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ERGONOMICS RISK MANAGEMENT IN THE INDUSTRY (ERMI)

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Abstract: In Romania, most workers' health problems are caused by work situations in which ergonomic principles and regulations are not respected. It was found that in many situations, not only the workers, but sometimes even those responsible for safety and health at work, do not know these ergonomic principles and rules, this fact reveals that, at the enterprise level, there is no management conscious, assumed and planned for the ergonomic risks. In this article, we propose a systematic, step-by-step approach to effective management of ergonomic risks. This methodology was implemented in several companies in Romania, and the results, both in terms of workers' health and work productivity, were excellent.

Key words: ergonomics, risk assessment, ERMI, work procedure, action plan.

1. INTRODUCTION

In the industrial field, although technology has advanced to a significant extent, workers still face problems related to ergonomics [1-4].

These problems have several causes, including: poor organization of the workplace, the use of tools, work equipment that are not appropriate for the work situation or the respective activity, workers do not know how to work efficiently when performing some activities, and, often, even if they know the correct posture and benefit from the appropriate equipment, they ignore them and work in a wrong way, a fact that, in the end, affects their health and productivity [5-9].

This lack of awareness both at the level of workers, but also at the level of management, is caused by deficiencies in the understanding and implementation of ergonomic practices as well as by a deficient legislation that encourages bureaucracy more than holding workers accountable for even their own actions or inactions when it comes to even for their own safety.

In fact, in Law 319/2006 and HG 1425/2006, with updates, there is not even a sanction for workers who violate the principles of risk prevention, therefore also those related to ergonomics. All this, corroborated with the fact

that occupational safety specialists, besides the fact that they are not constrained to have specialized technical studies, they do not understand the operation principles of certain equipment, the interactions between equipment or between workers and equipment. This makes them less efficient in properly training the workers regarding ergonomic risks.

It is obvious that working without being aware of the ergonomic principles, can result in health problems, even with the most serious effects, in a longer or shorter time (sometimes even during the performance of activities).

Knowing that applied ergonomics means that workers have a "well-being" during the activities, all aspects that can have an impact on workers must be considered, such as body posture, posture duration, posture frequency, work environment (lighting, noise, dust, air currents, movements around the equipment), psychosocial state, among others [10-17].

An effective management of ergonomic risks must consider all these aspects and integrate them to prevent possible health problems of the workers and increase efficiency in the activity, improving the performance of the workers by reducing physical discomfort, fatigue and the risk of injury.

2. METHODOLOGY

For the effective implementation of ergonomic risk management, a systematic approach that includes several stages is necessary. The main stages in the effective management of ergonomic risks are presented in Fig. 1. To implement these stages of ergonomic risk management, some clarifications are necessary, such as in the stage of identifying the activities that the workers perform, special consideration will be given to the most demanding activities and those where workers have already reported discomfort after completing them. The work equipment, the height of the work planes, the workspace, the work environment (lighting, noise, dust, vapors, temperature, circulation paths, flows, etc.) will be observed and the workers who perform those activities will be identified. For workers, it is important to know a series of information such as height, weight, age, gender, experience, etc.

The next step is the identification of ergonomic risks, through the direct observation of the workers during the activity, the possible dangers that the workers must avoid or must face and the ergonomic risks associated with them. Possible rationally foreseeable scenarios that may occur during the activities will be considered.

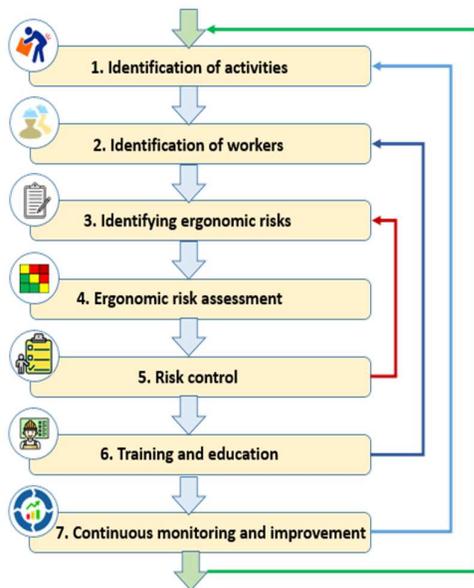


Fig. 1. The main stages of the ergonomic risks effective management.

Additionally, the evaluation team requests that questionnaires and interviews be conducted with the workers to gather information about any physical discomfort, pain, or mental distress they experience during work. In the ergonomic risk evaluation stage, the evaluation method is chosen that the evaluator considers the most suitable for achieving the evaluation objectives. In general, for complex activities that, for example, involve both posture aspects and mass manipulations, several assessment methods can be used. Established methods based on questionnaires can be used, such as: RULA, REBA, QEC, Snook Table, NIOSH Lifting Equation, etc. The collected data is analyzed to determine the factors that contribute the most to the ergonomic risks and the risks are prioritized to determine which are the most urgent to address.

The risk control stage involves drawing up a plan of measures following the assessment of ergonomic risks, which may involve: modifying workstations, equipment or work processes to reduce ergonomic risks (for example, adjusting the height of work tables, using ergonomic chairs), personal protective equipment that can reduce the physical stress on employees (for example, anti-vibration gloves or lumbar supports) and, of course, if appropriate, automation and mechanization by introducing machines and equipment to take over the difficult physical tasks for workers.

The stage of training, educating and instructing workers on safe and ergonomic work techniques (for example, how to properly lift heavy objects or how to use suitable work equipment such as ladder with platform vs simple ladder). These can be achieved by promoting workers' awareness of the importance of ergonomics and health at work.

At the same time, maintaining and developing the physical and mental abilities of the workers is a desire that must be pursued permanently, and this can be achieved by encouraging the workers to take adequate regular breaks and warm-up and relaxation exercises to reduce muscle tension and fatigue and to increase muscle and mental tone.

Of course, once these stages have been implemented, monitoring and continuous improvement of the entire process is required.

Table 1

The weighting coefficients, depending on the body parts, are considered in the evaluation of ergonomic risks.

	Posture	Force	Duration	Repetition	Static exertion	Contact stress	Impact stress
Neck	5	-	5	3	5	-	-
Back	5	5	5	5	5	2	5
Shoulder	3	3	4	3	4	3	3
Elbow	2	3	3	3	3	1	2
Wrist	3	3	4	3	4	3	3
Leg	3	1	3	2	3	1	2

Table 2

The weighting coefficients for environmental and state factors, considered in the evaluation of ergonomic risks.

	Vibration	Temperature	Noise	Lighting	Dust	Steam	Space	Physical condition	Mental state
Add	4	4	2	4	3	3	5	5	5

This can be achieved through continuous surveillance, i.e. constant monitoring of working conditions and the health of workers to prevent and quickly detect any problem and periodic review through periodic evaluation of the effectiveness of implemented measures and to adjust if necessary. Therefore, the effective implementation of ergonomic risk management requires a systematic approach and the collaboration of all parties involved, i.e. workers, management starting at the highest level and health and safety specialists.

The ergonomic risk assessment methodology must consider the interactions between different parts of the body and the elements related to the actual activity, and this interaction can be highlighted by using adjustable weighting coefficients (an example is shown in Table 1) depending on the specific work situation.

We must also consider the environmental factors in which the activity is carried out and the state factors, specific to each worker (an example is presented in Table 2), since these factors might worsen or improve the work situation.

For example, the mental state of the worker during the exercise of the workload has a significant impact on safety and productivity in the workplace. Stress, anxiety, depression and other mental disorders can negatively influence the worker's performance and behavior, because they decrease concentration and attention, which can even lead to accidents, increase the error rate, decrease productivity, etc., while a good mental tone motivates the worker to carry out when fulfilling the work task, having a

beneficial impact on safety, work quality and efficiency.

Although these things are demonstrated in practice, however, as a rule, these factors, especially those regarding the mental state of the workers, are completely ignored. In fact, in practice, in Romania many labor inspectors even refuse to accept that the negligence of the worker could be part of the causes of any accident.

In the effective management of ergonomic risks, we must consider the relationship between all these ergonomic parameters and factors and productivity, both to achieve the objectives related to safety and production and to demonstrate the extent of the implementation of this management in practice. To highlight the relationship between ergonomics and productivity, we used a simplified mathematical model, presented in equation (1), that considers the main influencing factors.

$$P = P' + x \times E + y \times C + z \times R \quad (1)$$

where:

P - productivity.

P' - the reference productivity of the system before considering the specific influences of E, C, R.

E - ergonomic efficiency (assessed by factors such as reduction of discomfort and fatigue).

C - worker comfort (determined by questionnaires and interviews with workers).

R - injury reduction rate.

x, y, z - coefficients that determine the impact of each factor on productivity.

In equation (1), we start with the initial productivity, the reference, from the moment of

starting the implementation of this management methodology and consider the ergonomic efficiency gained following the implementation of the measures, the comfort that the workers feel, as well as the rate of accidents. All these parameters will be weighed with specific parameters that amplify or do not have the impact of the respective factors on productivity. The values of these coefficients will be established by the team considering the specifics of the activity and can be influenced by the management objectives that must be achieved.

3. RESULTS

The ERMI methodology was implemented in several companies in Romania. These have different fields of activity. The data presented in Table 3 come from four of these companies. In these companies, questionnaires were used for at least 80% of the workers who worked in production and about 15% of them were interviewed. These percentages were considered sufficient for the identification of problems related to ergonomics, because the surveyed workers were chosen from all production sectors in the company, in larger numbers those who worked in production and in working conditions

with greater risks. Also, the percentage of those interviewed was relevant for the study, because these workers were chosen from all categories of staff, in larger numbers also from areas with higher risks, and the corroboration of the answers pointing to the ergonomic risk factors corresponded almost entirely, resulting in the fact that those surveyed and those interviewed offered relevant opinions and perceptions for all workers in the company.

The graphic representation of these data is presented in Fig. 2. The obvious improvement in productivity can be observed, especially with the decrease in the accident reduction rate due to the improvement of ergonomic conditions for workers. Of course, the calculation formula used for Productivity can be developed, considering several other parameters, such as reducing the duration of the activity, or reducing the costs of medical leaves, absenteeism and medical recoveries.

Special attention was given to the activities that challenge the workers on multiple levels: the forced posture adopted, the applied force, the manipulated masses and the duration of these actions. Activities such as those presented in Fig. 3, 4 and 5 demand a lot of attention and effort from the workers.

Table 3

The results obtained following the implementation of ergonomic risk management.

Company	Field of activity	No. workers	P'	x	E	y	C	z	R	P
Company 1	Automotive	880	100	0.20	28	0.15	26	0.1	10	110.50
Company 2	Automotive	533	100	0.20	32	0.15	23	0.1	19	111.75
Company 3	Metal processing	114	100	0.25	20	0.20	18	0.1	41	112.70
Company 4	Manufacturer of spray paint	239	100	0.20	30	0.20	20	0.1	11	111.10

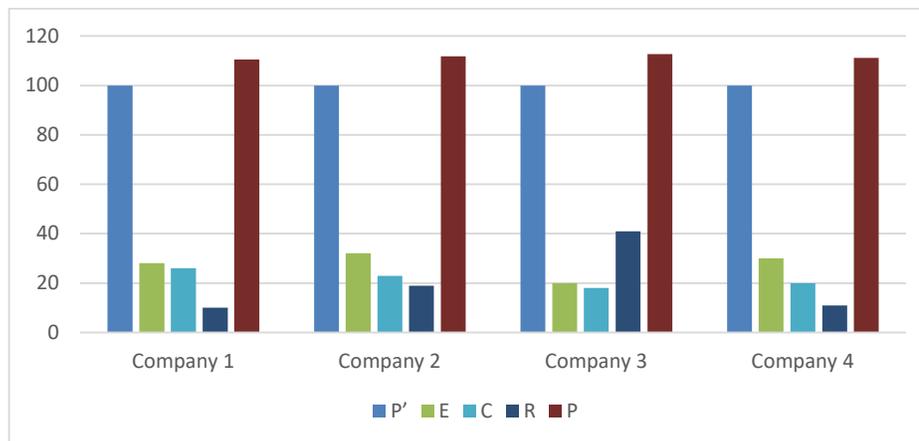


Fig. 2. Graphic representation of the parameters obtained in 4 companies: P' - reference productivity of the system; E - ergonomic efficiency; C - worker comfort; R - injury reduction rate; P – productivity.

This is because these positions are forced, due to the physical constraints of the equipment but also of the work area being too high, which causes the workers to hold their arms above their heads, having hand tools and objects that can reach 3-4 Kg, having to apply a certain force, having the spine and neck in extension and even rotated or inclined or, in the situation in Fig. 5, when the worker is a woman (who has a frailer physical constitution) and performs grinding with the angle grinder that takes a long time and, very often, she has to bend and turn to reaches the place to be polished.

Considering the duration and frequency of these actions, it is obvious that the workers who perform them are feeling it.

In many industries in Romania, many activities that require strength, duration and are performed in a polluted environment, are performed by women or by workers who are over 45 years old. Obviously, these workers are physically and mentally affected to a very high degree.

In addition, the situation related to ergonomics, with direct implications even in the safety of workers, is that they resort to improvisations (e.g. the ladder and the tools in Figure 3) or use tools and equipment that are not appropriate for the activity they perform (e.g. even the angle grinder used without the protective guard because it would be inconvenient for the worker to perform grinding in certain areas of the metal profile).



Fig. 3. The worker when welding has his torso bent almost 90° but depending on the place of welding, he must bend even more or weld above the shoulders.

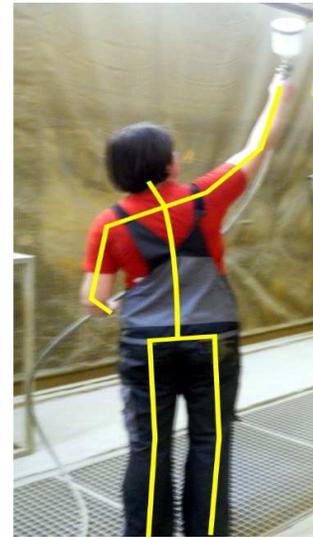


Fig. 4. The worker has his hand above his head and the duration of the action is too long.



Fig. 5. The worker polishes with the angle grinder that weighs 5.2 Kg.

Following the analysis of ergonomic risks, a series of measures were taken, both technical and organizational, and the situation improved significantly, which also led to an increase in worker productivity.

4. DISCUSSIONS

Following the analysis of the ergonomic risks, detecting a series of work situations that greatly affected the health of the workers, even leading to a series of accidents and affecting

productivity, certain measures were taken. A series of technical improvements of the work equipment were carried out, among them there were special devices that raised/lowered and rotated the workplan so that the worker could work as long as possible in a neutral position. At the same time, a series of devices were provided that took a large part of the mass of the tools and objects handled by the workers.

Regarding the organizational measures, the workers benefited from an instruction and training program after which they became aware of the importance of respecting the ergonomic rules, in parallel with the planning of the activities so that the workers can alternate the activities and through the implementation of a special program in which all the workers and warm up the body before starting the activity through specific exercises, as well as taking active breaks, through which the workers can recover physically after the effort.

After the implementation of each measure, its effectiveness was analyzed and, depending on the results, the actions were adjusted to achieve the expected improvement.

Analyzing the effectiveness of the measures in improving working conditions, both those that concern the comfort of workers and those that concern productivity, it was observed that equipment that can be adjusted directly and easily by workers had the best impact, followed by training with practical demonstrations on how to properly use equipment and tools. In some situations, the simple rearrangement of the workplace (for instance the case of welding operations - the most difficult and inconvenient), greatly increased the degree of comfort and efficiency of the workers. In other situations, e.g. manual picking of parts from boxes on pallets, transport and placement on the platform of a processing machine, was replaced with a system of lifting and transport through conveyor belts, bringing the parts to the same height as the platform of the machine, the worker only taking the part from a tape, visually checks the piece and places it on the platform at a short distance. In this way, the worker no longer bends down for the pieces, no longer moves and turns with the piece in his hands, etc., but only performs simple and small movements at the optimal height.

5. CONCLUSION

The application of an effective management of ergonomic risks, which involves the identification of situations with significant risk from an ergonomic point of view, the evaluation of these risks, the preparation of an action plan, their implementation and performance verification, leads to increased productivity due to the increased efficiency of workers in the activity, because they reduced fatigue and discomfort, reduced musculoskeletal disorders, decreased work accidents, all of which reduced the costs of companies and increased the well-being of workers.

The methodology presented in this article is one that has proven to be practical and efficient in preventing and solving ergonomic problems in the companies where it was implemented.

One important aspect of its successful application is the conscious and assumed involvement of all the responsible factors in the enterprise, starting with those from the highest management level.

In the future development of this ergonomics management methodology in industry, the following aspects will also be considered:

- Integrating new technologies and artificial intelligence (AI), these could be achieved through real-time monitoring using sensors integrated into equipment or worn by workers and which can monitor posture, level of effort and repetitive movements to prevent ergonomic risks;
- Virtual Reality (VR) (which contributes to Augmented Reality (AR)) through ergonomic training in VR which should aim at both adequate training and simulations of some work techniques so that the worker knows practically the modes of action;
- Automating repetitive processes through the use of robots or automated systems to reduce repetitive physical tasks that can lead to musculoskeletal injuries;
- A good customization of ergonomic solutions by adapting and adjusting equipment and workstations to the individual characteristics of workers, such as height, physical abilities such as strength and mobility, etc.);

- Finally, the much more efficient promotion of warm-up programs and preparation of the body and mind before starting work. We consider this aspect to be particularly important, but, unfortunately, it is almost completely ignored in practice.

The limitations of the research regarding the presented methodology were determined by the method of data collection and analysis, caused by a relatively small sample that can limit the generalization of the results. However, because the chosen sample of workers is representative for most workers in Romania, regarding the perception of ergonomics in general, it can be concluded that the results obtained are relevant.

However, considering the general perception of the population in Romania towards risks in general and obtaining a state of well-being and safety during work, we appreciate that the efforts to raise the awareness of the company's management personnel and the workers of those companies and to begin the implementation of this ergonomic risk management methodology a significant effort will be required.

Therefore, effective management of ergonomic risks, leading to the implementation of ergonomic measures, is not only an investment in the health and safety of employees, but also a smart business strategy related to ergonomics solutions implementation [18-20]. Although this article analyzes results from only four companies, it is important to note that challenging working conditions with significant ergonomic implications are present in many other companies across Romania. Extending research into a larger number of companies will be part of our future activity [19].

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Managementul riscurilor ergonomice în industrie (ERMI)

În România, cele mai multe probleme de sănătate ale lucrătorilor sunt cauzate de situațiile de muncă în care nu sunt respectate principiile și regulile ergonomice. S-a constatat, că în foarte multe situații, nu numai lucrătorii, dar chiar și responsabilii cu securitatea și sănătatea în muncă nu cunosc aceste principii și reguli ergonomice, acest fapt dezvăluind că, la nivel de întreprindere, nu există un management conștient, asumat și planificat pentru gestionarea riscurilor ergonomice. În acest articol, propunem o abordare sistematică, pe etape, a unui management eficient al riscurilor ergonomice. Aceasta metodologie a fost implementată în câteva companii din România, iar rezultatele, atât în ceea ce privește sănătatea lucrătorilor cât și productivitatea muncii, au fost excelente.

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