the human body depend on 4 factors:

- Application points on the body
- Frequency of oscillations
- Acceleration of oscillations
- Duration of the action

Short-term effects of exposure to vibrations include muscle pain, abdominal pain, nausea, increased heart rate and loss of balance. The employee may also experience vascular disorders (Raynaud's Syndrome, which impairs blood supply to the hands due to obstruction of vessels and arteries); neurological disorders, such as tingling or numbness in the fingers and hands; muscle disorders, because of prolonged exposure, can lead to muscle weakness, pain in the hands and upper limbs and decreased muscle strength. Among the effects experienced by employees' subject to the effects of vibrations, there is also back pain and disorders in the back, shoulders or neck, leading to early degeneration of the spine and the appearance of herniated discs.

The main sources of vibrations at work are demolition, pneumatic, drilling and percussion drills; chainsaws and sanders and backhoe loaders with wheels, agricultural tractors; forklift trucks and even excavators, among others.

Evaluation of Vibrations in Workplaces

Performing the measurement of occupational vibration is a safeguard for the health of the employee; it is a legal obligation of the employer and a guarantee for a healthy, productive and successful company in the long term.

Measuring Instruments

Decree-Law No. 46/2006, of February 24th [1], regulates the criteria that guide the vibration assessment process in accordance with the NP EN ISO 5349- 1:2009 "Mechanical Vibrations" standards [2]. In light of the RELACRE Technical Commission (CTR) "Vibrations" (2014) [3], the evaluation of exposure to vibrations should follow the following steps:

- Identification of the individual operations that constitute the normal way of working.
- Organization of the operations to be measured.
- Vibration measurement for each selected operation.
- Estimate of the representative daily exposure time for each identified operation.

The measurement and evaluation of the exposure of individuals to vibrations transmitted by the hand-arm system must consider Part 1: General requirements and EN ISO 5349-2:2001 [4]. "Mechanical vibration – Measurement and evaluation of human exposure to hand- transmitted – Part 2: Practical vibration guidance for measurement at the workplace" [4].

The measurement and evaluation of the exposure of individuals to vibrations transmitted to the whole body must follow the criteria established in Decree-Law No. 46/2006, of February 24th [1] and in the NP ISO 2631-1:2007 "Mechanical shock [5]. Evaluation of whole-body exposure to vibrations. Part 1: General Requirements" [6] and EN 14253:2003+A1:2007 "Mechanical vibration – Measurement and calculation of occupational exposure to whole-body vibration with reference to health – Practical guidance" [6].

The EN ISO 5349:2 standard [7] establishes four ways of organizing measurement according to the characteristics of the operation.

Recommendations

Prevention measures for exposure to occupational vibrations can be carried out at several levels. In preferred order and cumulatively, it should be:

- Elimination or reduction of vibrations at the source;
- Decreased transmission of vibrations to the exposed worker;
- Use of Personal Protective Equipment;
- Information and training for workers.

III. NOISE IN WORK CONTEXT

Occupational exposure to noise is a risk factor to consider for the health of workers and occupies the third place in the ranking of occupational risks classified by the World Health Organization [8,9]. For (Seidman, 2010) [10] noise is defined as an unwanted sound or a combination of different types and frequencies of sound with probable adverse effects on health.

The national legislation regarding the promotion of safety and health at work, in DL n.º 102/2009 of 10 September [11], requires an organization to inform, train and ensure the health surveillance of workers, within the scope of its strategies of prevention of risks associated with noise.

In accordance with the provisions of article 5 of Decree-Law no. 182/2006 [12], of 6 September, it is the duty of the employer, within the scope of activities likely to present risks of exposure to noise, to carry out a risk assessment considering, among other aspects, the exposure limit values and the action values indicated in article 3 of the same diploma [12].

Risks Associated with Noise

Professional deafness fits into slow and progressive occupational diseases, as a result of exposure to intense noise or for longer periods.

In addition to hearing loss due to damage to the hair cells of the cochlea, part of the inner ear, other physical risks may occur, such as intolerance to loud sounds, tinnitus, transient changes in blood pressure, gastric disturbances, tachycardia, increased muscle tone, general fatigue, dizziness, migraines, anorexia, enlargement of the adrenal glands, as psychological risks aggression, stress, attention, sleep and mood disorders may occur, difficulties in social communication, increased risk of accidents.

Noise Assessment

The exposure of workers to noise must be evaluated in the following contexts, when applicable:

- After remodeling the facilities or changing the layout of the workspaces;
- After changing processes / work methods;
- After replacement of work equipment or machines;
- After implementation of prevention / protection measures;
- When requested by the competent authority;
- Within the scope of reasoned communication by workers.

Recommendations

Employees exposed to noise are all potentially at risk, and the higher the noise level and the longer the exposure to it, the greater the risk of damage caused by noise.

Employers are legally obliged to promote and protect the health and safety of their employees from all risks related to noise in the workplace, and for this purpose must:

- Carrying out a risk assessment involves carrying out measurements of noise in decibels at least once a year whenever 85dB is reached [12] using a sound level meter (used to read the noise level in any environment), and which must take into account all potential risks arising from noise and draw up a measurement program with the aim of, whenever possible, eliminating sources of noise and reducing noise at the source to a minimum;
- Reduce workers' exposure through collective work organization and workplace measures, including demarcating and restricting access to areas of the workplace where workers are likely to be exposed to noise levels in excess of 85 dB (A); and exposure to noise that reaches or exceeds 87 dB or peak value equal to or greater than 140 dB is not allowed.
- Provide workers with EC personal protective equipment (ear plugs or phones) whenever the lower action value (80 dB) is reached, and require the use of PPE whenever the higher action value (85 dB) is reached after potentiation prior to collective protection measures. These must have adequate attenuation, compatibility with tasks and other protective equipment used simultaneously. The effectiveness of these will depend on the time of use, correct use, shape/dimension, adjustability to the ear, pressure applied (on the head and/or ear), resistance to extreme temperatures and material.
- Inform, consult and train workers on the risks they run, on low-noise work procedures and on how to use protective equipment against noise.
- Control risks and re-evaluate prevention measures, which may involve medical surveillance of workers, every two years if it reaches 80 dB or annually if it reaches 85 dB.

The workers' opinion is a legal requirement that contributes to the choice of PPE; ensuring their commitment to safety and health procedures, as well as their improvement, their knowledge contributes to ensuring the proper detection of risks and the adoption of viable solutions.

IV. LIGHTING

It is known that the lighting levels in the workplace must be studied in view of the demands of the tasks that an employee is carrying out, especially since vision plays a fundamental role in controlling the movements and activities that he is developing. The existence of adequate lighting in the workplace is an essential condition for obtaining a good working environment. In fact, all the activities carried out, with the exception of those carried out outdoors during the day, require lighting levels adjusted to the requirements of the tasks.

Risks Associated with Light Deficit

It is important to understand which risks are associated with inadequate lighting in workplaces and workstations, which encourages the adoption of unsafe behavior for the employee and for the organization itself, for example, facilitating the adoption of incorrect working postures, leading to musculoskeletal injuries or facilitating falls on employees and objects, situations of running over, crushing and entrapment due to incorrect handling or driving of machines or work equipment. All these phenomena can condition productivity and be facilitating factors for the occurrence of accidents at work.

Evaluation of Lighting in Workplaces

It is up to the employer to evaluate the lighting conditions whenever there has been a remodeling of the facilities and/or changes in the layout of the workspaces and also whenever there is a change in the workstation itself and/or alteration of the processes and work methods. The lighting conditions must also be evaluated whenever work equipment and/or machines are replaced; after implementation of prevention / protection measures or when requested by the competent authority or even within the scope of reasoned communication from workers.

Health Effects of Poor Lighting

The effects on health resulting from inadequate lighting levels are felt, mainly, at the level of the visual system, characterized, in a first phase by a feeling of irritation, dryness and eye fatigue, evolving into loss of visual acuity, and in a second phase for headaches and feelings of malaise and insomnia. It is up to the employer to adopt preventive measures and good practices to prevent harmful effects on health, resulting from working with inadequate lighting levels. Among the technical measures is the installation of lighting adapted by levels, depending on the workstations and workplaces and in view of the degree of visual demand associated with the tasks performed and the characteristics of the installations (application of technical standards). The implementation of an artificial lighting system should allow uniform and constant lighting, as well as the reduction of reflections and glare. Lighting must also be suitable for areas where people circulate; circulation of machinery, vehicles and work equipment, as well as stairways and gaps, and technical areas. The implementation of a lighting system should also include emergency lighting for the premises; it must be able to avoid reflections, and the display and surfaces of the worktop have anti-glare characteristics and the components of the workstation must obey an efficient spatial arrangement.

With regard to the EDV, these must allow the correct placement of the display, keyboard and mouse on the work surface while ensuring ergonomic gains. The glazed surfaces must have mechanisms for regulating and controlling the entry of natural light. It is up to the employer to guarantee the inspection and maintenance of the components of the artificial lighting systems on a routine basis, as well as to ensure the rotation of workers in the development of tasks that require greater visual acuity, introducing and ensuring breaks while carrying out the work. It is also up to employers to inform employees about the risks associated with inadequate, insufficient and/or excessive lighting levels and to ensure that employees are trained on procedures and good practices to adopt. At the same time, measures of medical and optometric surveillance of the visual acuity of workers must be guaranteed.

Recommendations

It should be noted that national legislation obliges employers to adopt preventive measures and good practices to prevent harmful effects on health resulting from working with inadequate lighting levels. Indeed, it is recommended that measures of a technical, organizational, information and training nature and medical surveillance measures be adopted.

1. Technical measures - It is recommended that the lighting levels be adapted according to the workstations and their associated degree of visual demand, the functions performed and the characteristics of the facilities (application of technical standards). The employer should ensure that the artificial lighting system provides uniform and constant illumination and contributes to the reduction of glare and glare. The technical measures must ensure that the lighting is suitable for the areas where people, machines, vehicles and work equipment circulate, stairways, openings and technical areas. They must also take into account the emergency lighting of the premises and must avoid reflections, particularly on display screen equipment and work plan

surfaces, which in turn must also have anti-reflective characteristics. It is also recommended that inspection and maintenance routines be implemented for the components of the artificial lighting systems.

2. Organizational Measures - It is recommended to promote the periodic evaluation of occupational risks, of the levels of lighting at workstations and in work spaces; to ensure the rotation and breaks for workers in the development of tasks that require greater visual acuity.

3. Information and training measures - It is recommended that employees be provided with information about the risks associated with inadequate, insufficient or excessive levels of lighting and that training programs be implemented on procedures and good practices to be adopted.

4. Medical surveillance measures - It is recommended that medical and optometric surveillance programs of visual acuity be adopted for employees.

V. TEMPERATURE

Thermal factors are of fundamental importance in workplaces as they will influence productivity, workers' performance and their well-being [13]. Article 15 of the Legal Regime for the Promotion of Safety and Health [14] states that the employer's obligations must "ensure, in the workplace, that exposure to chemical, physical and biological agents and psychosocial risk factors does not constitute a risk to the worker health and safety." (Law No. 102/2009, p.6170) [11].

In turn, Decree Law n° 243/86, of 20 August [15], which regulates the general regulation of hygiene and safety at work in commercial, office and service establishments, states in its article n° 11 that "workplaces as well as common facilities, must offer good conditions of temperature and humidity, in order to provide well-being and defend the health of workers". This decree states that the temperature of workplaces must range between 18-22°C, with the exception of certain conditions in which they can reach 25°C.

Humidity in the workplace should range between 50-70%. Article 12 [15] of this legal regulation states that employees should not be exposed to sudden changes in temperature. There must be transition chambers so that employees can progressively warm up or cool down to the outside temperature with individual protection equipment or suitable clothing. This air-conditioned space should allow employees to warm up in the case of cold rooms and to drink hot drinks. Article 13 [15] states that in situations of great thermal stress there should be breaks in the worker's schedule or reduce his exposure to this thermal risk. Article No. 31 [15] deals with worker protection and refers to the existence of protective clothing in thick wool, neck and head protection and footwear protected from the cold and humidity for employees who work in refrigerated chambers.

Ordinance No. 987/93, of October 6th [16], in Articles 6 and 7, state that closed workplaces must have enough pure air to carry out the tasks to be carried out, the humidity and temperature must be adequate considering the working methods and the physical constraints that employees are exposed to. This ordinance states that the average flow of fresh and pure air must be 30 m³ per hour and per employee, which can be increased to 50 m³ in more demanding environmental conditions. A thermal environment that promotes the well-being of employees results in the simultaneous control of humidity, air renewal and temperature in the workplace. These factors are related to each other, since one is influenced by the other and by ventilation.

Risks Associated with Temperature

In the face of very high temperatures, sweating, drowsiness, excessive fatigue and a sharp drop in blood pressure can arise, energy consumption increases, reducing the productivity of employees. In very cold environments there is slowness, loss of attention, concentration, inattention and risk of respiratory infection [17].

Temperature Assessment

The assessment of the thermal environment must be carried out whenever there is a remodeling of facilities or changes in work processes/methods; after replacement of work equipment or machines; after implementation of prevention/protection measures; when requested by the competent authority or when there is a reasoned communication by the employees, so thermal stress must be valued, that is, the psychophysiological state in which the employee is exposed to extreme cold or heat environments and also thermal comfort, which, excluding extreme temperatures, are related to air velocity, humidity and temperature which together can cause discomfort. Employees exposed to unfavorable environments should also be quantified, with a view to identifying and proposing preventive and corrective measures.

According to the IQS (2023) [18] the evaluation of the thermal environment must be carried out with specific technical bases described in ISO standards, through the calculation of indices that allow drawing conclusions about the thermal conditions of a workplace. As normative references, the ISO 7730:2005 [19] standards are applied to moderate thermal environments, and the ISO 7243:2017 standard [20], referring to hot environments. These indices are calculated based on measurements of air velocity, relative humidity, temperature, radiant heat and data on employees' clothing at the location of their activity.

Recommendations

According to Santos and Almeida (2016) [21, 22] in cold environments the following recommendations can be adopted:

- Avoid working alone in cold environments;
- Avoid work overload in order to avoid intense sweating to prevent clothes from remaining damp, change clothes in heated shelters whenever necessary;
- When the clothing or protections provided to the worker are not sufficient to prevent hypothermia, the duration of work must be changed;
- The cold room should never be used as a leisure area, there should be no unprotected metal seats on chairs;
- The doors of the refrigerating chambers must have a system for opening the doors internally, in case workers are involuntarily trapped.

In hot environments, the following recommendations can be adopted (DGS, 2023) [23]:

- Increase your water intake or drink natural fruit juices frequently
- Avoid direct exposure to the sun between 11am and 5pm.
- Wear cotton clothing that covers most of the body, use ultraviolet protection glasses;
- Avoid activities that require great physical effort.

According to Freitas and Cordeiro (2013) [24] as referred to by the ACT, action is proposed in several dimensions:

A) Measurements on the structures:

- Dimensioning and design of workplaces suitable for the production process
- Implement appropriate insulation measures: glass protection, thermal insulation of walls and roofs.

B) Technical measures:

- Monitor the quality of installation and selection of HVAC equipment
- Implement preventive inspection and maintenance programs for air conditioning and ventilation systems
- Promote localized ventilation and aspiration
- Evaluate thermal comfort whenever necessary
- Carry out a careful selection of qualified suppliers of technical services and equipment.

C) Measures on the organization of work:

- Promote the periodic assessment of professional risks
- Reduce the number of workers exposed, the duration and degree of exposure
- Promoting employee turnover
- Introduction of breaks in tasks with exposure to extreme thermal contexts
- Selection of periods of the day most suitable for the execution of the works
- Promote the use of appropriate PPE (clothing, footwear, protective gloves)

D) Information/training measures:

- Inform workers about the risks of exposure to unfavorable thermal conditions and poor ventilation in the workplace
- Train workers on good safety practice procedures to be developed
- Specific surveillance of the health of workers exposed to extreme thermal environments.

VI. CONCLUSIONS

In view of the above, the environment where a professional activity is carried out can expose the employee to inappropriate levels of vibration, noise, lighting and temperature. Continuously, this exposure can have negative consequences, real or potential, either in physical terms or in psychological terms, according to the specificity of each exposure.

Employers are morally and also legally responsible for protecting workers, namely through safe working practices, not only to maintain or even improve productivity levels, but also to provide workers with health protection, satisfaction with performance of their activity and physical and psychosocial well-being.

The occupational health nurse is, par excellence, the qualified professional to, together with the rest of the occupational health team, make working environments healthier and safer, by integrating knowledge in areas such as ergonomics into their practice, thus allowing employers to take care of their greatest asset, that is, the group of its workers.

Physical risks are related to work factors such as accidents and productivity. Bearing in mind that the human response depends on environmental, physiological and psychological factors, it becomes necessary to find engineering and management measures in the organization of work to reduce exposure and the consequences for workers exposed to adverse physical environments.

More and better health and safety in the workplace translates into health gains for all, with a positive impact on the costs associated with treating accidents and work-related illnesses.

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