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## HUMANOCENTRIC DESIGN OF PRODUCTION PRECESSES

### Abstract

*Nowadays, changes in many fields, such as technologies are visible in Industry 4.0 context. Questions of human work effectiveness increase arise due to constant productivity increase and innovation implementation into products and technologies. Moreover, this pressure is also reflected on demands for employees, their performance, productivity, and overall workplace well-being. Today, ergonomics implementation has proved to be effective in terms of human work. In addition, ergonomics offers productivity and quality increase, as well as company cost decrease.*

### 2.1. INTRODUCTION

One of the ways how to achieve the already mentioned advantages is to implement ergonomic prevention programs in enterprises. In the USA and some western European countries, ergonomic prevention programs have become a tool for increasing labour productivity and a part of enterprises processes. What is emphasized is mainly their anti-crisis potential. Moreover, it is not very often to adapt work environment and production facility to employees in majority of Slovak companies. It is mainly focused on activities resulting from current legislation and which are monitored by public authorities of healthcare and other institutions from the field of Health and Safety at Work. However, there are enterprises which tend to adapt work conditions to their employees, but these are mainly abroad. Work with hands above head is considered to be the riskiest and that is mainly during assembly in automotive industry. Some enterprises have implemented a way of vehicle tilting on an assembly line, so the employee would not have to raise hands above his or her head. This example points out that there is always a solution for everything when effort is there. One of the most effective procedure to solve problems of ergonomic in enterprise processes is the methodology for creation and implementation of ergonomic prevention programs aiming to reduce exposition level Musculoskeletal Disorders (MSDs) risks. Procedure is proposed via specific steps that could be generally implemented in the enterprise. Through their way of implementation, is possible to

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achieve positive influence not only on employee's health but it is also possible to achieve significant economic savings for the enterprise. Prior to the introduction of ergonomic prevention program methodology, it is important to focus on a consistent image about ergonomic and the meaning of ergonomic prevention programs. It is also necessary to have knowledge about abilities, requests, and possibilities related to work and the working process. Therefore, it is necessary to analyse not only the working processes but all aspects of the process. (Dulina, 2018)

## 2.2. ERGONOMICS IN A CHANGING ENVIRONMENT

Nowadays, changes in many fields, such as technologies are visible in Industry 4.0 context. Questions of human work effectiveness increase arise due to constant productivity increase and innovation implementation into products and technologies. Moreover, this pressure is also reflected on demands for employees, their performance, productivity and overall workplace well-being. Today, ergonomics implementation has proved to be effective in terms of human work. In addition, ergonomics offers productivity and quality increase, as well as company cost decrease. One of the ways how to achieve the already mentioned advantages is to implement ergonomic prevention programs in enterprises. In the USA and some western European countries, ergonomic prevention programs have become a tool for increasing labour productivity and a part of enterprises processes. What is emphasized is mainly their anti crisis potential. Moreover, it is not very often to adapt work environment and production facility to employees in majority of Slovak companies. It is mainly focused on activities resulting from current legislation and which are monitored by public authorities of healthcare and other institutions from the field of Health and Safety at Work. However, there are enterprises which tend to adapt work conditions to their employees but these are mainly abroad. Work with hands above head is considered to be the most risky and that is mainly during assembly in automotive industry. Some enterprises have implemented a way of vehicle tilting on an assembly line so the employee would not have to raise hands above his or her head. This example points out that there is always a solution for everything when effort is there. One of the most effective procedure to solve problems of ergonomic in enterprise processes is the methodology for creation and implementation of ergonomic prevention programs aiming to reduce exposition level Musculo Skeletal Disorders (MSDs) risks. Procedure is proposed via specific steps that could be generally implemented in the enterprise. Through their way of implementation, it is possible to achieve positive influence not only on employee's health but it is also possible to achieve significant economic savings for the enterprise.

Prior to the introduction of ergonomic prevention program methodology, it is important to focus on a consistent image about ergonomics and the meaning of ergonomic prevention programs. It is also necessary to have knowledge about abilities, requests, and possibilities related to work and the working process. Therefore, it is necessary to analyse not only the working processes but all aspects of the process.

**2.2.1. System conception of ergonomics**

Growing relationship complexity among a human, work environment and an object of work has been culminating over the last period of time. Human activity at work is increasing but also work conditions and demands on an employee are increasing. Also, development of science and technology today significantly interferes with structure of society’s production forces. Moreover, it influences a relationship of a person with work and his or her work conditions. Therefore, it influences his or her lifestyle. There is a decrease in demands for motor skill development and increase in sensorimotor skills and theoretical and motor knowledge. Due to this, there is a change when performing work. Is it mainly a change related to technology which influence work environment, but also changes in human behaviour. These could be expressed in positive or negative reactions that have impact on a satisfaction level, effort made, performance and the health of employees could be in danger when performing tasks. Foundation for correct system functioning human – machine – environment is the respect of anthropocentric principle during its design. (Fig. 2.1.) It is necessary to realise that it is actually the human that is the most risky „article“, and therefore all the other system elements should be tailored to human abilities and capabilities.

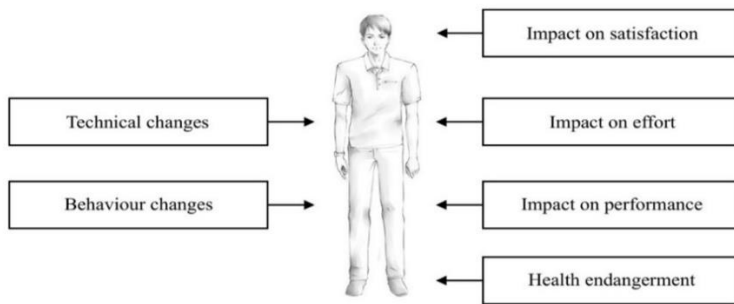


Fig. 2.1. Change impact on a human [own elaboration]

Ergonomic system shows that mutual element interaction is characterised by a two-way influence. It is possible to reach the maximum safe human behaviour by editing of system elements and their basic factors. This is possible due to system approach to a solution of the specific situation and by adjusting basic factors.

**2.2.2. Ergonomic solutions in enterprises and efficiency indicators**

From experience, it is possible to point out that ergonomic questions based on complex research dealing with special scientific disciplines helps humanisation of work, optimisation of work conditions and also the growth in productivity and quality of work. With use of ergo-nomic knowledge, it is possible to provide efficiency of work process elements through securing that impact on employee’s health and increase of

contribution from costs involved. This efficiency could be evaluated in three basic directions:

- Economic efficiency.
- Social efficiency.
- Ecological (humanised) efficiency.

Basic principle that helps evaluate efficiency of ergonomic solutions is the ratio of resource volume used for implementation of ergonomic solutions and contribution volume gained through their use.

### 2.2.3. Economic efficiency of ergonomic solutions

When selecting and evaluating ergonomic solution, there are two basic and important decisions. First decision is investment and the second finance. Economic efficiency is expressed by a ratio of a useful result and its ergonomic solution and one-off costs according to the relationship (2.1) (Všetečka, Belan, 2006):

$$e = \frac{E}{J} \tag{2.1}$$

where:  $e$  is economic efficiency;  
 $E$  is useful result, EUR;  
 $J$  are one-off costs, EUR.

Ergonomic solution is effective if  $e > 1$ , ineffective if  $e < 1$  and neutral if  $e = 1$ . Useful result could also be defined as increase in profit, which could be achieved by using ergonomic solution. One-off costs represent the size of costs put into implementation of ergonomic solution.

According to Sablik (1994), evaluation of ergonomic solution and its economic efficiency is implemented by a calculation of indicators:

- Synthetic, also called ratio indicators, these evaluate the ratio of cost saving and size of capital invested (e.g., total cost size of ergonomic solution, capital return invested into solution implementation, payback period of invested capital, etc.).
- Analytic, quantifies cost size of particular cost item (e.g., wage cost saving for a production unit, material cost saving for a production unit, cost saving for electric energy, technological purposes, etc.).

### 2.2.4. Social and human efficiency

As Sablik (1994) states in his literature, it is possible to track benefits in social and ecological area, thanks to implementation of ergonomic solutions. Social effects could be evaluated by following indicators:

- Cost saving from occupational disease and sick leave decrease.

- Cost saving from employee fluctuation decrease.
- Cost saving from fatigue and injury rate decrease.

Social efficiency indicators could be calculated based on social effect rate quantification and size of its economic impact. Relationship could be recorded as (2.2) (Sablik, 1994):

$$k_{se} = \sum_{i=1}^n (m_{se_i} * e_{u_i}) \quad (2.2)$$

where:  $k_{se}$  is social efficiency indicator;  
 $m_{se_i}$  is social effect rate;  
 $e_{u_i}$  is economic impact.

Human (ecological) efficiency of ergonomic solutions could be evaluated by indicators such as:

- Aesthetic quality of workplace indicator.
- Improvement coefficient of workplace environment and its individual components.
- Coefficient of water, land and air pollution.

Indicator calculation for human efficiency could be expressed by parameter value comparison of tangible work environment, aesthetic side of workplaces and number of workplaces, that will be affected by ergonomic solution implementation. It is as follows (2.3) (Sablik, 1994):

$$k_v = \frac{\sum_{i=1}^n (k_i * d_i)}{\sum d_i} \quad (2.3)$$

where:  $k_v$  is final indicator of work environment;  
 $k_i$  partial coefficient of work environment, which expresses ratio of real and admissible value of the parameter concerned and work environment;  
 $d_i$  number of workplaces which belong to evaluation (particular solutions).

### 2.3. MODERN ERGONOMICS

Ergonomics has started to be divided into micro-ergonomics and macro-ergonomics due to practical reasons. However, this division is still not so popular in Slovakia. It is not applied, used in legislation or with ergonomics in enterprises or when teaching ergonomics. Micro-ergonomic and macro-ergonomic strategy aspects are shown in the fig. 2.2.

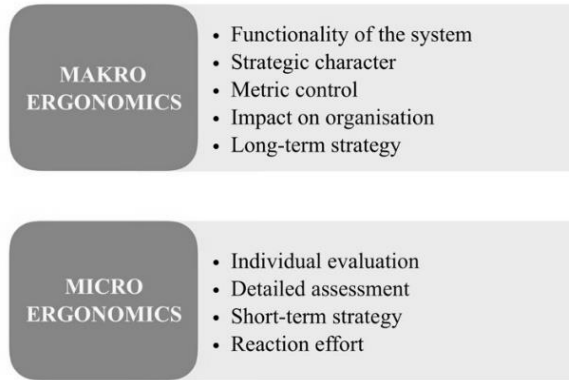


Fig. 2.2. Macro and micro-ergonomic aspects (Missar et al., 2012)

As Hattiar (2008) states, macro-ergonomics includes understanding of ergonomics as a whole. Its focus is mainly on development of new devices and systems. For these reasons, specific ergonomic databases are made based on research results. These could be used with ergonomic rationalisation of labour and organisation system, legislation creation and in strategic planning.

As Missar (2012) states, such complex extent of ergonomic questions is solved by macro-ergonomic strategy. Such approach indicates all relevant workplace factors as well as individuals individual work units. That is why it is important to deal with macro elements which could influence overall costs caused by risk in workplace and they could also improve ergonomic prevention program efficiency. Individual macro-ergonomic areas could be transferred to work activities in working process. (Fig. 2.3.) (Zulch, 1992).

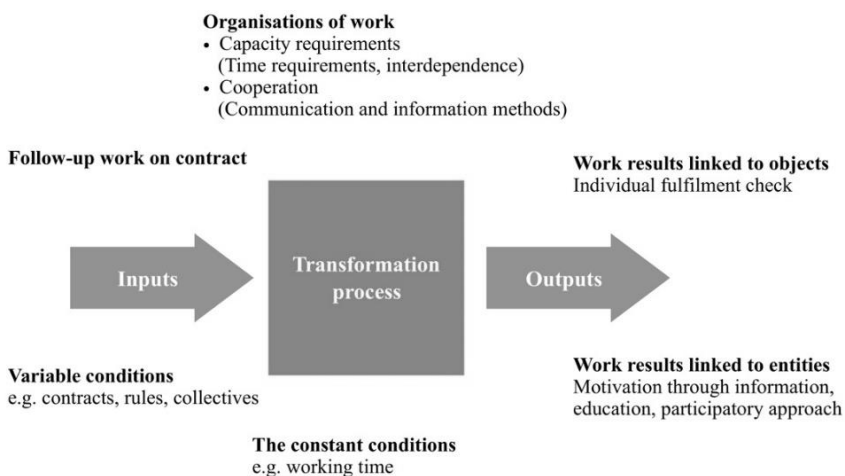


Fig. 2.3. Reference organisation framework in macro-ergonomics (Zulch, 1992)

When designing new devices and systems we should work on valid legislation and use such data that characterise population as precisely as possible. Solutions are intended for this legislation. It is in other words Proactive approach. It is important to realise that data of high quality and used methods reflect the reality with only certain probability. Therefore, it is important to consider whether valid legislation requirements, hygiene regulations and anthropometric data of target population are respected. Micro-ergonomics tries to systematically solve ergonomic problems in enterprises. It also tries to reveal negative impacts of work factors and work environment on employees through ergonomic analyses and methods. There is mainly a try to eliminate difficulties of support and movement system which identify lack of workplaces (Missar et al., 2012). The main aim of micro-ergonomic is to remove these discovered difficulties or in other words, to achieve positive impact on employee’s health and benefits from invested costs (Hatiar, 2008). It is about reevaluation of original macro-ergonomics solution but through particular real impacts in a real situation. Therefore, it is necessary to focus on health implications and not only whether work conditions are in conformity with legislation. Under micro-ergonomics, it is possible to apply ergonomic preventative programs as a process of constant work condition improvement. These could be applied individually or as part of pro-grams focusing on health and safety. Thus, it is important to realise that each workplace is characterised by external factors for all individuals in workplace. However, individuals react to these differently, depending on individual characteristics and abilities. (Fig. 2.4.) If we would like to have a good track of factors influencing work and system itself, created by human – machine – environment elements, it will be necessary to look into information flow in working process. (Hendrick, 2005; Hatiar, 2008)

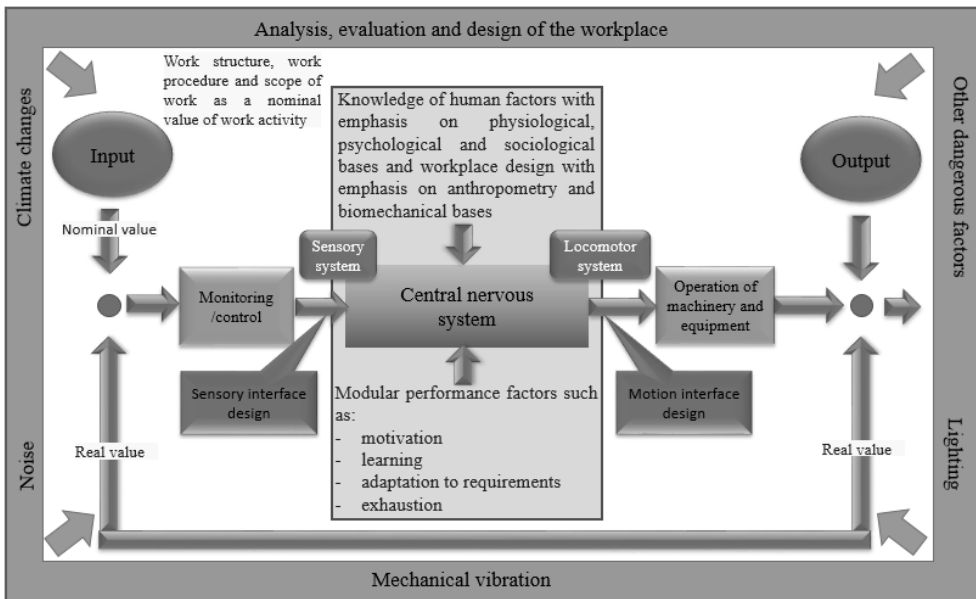


Fig. 2.4. Micro-ergonomics aspects in working process (Strasser, 2009)

Board of Certification in Professional Ergonomics – BCPE approves and solves a relationship between organisation, technological, environmental and other subsystems belonging to one system representing ergonomics as a whole. This is done through macro and micro-ergonomics. According to Robertson (2001) the main point of this model is integration of organisation subsystem together with its harmonisation when achieving objectives and mission of each enterprise.

### **2.3.1. Ergonomic prevention programs**

Working conditions are for people working in enterprises adapted only in exceptional cases. Based on a few answers from ergonomics, nowadays, it is employees themselves protesting against condition improvement in workplace. This is due to their fear from taking their allowance for a risky job and losing their job. Due to practical reasons, ergonomics could be considered as science trying to provide work environment enabling a human to work comfortably and be beneficial for an enterprise. By increasing the efficiency of human work, enterprise competitiveness is also increasing. Enterprises can then adapt to supply and demand conditions on market. Countries with advanced market economies could be used as an example. Slovakia will be able to achieve long-term economic stability and competitiveness after applying ergonomic approach when preventing occupational diseases. The main task of ergonomics should therefore be creation of suitable ergonomic prevention programs which will be based on scientific approach to problem solving in workplaces. Ergonomics is part of 2 types of processes. First type represents processes which protect employees whilst working. Ergonomic solutions which prevent against negative consequences of physical, chemical, biological and social factors are carried out. Second type of process is the one from occupational medicine. There is a preventive effort against already mentioned factors which could cause various types of diseases. It involves early diagnosis and subsequent treatment so that an employee is able to return back to work without any health problems.

### **2.3.2. Ergonomics Maturity Curve**

Ergonomics Maturity Curve illustrates development process of enterprise development towards sustainable success of Ergonomic Prevention Program with the aim to eliminate difficulties of musculoskeletal system. The key success is direction towards the upper-right corner (Fig. 2.5.) in 4 basic approaches in an enterprise ([www.humantech.com](http://www.humantech.com)).

#### **Reactive approach**

This approach involves quantification of risk factors that have causes MSDs difficulties and the order for their elimination, depending on gravity, will be set. As soon as the risk factors are identified, proposal of remedial measures follows. These include for example: how to improve workplace, machines or devices in a way they would be adjusted to physical capacities of employees.



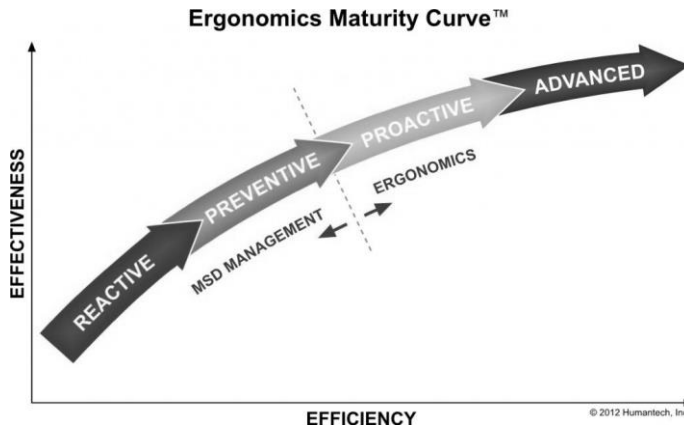


Fig. 2.5. Ergonomics Maturity Curve of an Enterprise (www.humantech.com)

### Preventive approach

During preventive phase, emphasis is put on measuring physical abilities of an individual (power, impact zones, etc.) which correspond to a carried-out activity. During this phase, physical difficulty analysis is implemented in the carried-out work.

### Proactive approach

If an employee has problems with musculoskeletal system whilst working, he or she must be treated, cause which has caused it must be identified and remedial measures must be proposed. In other words, everything that causes MSDs difficulties must be eliminated. The employer must find another way how to carry out such work and also keep process effectiveness.

### Advanced approach

In advanced approach, proposals are applied which are implemented during Proactive approach through ergonomic standards applied in individual process phases for future cases.

#### 2.3.3. Ergonomic prevention programs and their meaning

Ergonomic prevention program represents systematic process for identification, evaluation and monitoring ergonomic risk factors in workplace causing musculoskeletal system problems (Cantley, 2014). Its main task is to apply ergonomic principles in workplace with aim to eliminate number and gravity of musculoskeletal system difficulties (MSDs).

Through ergonomic prevention programs is it possible, in set intervals, to re-evaluate consequences of implemented solutions in order to improve employee's health

condition and therefore achieve benefits from costs involved. In case of no improvement in health condition and in economic benefit for enterprise, more analysis and more ergonomic solutions are carried out. Ergonomic prevention programs represent a valuable opportunity thanks to which it is possible to reduce number and gravity of musculoskeletal diseases (MSDs) which are related to work. During their implementing it is important to determine ergonomic team composition and their roles, assign responsibilities to individual team members, continuous group consultations among team members and support from all participant parties. As Schneider (2014) states, condition setting of ergonomic prevention program and its successful application is based on two criteria:

- decrease the number and malfunction gravity of musculoskeletal system,
- achieve reduction for an enterprise on acceptable terms.

If ergonomic prevention programs do not achieve both of these goals at the same time, their application will not be considered successful. Schneider (2014) set criteria based on interviews with hundreds of high-ranking managers and managerial personnel in companies which aim was to achieve the already mentioned criteria. Therefore, in order to achieve the already mentioned goals, employee health protection and economic benefits for a company, the necessary measures must be adopted. As Hatiar (2005) states, measures must be implemented in the form of studies. Consequences for employee health could be evaluated by methodologies of non-infectious disease epidemiology and company economic benefits through cost-benefit analysis (CBA).

#### **2.3.4. General procedure proposal of ergonomic prevention program implementation**

In order to implement ergonomic prevention program in a company, it is necessary to nominate and train ergonomic company team with a coordinator and also ergonomic working groups in each department. Brief implementation proposal of ergonomic program is available. Authors of this proposal, Cook, Sakál and Hatiar (2007) divided it into 3 phases:

- **First phase** – ergonomic prevention program initiation (create personal prerequisites, implement basic ergonomic trainings).
- **Second phase** – ergonomic prevention program start-up (workplace evaluation, employee examination, data processing, conclusion and recommendation preparation, specific procedure proposal, basic training implementation about workplace analysis results, working groups creation and thematic task proposal, precautionary measure efficiency and its evaluation).
- **Third phase** – ergonomic prevention program implementation (detailed ergonomic analysis, employee examination, data processing and analysis, training implementation, preparation of materials, thematic task proposal, precautionary measure annual assessment of efficiency).

If ergonomic prevention program is applied, it will result in operation effectiveness security, increase in quality of products, reduction of production costs and cost management for employee protection. Participative approach is closely linked to health security and care of employees when it comes to ergonomic problems. This is called Participative Ergonomics. Stakeholder involvement could result in profit through decrease in injury, morbidity, costs for employee treatment, fluctuation and increase in labour productivity, product quality increase and customer services.

### **2.3.5. Ergonomic prevention program in relation to valid Slovak legislation**

If enterprises wish to implement measures set out in Act No 124/2006 of the Slovak National Council, on the health and safety at work and change and amendment of certain acts, ergonomic prevention programs should be the first step. When it comes to their creation and application, regular risk analysis (risk assessment) is very important. Subsequently, it is familiarising of employees with risks (risk announcement) and precautionary measure implementation (risk management). (Oakman, 2014)

Opinions on questions regarding human and work may differ. As Hatiar (2005) mentions, on one hand, enterprises try to increase productivity at the expense of employee's health. On the other hand, experts and occupational health services put emphasis on security and employee health protection. However, if greater emphasis is put on economic and not on health aspects, pressure on health sector is increasing, as well as cost increase of insurance companies.

Questions related to a human and work may differ. As Hatiar (2005) mentions on one hand companies try to increase productivity at the expense of employee's health and on the other hand experts and occupational health services put emphasis on security and employee health protection. In case greater emphasis is put on economic aspects and not on health, there is an increase in pressure on health sector and cost increase of insurance companies. On the other hand, in case of greater emphasis on social and health aspects, higher pressure is put on the Ministry of Labour and Social Policy. Majority of prosperous companies in developed countries, mainly the US, have achieved their goals by implementing enterprise ergonomic programs. By their implementation there should be synthesis among questions related to employee health protection and economic questions. The most suitable option would be ergonomics as part of these programs focusing on health and safety. By implementing ergonomic programs, work quality and security increases which is one of the signs of a prosperous enterprise.

Basic conditions to ensure health and safety at work are set by law and legislation in Slovakia, regulating health and safety sector at work. Another important task is recording hazardous work in local county, region and the Slovak republic of the Ministry of Health Decree-Law No 448/2007 on details and labour factor of work environment in relation to work categorisation regarding health risks and details of

proposal to classify jobs to categories. It is necessary to monitor work conditions of employees, exposure rate, remedial measures application by an employer where employees carry out risky work. Also, preventive medical check-ups and their results and intervals should be constantly monitored due to employee's reintegration into workflow based on health service's medical fitness results. The Ministry of Health Decree-Law No 542/2007 applies to health protection from physical, mental and sensory strain with focus on a place of work revaluation, relevant value of physical strain, average working position, work organisation, regime, rest and revaluation of other factors contributing to diseases. This is done in order to eliminate occupational diseases from a long-term, excessive and one-sided burden and also to prevent spinal diseases related to work. (Preventive occupational medicine sector, 2014).

Moreover, Slovak versions of European standards from STN EN 1005-1 till 4 + A1 and STN EN 1005-5 play a significant role. These deal with device safety and human physical performance. Therefore, ergonomics and also ergonomic prevention programs are indirectly included in laws and regulations amending health and safety at work.

### **2.3.6. Importance of Ergonomics prevention program application**

Musculoskeletal disease (MSD) and injury system is considered to be a serious problem not only in Slovakia. It is actually musculoskeletal system diseases that belong to the group of the most frequently diagnosed occupational diseases and their presence could be found in all employment sectors (Giaccone, 2014). These diseases are long-term, and their cure and compensation are consuming.

MSDs origin is related to its method of production. Production in-Time (JIT) has been popular for a period. This production prefers product delivery directly to customers without ready product storing. This system is about work that is impulse and does not suit employee's abilities. Professional activity carried out by an employee is characterised by a long-term and repetitive move in a compulsory working pattern with excessive static burden. These types of burden could be a reason for musculoskeletal system injury of employees. The already mentioned MSDs difficulties cause reduction of work performance, total production and quality of products and services. Employees should be offered adequate treatment and their re-employment. That is why the purpose of ergonomics prevention program is prevention of diseases and musculoskeletal system injuries. By early identification of musculoskeletal system injury symptoms, effectiveness of disease prevention related to work, work performance and quality of work could be increased. Musculoskeletal system diseases are also called long-term, excessive, and unilateral diseases. These affect bones, joints, tendons, muscles, nerves, and vessels. They may occur during various work activities that are connected to long-term, excessive and unilateral burden of limbs with insufficient time to rest and recover. (Hatiarová, 2007)

2.3.7. Occupational diseases and statistics

Emergence of occupational diseases and other health injuries caused by worked performed is the important indicator of working condition level. Diseases of long-term, excessive and one-sided load are not only in Slovakia but one of the most notifiable occupational diseases around. National Centre for Health Information published statistics called Occupational Diseases or Occupational Disease Threat in the Slovak republic, 2016 (Tab. 2.1.) (Fig. 2.6.). Statistics shows evolution of occupational diseases from 2001 up to 2016. In total, Slovakia recorded 316 cases of occupational disease and professional poisoning (136 women and 180 men) in 2016. Compared to 2015, the number reduced by 12 cases which is 3,7%. However, this reduction is in my opinion influenced by many factors, such as employment reduction in some sectors, increase in number of self-employed people, fear of job loss, as well as occupational disease unawareness.

Tab. 2.1. Percentage share of newly-born occupational diseases during 2009 – 2016. (Statistical publication: Occupational diseases or occupational disease threat in the Slovak republic, 2016)

	2009	2010	2011	2012	2013	2014	2015	2016
Industrial production	50.9 %	52.6 %	48.7 %	51.2 %	50.5 %	53.9 %	45.7 %	52.5 %
Mining and quarrying	21.3 %	19.3 %	14.7 %	16.3 %	20.9 %	18.2 %	21.6 %	20.9 %
Hunting and Forestry	12.2 %	12.6 %	10.7 %	12.5 %	10.3 %	9.7 %	10.9 %	7.6 %
Health	6.1 %	6.2 %	10.1 %	6.1 %	4.7 %	6.17 %	8.5 %	7.9 %
Construction	2.9 %	2.3 %	4.8 %	5.5 %	6.6 %	5.36 %	6.7 %	5.7 %

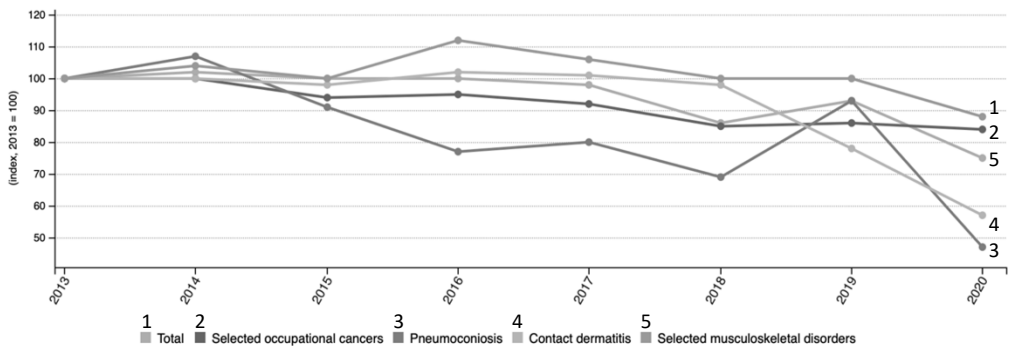


Fig. 2.6. Development of occupation diseases – total and groups, EU, 2013 – 2020 (Eurostat, online data code: hsw\_occ\_ina)

The most common occupational disease in 2016 was bone, joint, tendon and limb nerves due to long-term, excessive, and one-sided upper limb load. There were 173 cases in total, which is 54,7% out of all reported professional diseases (these were mainly diseases such as Carpal Tunnel Syndrome (CTS) and Rotator Cuff Syndrome). The highest incidence of occupational diseases and occupational disease threats of the total 68 was recorded in metallurgical engineering – coal and lignite mining (38) and mechanical engineering – metal production and processing (30). Occupational diseases were mainly recorded in the region of Košice (90) and Banská Bystrica (69).

**2.3.8. Participative ergonomics**

Participating or Participative Ergonomics is defined as a process of people's involvement into planning and managing of their own work activities with a possibility to influence processes and results in a way desired objectives could be achieved (Wilson, 1997). Participative ergonomics introduces so-called Hybrid of various organisational and managerial activities. It's ergonomic solution in a co-operation with employees. Employees of various professions and functional classification may collectively communicate with functional ergonomics teams about ergonomics solutions. Programs of participative ergonomics enable to eliminate musculoskeletal system problems. It is possible to achieve a balance between macro-ergonomic and micro-ergonomic problems mainly through participative ergonomics. Model of participative ergonomic process is shown below. (Fig. 2.7.)

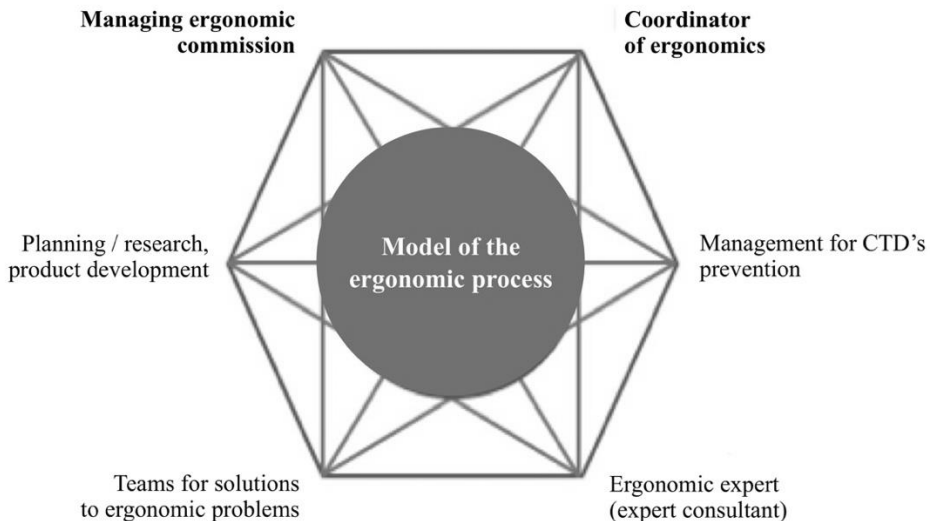


Fig. 2.7. Model of participative ergonomics process (Hatjar and colleagues, 2005)

In order to have a successful participative ergonomics program, it is necessary to provide the following partial goals (Eerd D., 2008):

- Team creation of participative ergonomics including employee, supervisor, manager and consultant representatives.
- Key element / obstacle determination for a program implementation of participative ergonomics.
- Involvement of the right people from workplace.
- Providing ergonomics training.
- Coordinator selection of participative ergonomics program who will lead and monitor the whole process.
- Definition of competence and team member responsibilities.
- Reassuring, decisions are made based on group consultation because every opinion matters in participative ergonomics.

In 2012, Institute for Work and Health in Toronto conducted a study based on which evidence was collected to prove the intervention of participative ergonomics has got a positive impact on musculoskeletal system and its problem elimination. 52 examined documents proved a positive impact of participative ergonomics. 33 documents were positive and result of the remaining 19 documents was not clear (Eerd, 2008). Most of the documents informed about the intervention of participative ergonomics in Canada, US, Netherlands, Sweden, Australia, Finland, Iran and Japan. 60% of the total participative ergonomics was in production sector. The main reason for participative ergonomics application was compensation fees, regular absence and problems regarding return to work in 50% of examined documents.

### **Participative ergonomics advantages**

It is possible to improve results in health sector and reduce the unemployment rate, injury costs and problems related to work. Moreover, to eliminate problems related to MSDs (Rivilis, 2008). We could consider it as strategy that could improve psychosocial factors and not only physical ones in workplace. Another benefit could be ([www.pshsa.ca](http://www.pshsa.ca)):

- Employee safety increase.
- Satisfaction improvement in workplace.
- Employee performance increase.
- Moral improvement in workplace and authority.
- Employee return process to work.
- Employee faster acceptance of remedial actions.
- Productivity increase.
- Increase in quality of work.
- Injury cost saving related to work.

It is important to point out that relation between an enterprise management and employees is supported through participative ergonomics.

**Participative ergonomics implementing obstacles**

Even though participative ergonomics has many advantages, there are also obstacles which can disrupt participative ergonomics implementation. These could include (www.pshsa.ca):

- Financial restrictions.
- Insufficient support from management.
- Time restrictions.
- Participant’s perception of extra work.
- Conflicts with work responsibilities.
- Lack of interest and employee’s participation.
- Resistance to proposed changes.
- Internal ineffective responsibility system.

**2.3.9. Ergonomics solution process in participative ergonomics**

Direct member representation of various organisation company levels is essential for development and implementation of successful participative intervention. Approach which is generally implemented is the one that is layered (St-Vincent, 2006), it includes upper layer (multidisciplinary management committee) and lower layer (so-called team for proposed changes) which should mutually cooperate.



Fig. 2.8. Layered approach of participative intervention (St-Vincent, 2006)

Multidisciplinary management committee is an intermediary between top management and a team for proposed changes. This team mainly consists of 4 to 8 people – employees from production and above-mentioned departments (Fig. 2.8.) which task is to identify and analyse ergonomic problems as well as propose solutions.



It is then ensured the employees are actively participating in process of ergonomic solutions. Moreover, the basic concept of participative ergonomics recognises the value of experiences employees and importance of teamwork. (Rivilis, 2008)

Ergonomic solution could be applied in two basic approaches (Hatiar, 2004):

- First approach could be labelled as expert. Its implementation is mainly used in new product and device development. It is possible to act proactively against risk factors which are related to long-term, excessive and unilateral burden. This could be done through precautionary measure implementation.
- Second approach is the participative ergonomic approach which is systematically implemented in companies within ergonomic programs. It is a process of working condition improvement through ergonomic rationalisation with the use of group problem solving method in cooperation with employees.

Ergonomic solution model could be compared to DMAIC cycle. (Fig. 2.9.) This cycle represents structured methodology primarily focused on problem solving with wide application. Letters represent 5 phases of improvement (Pande, 2002): D – Define (1<sup>st</sup> phase), M – Measure (2<sup>nd</sup> phase), A – Analyse (3<sup>rd</sup> phase), I – Improve (4<sup>th</sup> phase), C – Control (5<sup>th</sup> phase).

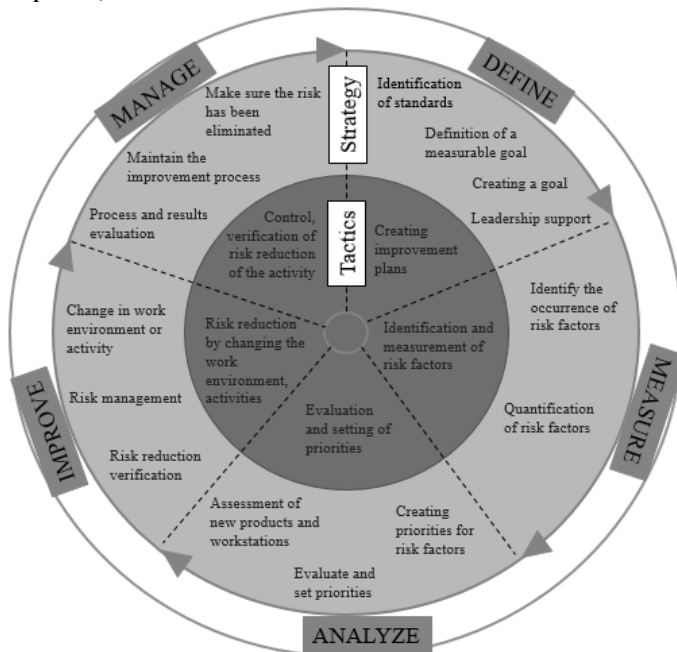


Fig. 2.9. DMAIC cycle principle in ergonomic process (worked out according to Lotz, 2014)

As Pande (2002) states, these phases show steps from problem determination through solution implementation which relate to basic causes and best solution proposal

up to realising that solution will be unchanged. Despite the fact DMAIC principle cycle is not a direct ergonomic method but a quality management method, it is possible to use this principle for ergonomics evaluation in a company. Furthermore, this principle could be used in planning, control implementation, impact evaluation which will lead to constant ergonomics improvement in an enterprise. DMAIC cycle is universal for all types of improvement as well as in ergonomics. It is essential to apply good teamwork and keep order. In case one point which seems to be fulfilled or even insignificant is skipped, effectiveness of already fulfilled steps could be decreased significantly. That is why it is necessary to check the series of steps.

### 2.3.10 Musculoskeletal problems

Musculoskeletal problems are health problems related to musculoskeletal system affecting nerves, tendons, muscles, ligaments and cartilage. These problems are mainly back problems, back injuries and upper limbs. Lower limbs could also be affected. Some of the examples of MSDs (Osborne, 2012) are:

- Carpal Tunnel Syndrome.
- Tendon inflammation (Tendinitis).
- Epicondyle inflammatory disease (Epicondylitis).
- Synovial membrane inflammation (Synovitis).
- Muscle Strain.
- Raynaud syndrome (Raynaud's Phenomenon).
- Rotator Cuff Injury.
- Shoulder Bursitis.
- Carpectomy – wrist bone removal.
- Trigger Finger.
- Lower back pain.
- Damaged elbow nerve (Nerves Cutaneous Femurs Laterals syndrome) and other.

Musculoskeletal problems related to work could have following consequences:

- Pain, anaesthesia and pins and needles in limbs.
- Lower productivity and quality of work.
- Temporary or permanent disablement.
- Inability to complete job tasks.
- Cost increase for health care compensation.
- Increased muscle fatigue.

These diseases are often linked with ergonomics and that is why they can be seen as problematic and ergonomics as a solution. If emphasis is not put on balance between employee and work, it can result in permanent health damage. Therefore, it is necessary to realise MSDs are not easily treat-ed in later phases and early signal reporting is essential. (Fig. 2.10.)

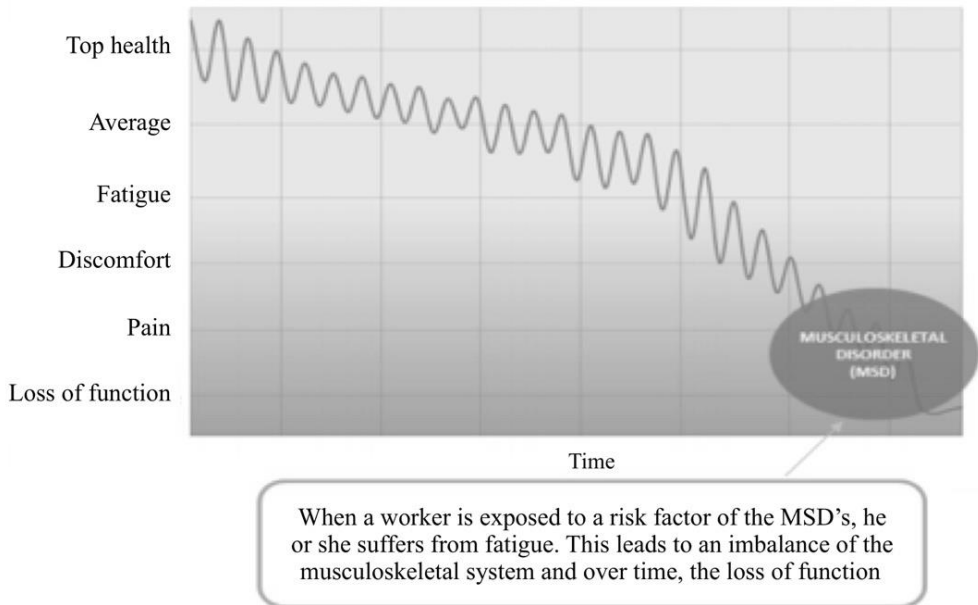


Fig. 2.10. MSDs manifestation phase (Osborne, 2012)

### 2.3.11. Causes related to musculoskeletal problems

If an employee is exposed to risk factors related to MSDs, he or she will feel tired. During this state, body does not have time to recover, and musculoskeletal imbalance occurs. Over time as tiredness of muscles persists together with imbalance, musculoskeletal problems occur. The already mentioned risk factors could be divided into 3 categories (Malchaire, 2004):

- **Physical factors** – use of muscle strength, frequent movements, artificial work locations, repetitive squeezing of certain work structures (e.g., hand use instead of hammer), high ratio of static work burden, vibrations, artificial microclimatic conditions. They are related to workplace arrangement and proposal of employment itself by used machines and instruments.
- **Organisation a psychosocial factor** – psychological work intensity, repetitive work, compulsory and fast pace of work, lack of own decision-making opportunity, inappropriate work organisation and time pressure. These factors are often underestimated in Slovakia, even though their cause for MSDs has been proven.
- **Individual factors** – age, sex, genetic factors, physical fitness etc.

Causal dependence between chosen work factors and emergence of MSDs has been analysed in detail by Bernard (1997) in his study. In his work, he included information from more than 600 studies and not one of these studies met criteria to answer the questions of causality. However, results of epidemiological studies may contribute to receiving evidence about causal link in a relationship between risk workplace factors

and MSDs emergence. Framework that was carried out by Bernard includes power of association, cohesion, timing, relation – exposure – reaction and evidence cohesion. Closer attention was paid to studies which used specific diagnostic criteria to identify health results focused mainly on upper limbs of a human body. Health results were based on clinical examination by standard methods.

Moreover, it is possible to divide evidence linked to relation between risk factors of a workplace an emergence of MSDs of epidemiology studies into several categories, which are indicated below. (Tab. 2.2.) (Bernard, 1997, Hatjar, 2012).

### **Strong evidence**

Strong evidence is considered when causal relationship between intensive or long-term exposition to a specific risk factor or MSDs problems when based on epidemiology causality criteria causal relationship shows between intensive or long-term exposition to specific risk factor or factor with MSDs difficulties as very probable. MSDs were monitored in several studies where likelihood, bias and confusing factors were excluded.

### **Evidence**

We can talk about evidence when some identical epidemiology evidence points at causal relationship between intensive or long-term exposition to specific risk factor or factor and MSDs difficulties. Positive relationship between exposition to a specific risk factor and MSDs difficulties in studies we monitored, where likelihood, bias and confusing factors are not probable explanation.

### **Insufficient evidence**

There is insufficient evidence when there are not accessible, low quality, poor consistent and statistically proved studies which would allow to come to a conclusion about presence or absence of causal links. Some studies show relationship to specific risk factors which could be explained by a chance of bias or confusing factors.

### **Non-action evidence**

Non-action evidence could be discussed when relevant studies show that specific risk factor (factors) are not related to rise of MSDs problems.

Workplace adjustment plays the key role in MSDs development. If an employee is obliged to carry out a task, he or she is unable to perform, the musculoskeletal system is then in danger. In such situations, objective workplace evaluation is necessary as the employee would not be otherwise able to overcome tiredness due to carried out work. The evaluation would confirm or disprove whether risk factors are present and whether there is a likelihood of movement imbalance and musculoskeletal problems. If work conditions and work itself combine the above-mentioned risk factors, the risk of problems related to musculoskeletal system emergence increases. Risk ration depends on how long the employee has been exposed to risk factors.

Tab. 2.2. Causal relationship evidence between chosen factors of physical work and MSDs. (Bernard, 1997; Hatjar, 2012)

<b>BODY PART</b> (syndrome) <i>Risk factor</i>	<b>Strong evidence</b>	<b>Evidence</b>	<b>Insufficient evidence</b>	<b>Non-impact evidence</b>
<b>Neck</b>				
Revision		x		
Strength		x		
Location	x			
Vibrations			x	
<b>Shoulder</b>				
Revision		x		
Strength			x	
Location		x		
Vibrations			x	
<b>Elbow</b>				
Revision			x	
Strength		x		
Location			x	
Factor combination	x			
<b>Wrist and hand</b>				
<b>Carpal tunnel syndrome</b>				
Revision		x		
Strength		x		
Location			x	
Vibration		x		
Factor combination	x			

Tab. 2.2. Causal relationship evidence between chosen factors of physical work and MSDs – continuation. (Bernard, 1997; Hattiar, 2012) - continuation.

BODY PART (syndrome) Risk factor	Strong evidence	Evidence	Insufficient evidence	Non-impact evidence
Wrist and hand				
Tendovaginitis				
Revision		x		
Strength		x		
Location		x		
Factor combination	x			
Wrist and hand vibration syndrome				
Vibration	x			
Back				
Lifting and power movements	x			
Inappropriate work positions		x		
Difficult physical work		x		
Whole body vibrations	x			
Static work positions			x	

### 2.3.12. Occurrence and prevention of MSDs

Musculoskeletal Disorders are of the most common diseases related to work. These diseases affect all employees working in all employment sectors. Employees with musculoskeletal system problems cost the company a lot of money and the following data can prove it (osha.europa.eu):

- 45% of European employees state they perform work in painful and exhausting locations.
- 33% of employees manipulate with heavy items at work.
- 30% of employees complain about back pain during their work (it is approximately 44 millions of European employees).
- 17% of employees have muscle pain in their hands and legs during work.

Health problems manifest themselves in a form of discomfort, mild pain up to more serious health problems which often require healthcare and even hospital treatment in some cases. In more serious cases it might lead to the inability to work and job loss. Prevention is the answer to this issue, in a form of ergonomics prevention program implementation. In order to prevent MSD, approach eliminating risk factors at workplace must be implemented.

The National Institute for Occupational Safety and Health (NIOSH) is an agency carrying out re-search an issues recommendations preventing employee's injury at work. NIOSH is a part of Centre for Disease Control and Prevention. It implements a significant part of research focused on musculoskeletal system diseases. Nowadays, agency addresses more than 80 projects focused on MSDs related to work ([www.cdc.gov](http://www.cdc.gov)).

**2.3.13. Successful projects focused on MSDs elimination**

Every process in a company starts with person's thinking. It is the same with ergonomics prevention programs. Examples of a few case studies are shown below. In these studies companies have achieved good results in the field of improving health conditions and reducing incapacity for work thanks to MSDs elimination. This has been achieved through ergonomic principle implementation which support creation and implementation of ergonomics prevention programs. This is a company in the USA specialising in lightning and components (Juno Lightning Group). Also, number of recorded injuries related to MSDs was reduced by 93%. In addition, number of days when employee was unable to work from 288 to 0 during 4 years. Thanks to this elimination of incapacity for work, overall costs reduced by 78% (Fig. 2.11.).

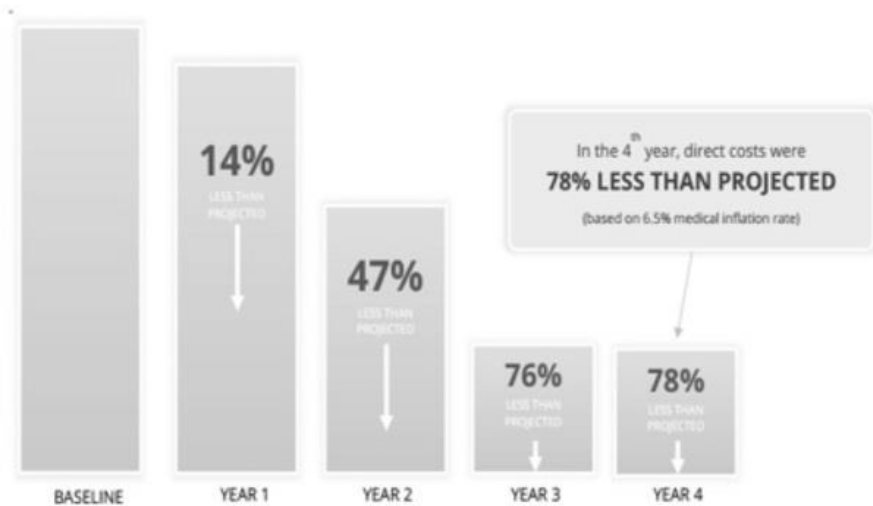


Fig. 2.11. MSDs reduction in Juno Lighting Group enterprise ([www.junolightinggroup.com](http://www.junolightinggroup.com))

American enterprise Texas Instruments is one of the biggest chip producers. These chips are placed in calculators, steering controls and sensors. Number of recorded injuries related to ergonomics was reduced by 89%. Also, costs for paying compensation to employees who were injured, and this injury was related to musculoskeletal system problems by 92% were reduced (Fig. 2.12.). (www.seshaonline.org)

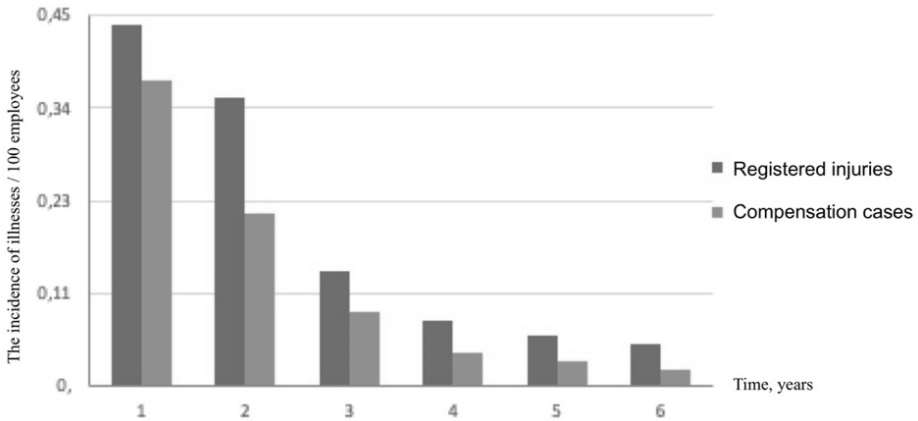


Fig. 2.12. MSDs reduction in Texas Instruments enterprise (www.seshaonline.org)

The Blue Cross & Blue Shield of Rhode Island enterprise providing services in health sector succeeded in reducing employee’s incapacity for work from 345 days/year to 104 days / year (reduction by 70%) thanks to a program eliminating MSDs problems. Also, they achieved to reduce costs for employee’s compensation by 89%, from 227,620 \$ / year to 26,010 \$ / year (mvspc.org).

**2.3.14. Risk assessment in the workplace**

Risk assessment in the workplace is an important step towards employee and company security, as well as abiding valid legislation. As Guangyan (2006) states, it is a process which is at the beginning of health and security management approach. The main task of this process is to focus on risks which are key in the workplace and could potentially cause health problems to an employee. In case, the mentioned process is not carried out as it should be or is not carried out at all, correct identification or adoption of preventive measures is unlikely. Moreover, in Handbook, Salvendy (2001) points out that during identification itself, it is necessary to raise awareness about possible risks in the workplace and understand assumptions which represent the evaluation base for potential consequences of these risks. These assumptions could be considered as combination of assumptions related to probability of presence and assumptions related to impact significance. (Fig. 2.13.)



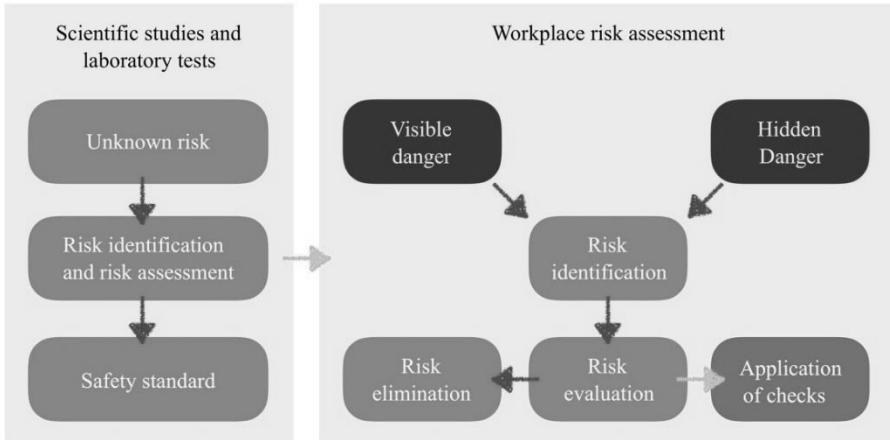


Fig. 2.13. Risk assessment in the workplace base on research study (3T Results, 2014)

There are not exactly defined law regulations at EU level, defining risk assessment. Also, there is no definition of how to eliminate all risks. However, despite this fact the employer must protect his or her employees, and when the enterprise decides to start risk assessment process, it is necessary to keep following principles (European Agency for Safety and Health at Work, 2013):

- Assessment to be carried out in a way all related dangers and risks will be solved (e.g., tasks such as cleaning which could be done outside of working hours, cannot be ignored, or also waste pressing.
- After risk identification, a question of risk removal possibility comes up.

Nowadays, thousands of people in the EU suffer from accident at work or serious health damage and this is the reason for risk assessment. Employees and other company staff have the right to be protected against health damage which could be caused by the inability to adopt adequate control measures. That is why it is necessary for all types of enterprises to regularly carry out risk assessment. The most important European regulation related to risk assessment in the workplace is the Framework Directive 89/391 on the introduction of measures to encourage improvements in the safety and health of workers at work. It contains general principles regarding prevention of health safety and security at work. Ergonomists claim that risk assessment in the workplace is an inseparable part of compulsory management to ensure safety and health protection at work. According to the above-mentioned Directive, employers are responsible for safety and health protection at work. This Directive belongs to national legal regulations of each country. Each member state could implement stricter measures for employee protection. The European Commission has produced a manual which should help all member states, employers, and employees during risk assessment according to the Framework Directive 89/391. It is called Risk Assessment Manual at work, published by the European Commission in 1996. This manual could also be found on the website of European Agency for Safety and Health at Work.

Risk assessment at work has been legal obligation 23 years in Europe and past 18 years in Slovakia. Even though it has been a long period of time, there are still many enterprises which do not fulfil their duties or they only do it formally. Based on Majer's practical experience from Slovak Association for Health and Safety at Work and Fire protection) there is an inability to adopt procedures of risk assessment. The main reason for this inability is a presentation of individual methods without preparation and implementation phase and also no knowledge of how to manage Health and Safety at work based on risk assessment principles. Majority of methods presents risk assessment as a four-level process consisting of the following steps (ww.hse.gov.uk, Majer, 2010):

- Danger and threat identification.
- Risk specification as function of probability and consequence.
- Risk acceptability assessment.
- Risk reduction measures proposal.

Reassessment efficiency of proposed solutions is missing in the mentioned process and also calculation of how risk will be reduced when implementing new measures.

### 2.3.15. Danger, threat and risk

As Lorko (2009) states it is necessary to realise what the difference is and also connection between danger, threat and risk. It is 3 sides of one subject. There is no threat without danger and no risk without threat. (Fig. 2.14.)

**Danger** is a source of threat. It is latent (concealed, hidden) object's characteristic, which causes unexpected negative phenomenon. It is activated by putting material, device or technology into service (Lorko, 2009) The example could be a device which is dangerous when negative phenomenon occurs during operation.

**Threat** is an active object's characteristics causing negative phenomenon, which has human or material character. It is a situation in which we cannot exclude there is no risk of employee's health. It could be claimed it is a threat in case a human or environment is exposed to danger (Lorko, 2009). Such example of a threat could be a device which will be put into service and its characteristics, which could cause danger, will not be considered.

**Risk** is quantitative and qualitative threat expression. In other words, it represents ratio or a threat degree. It is quite likely there will be a negative phenomenon (e.g., employee's health damage at work). What is also important to realise is what will follow (degree of possible health consequences). There two types of risks, acceptable or residual. Acceptable risk is the one where quantity and negative phenomenon consequences are within limits that could still be accepted. Residual risk is related to technical facilities which are not 100% safe, (Fig. 2.15.) (Lorko, 2009)

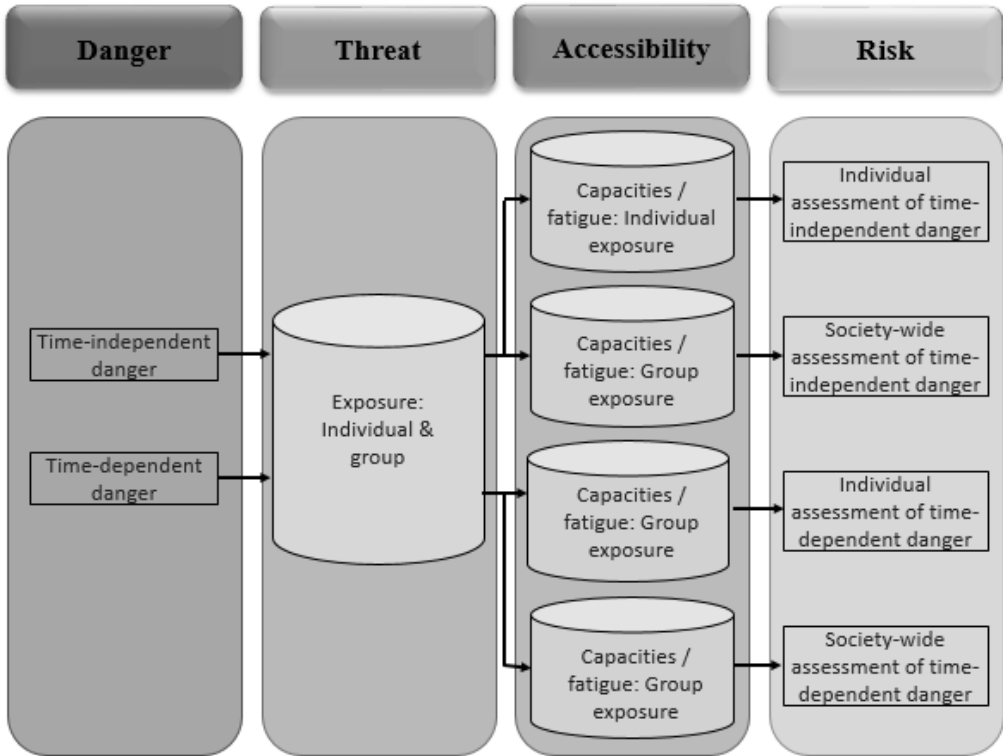


Fig. 2.14. Logical framework from danger to emergence of risk (European Facility for Earthquake Hazard & Risk, 2014)

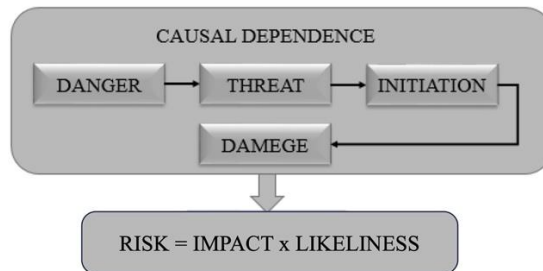


Fig. 2.15. Causal dependence of negative phenomenon (Pačaiová, 2003)

**2.3.16. Risk assessment meaning**

Employer’s responsibility is to provide health and safety at work in all aspects related to work. As the European Agency for Safety and Health at Work states, the main aim of risk assessment is to enable the employer to adopt necessary measures for health and safety at work. The mentioned measures are:

- Prevention from risks at work.
- Provision of sufficient information to employees.
- Provision of education to employees.
- Provision of means and organisation for implementing necessary measures.

The main aim of risk assessment should be risk elimination. This is usually not possible in real life and that is why existing risks should be restricted or at least controlled. As the European Agency for Safety and Health at Work states, risk assessment must be organised and carried out in a way it would be beneficial to an employer:

- Determine threats emerging at work, and after assess risks connected to these threats. The employer should know what measures would be suitable to adopt in order to secure health and safety at work, considering legislative requirements.
- Determine whether implemented measures are suitable.
- Determine priorities based on which next priorities would be carried out, if they were necessary.
- Show relevant authorities, employees, and their representatives that all factors related to work and risks have been considered and measures securing health and safety at work were proposed.
- Provide employee security through preventive measures and methods which are considered to be necessary, and which are implemented based on risk assessment.

### 2.3.17 Risk assessment in ergonomic prevention programs

As it has been already mentioned in previous chapters, the main aim of ergonomics prevention programs is reduction of musculoskeletal problem seriousness, with economically suitable conditions and acceptable costs for an enterprise. In order to provide efficiency of ergonomics prevention programs it is necessary to keep track of health risks regarding work security and epidemiological assessment of factors. These indicators could point out physical and mental difficulties which are a result of work. Epidemiological studies should quantify population's health damage presence. Following indicators could be used for this purpose (relative numbers) of health problem presence related to musculoskeletal system (Hatiar, 2004; www.cdc.gov):

- **Morbidity** expresses illness incidence or prevalence of population. It is a ratio of ill employees and monitored population (2.4). If we would like to get morbidity which is expressed in percentage, we multiply calculated ratio by 100. If we would like to get ratio for 1000 employees, we multiply by 1000.

$$\text{Morbidity} = \frac{\text{Number of ill employees in monitored group}}{\text{Number of all employees in monitored group}} * 100 \% \quad (2.4)$$

- **Prevalence (PR)** is one of the basic epidemiological morbidity parameters which shows certain illness presence of monitored population over a given period of time

(2.5). We can calculate as ratio of all registered people with illness against all people in registered group in a specific period of time. If we would like to gain prevalence expressed in percentage, we multiply calculated ratio by 100. This indicator is suitable for healthcare need estimation.

$$PR = \frac{\text{Number of ill employees in monitored group over a given period of time}}{\text{Number of all employees in monitored group over a given period of time}} * 100 \% \quad (2.5)$$

- **Incidence (I)** is an indicator of illness dynamics (2.6). It shows ratio of people in a monitored group who were initially healthy, and problems occurred in a monitored period. Incidence expressed in percentage is calculated if ratio is multiplied by 100.

$$I = \frac{\text{Number of new ill employees in a group over a given period of time}}{\text{Number of all employees in a monitored group over a given period of time}} * 100 \% \quad (2.6)$$

## 2.4. METHODOLOGY FOR CREATING AND IMPLEMENTING ERGONOMICS PREVENTION PROGRAMS

Based on the knowledge from first chapter, methodology for creating and implementing Ergonomics prevention programs has been created. Individual methodology steps are shown in a flow diagram. (Fig. 2.16.)

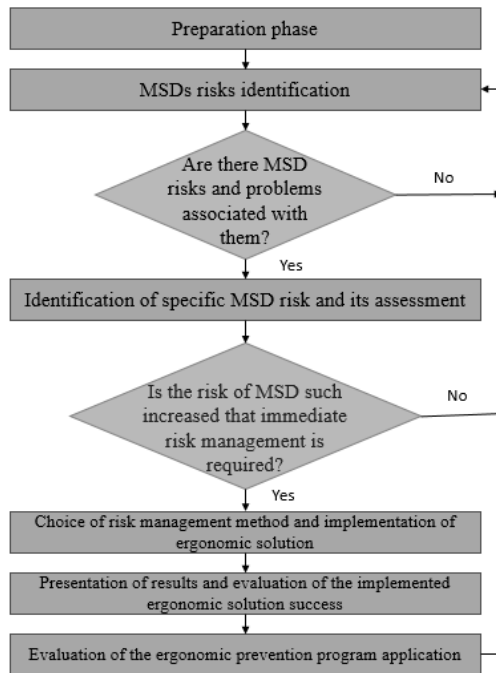


Fig. 2.16. Methodology steps for creating and implementing Ergonomics prevention programs [own elaboration]

**2.4.1. Preparation phase**

Ergonomics prevention program creation should not be separated from ongoing activities in a company. These activities are carried out in order to specify and eliminate danger in workplaces. Methods used to solve ergonomic problems use procedures which reveal risks causing injuries or illnesses related to musculoskeletal system. Fig. 2.17. shows basic steps of preparation phase creating the foundations for achieving ergonomics prevention program success. Prevention does not only alleviate health problems but it mainly improves company performance. This foundation building ensures the maximum recovery of made investments.



Fig. 2.17. Key steps of implementing Ergonomics prevention programs – Preparation phase [own elaboration]

**2.4.2. Management's expression of a commitment**

Management's commitment is the key and most important factor indicating whether risk elimination in workplace will be successful. It is important to realise that management's commitment is more than just help to implement ergonomics prevention programs. Moreover, management's commitment does not only mean support but mainly security including financial and non-financial provision of sources.

Management's commitment could be expressed in many ways. It is recommended to put emphasis on the following points (in case it is management's real commitment):

- Ergonomic effort should be promoted as one of the strategic company goals.
- Expected cooperation with all employees in order to create ergonomic improvements.
- Responsibility allocation to authorised people.
- Organisation's support, representing employee's interests.
- Specific goal setting, eliminating risk factors and prioritising those workplaces, which represent the highest risk to employees.

Resource provision for:

- Detailed training providing for those, who are expected to act responsibly when implementing ergonomics prevention program.
- Education providing for employees in order to identify ergonomics risk factors related to MSDs.
- External specialists and their consultation providing when necessary and until there is sufficient speciality of in-house employees.
- Implementation of proposed ergonomic improvements.

Furthermore, it is necessary to provide sufficient information to all parties and employees involved, who will be somehow affected by ergonomics prevention program creation and implementation. Misinformation or misunderstanding can negatively influence its implementation. If ergonomics prevention program implementation and management is seen as one of the ways of gaining new ideas in order to reduce costs or increase productivity not considering employee's needs, the program must be supported by employees. All the necessary information regarding injuries, production and costs must be available to those who will design and implement recommendations for solving existing problems.

### **2.4.3. Company ergonomic audit**

Objective assessment of ergonomic current state in a company could be implemented through company ergonomic audit. It should be implemented in regular intervals (each month if possible) and updated based on documents in which reports about problems related to MSDs, early interventions and proposed ergonomic improvements. It introduces a tool in a form of formula (Tab. 2.3.), which task is to investigate whether each proposed system element of ergonomics management does its job effectively. This system can be designed and supported through creation and implementation of proposed ergonomic prevention program focused on MSDs prevention. The already mentioned company ergonomic audit should guarantee all MSDs prevention procedures are recorded and real results could be obtained. It is important to implement ergonomic audit due to following reasons:

- Problem areas could be identified thanks to audit.

- It can specify ergonomic improvements.
- It refers to program value itself. It is possible to gain valuable data through this program value, which could demonstrate cost decrease, injury reduction related to MSDs, productivity increase etc.

The already mentioned ergonomic audit is mainly designed for general ergonomics and ergonomic risk assessment causing musculoskeletal system problems in a company. It can also be applied in various departments or particular workplaces. The formula consists of key elements:

- Management’s obligation.
- Employee involvement.
- Assessment, documentation and communication process.
- Work monitoring and assessment.
- Solution implementation.
- Training and education.
- Doctor’s assistance.

The key elements contain questions which answers are assessed in 0 – 3 range:

- 0 – not available.
- 1 – average, available sometimes.
- 2 – available, could improve.
- 3 – available, functions very well.

Tab. 2.3. Company ergonomic audit formula [own elaboration]

COMPANY ERGONOMIC AUDIT					
Key element	Points				
	Not available	Available in some cases	Available but could improve	Available, functions very well	Points in total
<b>Management’s commitment</b>					
Is there a long-term ergonomic strategy and vision?	0	1	2	3	
Is there an annual ergonomic plan with measurable goals, set sources and budget?	0	1	2	3	
Is matrix role of ergonomic team specified?	0	1	2	3	
Is there documented ergonomic process specifying objective, goal, requirements and duties?	0	1	2	3	
<i>Points obtained for management’s commitment</i>					



Employee involvement					
Are employees informed about ergonomic processes and do they know their responsibilities?	0	1	2	3	
Do employees know how to identify and report on time MSDs symptoms, and do they know importance of early reporting?	0	1	2	3	
Are there fast reactions to employee’s fears and subsequent recommendations?	0	1	2	3	
Can employees participate in identification and elimination of ergonomic risks causing MSDs difficulties?	0	1	2	3	
<i>Points obtained for employee’s involvement</i>					
Assessment process, documentation and communication					
Is there annual effectiveness assessment of ergonomic processes and their progress?	0	1	2	3	
Do ongoing ergonomic processes achieve results?	0	1	2	3	
Are ergonomic improvements documented and are all employees informed?	0	1	2	3	
Are best practices scale of company progress?	0	1	2	3	
<i>Points obtained for assessment process, documentation, and communication</i>					
Monitoring and analysis of risk work activities					
Are injury/illness reports used for ergonomic risk identification?	0	1	2	3	
Have ergonomic risks causing MSDs difficulties identified and priorities for solution set?	0	1	2	3	
Has detailed ergonomic assessment been implemented in all high and medium-risk workplaces?	0	1	2	3	
Are there same quantification tools and methods of ergonomic risk?	0	1	2	3	
<i>Points obtained for monitoring and analysis of risk work activities</i>					
Solution implementation					
Is there a plan for high-risk solution implementation?	0	1	2	3	
Has ergonomic solution efficiency been verified?	0	1	2	3	
Have solutions and experiences been applied in a company?	0	1	2	3	
Have ergonomic proposals and guidelines been applied?	0	1	2	3	
<i>Points obtained for solution implementation</i>					

Training and education					
Are employees trained in the field of Ergonomics?	0	1	2	3	
Are ergonomic trainings provided to certain groups of employees based on necessary skills and responsibilities?	0	1	2	3	
Are ergonomics questions and specific MSDs difficulties discussed during regular meetings related to health and employee security?	0	1	2	3	
Does a company have experts of the field of ergonomics who will apply ergonomic principles in all aspects of human performance?	0	1	2	3	
<i>Points obtained for training and education</i>					
Doctor’s assistance					
Are ergonomic risks assessed in workplaces where employees reported MSDs symptoms early?	0	1	2	3	
Are workplaces adjusted in a way they would be suitable to employees who have experienced MSDs difficulties or if an employee changes his workplace?	0	1	2	3	
Are employees experiencing MSDs difficulties regularly monitored in order to prevent further injury?	0	1	2	3	
Are physical demands analysed in all workplaces?	0	1	2	3	
<i>Points obtained for doctor’s assistance</i>					
TOTAL POINTS					

It is possible to gain maximum 84 points within company ergonomic audit.

0 – 31 points

Company does not have implemented system of ergonomic management. It is necessary for them to use technical assistance and experts’ advice from the field of ergonomics and MSDs difficulty prevention.

32 – 55 points

Company is in a system implementation initial phase of ergonomics management. Assistance and consultancy for key ergonomics element implementation might be required.

56 – 65 points

Company is in a system implementation advanced phase of ergonomics management (majority of key elements are implemented). Assistance and consultancy for key element implementation might be required.

66 – 79 points

Company has implemented system of ergonomics management. Adjustments and complementary activities within some key elements might be required.

80 points +

Company has implemented system of ergonomics management at very good level.

#### 2.4.4. Role allocation to ergonomics team members

Implementation and ergonomics prevention program extent will differ depending on a size of company. However, it is important to choose a person responsible for ergonomics program coordination. As a team member he or she adopts a role of ergonomics team coordinator, but one person cannot deal with all problems related to MSDs risks. That is why team approach should be applied when preparing ergonomics prevention program. Moreover, employees should be allowed to participate in a team member selection and these members will represent them when solving problems related to musculoskeletal system problems. Ergonomic team is responsible for achieving the common target eliminating risk factors causing MSDs problems. It is advised to fill the set of ergonomics team roles which is divided according to horizontal (functional) company organisation structure (Fig. 2.18.):

- **Top Management Representative** – coordination and team activity assessment, time and financial support.
- **Ergonomics Team Coordinator** – ergonomics prevention program creation and implementation.
- **Health and Safety at Work Staff** – safety measures at workplace (proposals and implementation).
- **Purchasing Representative** – machine and facility purchase in compliance with ergonomics requirements and economic company intentions.
- **Human Resources Representative** – organisation measures proposals and implementation.
- **Department of Engineering** – compliance with principles and activity coordination.
- **Healthcare Providers** – medical measure proposals and implementation.
- **Ergonomics Adviser** – assessing efficiency of precautionary measures.
- **Data Processing Coordinator** – data processing and assessing efficiency of precautionary measures.
- **Supervisors** – proposals and implementation of measures in operations and employee initiation to work condition improvement and thematic task solving focused on ergonomic measure implementation.
- **Employee Representative** – collaboration when identifying risk factors and proposing measures for improvement.

Representation of ergonomics team individual members depends on a company size. One person can have more than one responsibility. For example, a supervisor can be responsible for purchase and Health and Safety at Work staff can be responsible for selection of ergonomically appropriate machines and facilities. In majority of companies, subgroups are created in ergonomic teams, within particular departments, assembly lines and workplaces. For effective ergonomics prevention program implementation, all ergonomic team members should share their experiences and recommendations from their field.

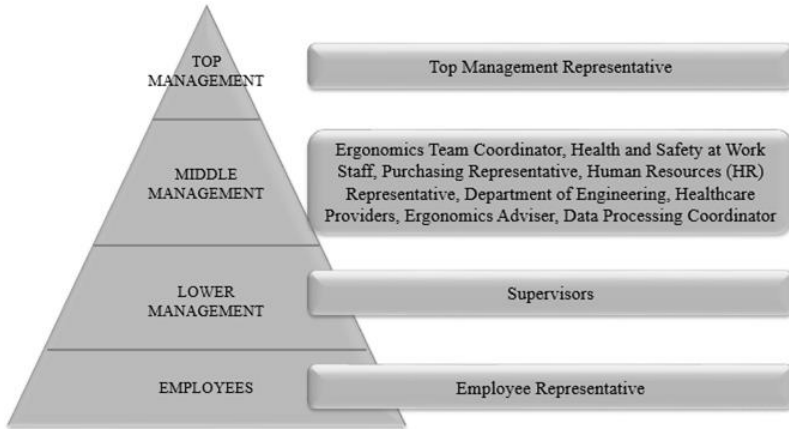


Fig. 2.18. Ergonomics team role according to functional organisation structure [own elaboration]

After consultation with the management, ergonomic team coordinator is responsible for assigning specific tasks, allocating responsibility and authority to ergonomic team members. This also includes authorisation matrix drafting of particular ergonomics prevention program roles. Authorisation matrix template of certain chosen roles with their authorisation could be found in Tab. 2.4.

Tab 2.4. Example of ergonomic team member responsibility matrix [own elaboration]

<b>Ergonomic prevention team role matrix</b>	<b>Coordinator</b>	<b>Managers</b>	<b>Supervisors</b>	<b>Employees</b>
Z – responsibility S – cooperation				
Provide training for responsible people who will participate in workplace assessment	Z	S		
Ensure partial tasks will be completed on time	Z		S	
Provide early reporting of problems and suspicions related to MSDs	Z		S	S
Ensure reports about problems regarding MSDs will be regularly updated	Z		S	
Health and all employee safety responsibility through active support of ergonomic prevention program	S	Z	S	
Allocation of human and financial resources		Z		
Provide trainings which will provide familiarization with ergonomic prevention program elements	Z	S		

Tab 2.4. Example of ergonomic team member responsibility matrix – continuation [own elaboration]

<b>Ergonomic prevention team role matrix</b> Z – responsibility S – cooperation	Coordinator	Managers	Supervisors	Employees
Ensure all employees undergo training	S		Z	S
Ensure recommended inspections are carried out	Z	S	S	
Check and assess training’s participation			S	Z
Ensure employees recognize MSDs symptoms and report them on time			Z	S
Provide quick reaction to reports from employees	Z	S	S	
Provide clear and continuous communication between management and employees	Z	S		S
Use aids, tools and facilities which are in compliance with ergonomic requirements	S		S	Z
Ensure machines and facilities are kept in a good technical condition, in case an error occurs, it is necessary to report it immediately			Z	S
Provide feedback to supervisors, relating to effectiveness of proposed and implemented changes (new machines and facilities) and other interventions			S	Z
Take responsibility considering your own health and safety	S		S	Z

**2.4.5. Process of improvement proposal and supporting activities focused on MSDs prevention**

In order to identify and effectively check MSDs risks, it is necessary to set processes focusing on improvement and risk removal and activities that focus on management of these risks. I introduce some of the activities which should be included in the process of improvement and implementation of ergonomic prevention program:

- Creating MSDs prevention plan which will contain set targets, used methods and expected activities for implementing MSDs prevention at workplace.
- Providing information to employees about MSDs risk identification and check.
- Responsibility and task allocation to all interested parties.
- Looking for MSDs risks during regular inspections at workplace.
- Risk identification when analysing work activities.

- Reassessing reports from employees about possible problems regarding MSDs.
- Risk assessment process of MSDs.
- Assessment and reporting to people responsible for ergonomic prevention program implementing.

#### **2.4.6. Providing employee participation in MSDs prevention process**

Employees who carry out particular work activity and know how their workplace is designed, use machines, facilities and tools can provide relevant information related to MSDs risks. They know when they are experiencing MSDs problems or discomfort and they often know the cause. Moreover, they have very good practical idea show to eliminate exposure to MSDs risks. Therefore, it is necessary to ensure active tasks will be accepted in the prevention process and that is through:

- Their experience and knowledge they could assess MSDs risks and have proposed effective solutions in order to secure their management and inspection.
- Trainings which will help them recognise musculoskeletal system symptoms and risks related to work performed.
- Providing instructions related to implemented solutions and proposed inspections with the aim to eliminate MSDs risks.
- Participation in planning and implementing any changes related to work activity.
- Encouraging employees to report experiencing MSDs problems.

#### **2.4.7. Promotion of timely reports and submission proposals for a solution**

In order for a promotion of timely reports to be guaranteed possible MSDs risks reports:

- Company management should promote and develop process of reporting experienced difficulties from employees, which might lead to musculoskeletal problems.
- All supervisors in a company should encourage employees to report MSDs symptoms on time.
- Management should accept these reports positively and adopt measures to eliminate pain and discomfort or even prevent further worsening.

Managers and supervisors should encourage employees to find a way how to reduce MSDs risks and submit proposals to improve workplace during planning or work organisation. These ideas might lead to MSDs risk elimination and improve productivity. In order for this to work, it is necessary to encourage and develop employees who have submitted improvement proposal.

Ergonomic prevention program will have a higher chance to succeed if there is a culture supporting open discussion relating to risks and communication about prevention to all employees. Such communication also expresses commitment to management's commitment and informing employees about steps that should eliminate risks at workplace.

### 2.4.8. Plan for providing training on MSDs prevention

Every employee in the workplace should receive training on the prevention of MSDs. This is to help all employees, supervisors and managers understand and perform their assigned tasks effectively. The mentioned trainings should be implemented at individual levels (Fig. 2.19.).



Fig. 2.19. Training levels for MSDs prevention [own elaboration]

Trainings to prevent MSDs for top management should be implemented through ergonomic team meetings where questions about ergonomics prevention program and proposal for its implementation would be discussed. Trainings related to MSDs prevention for employees in production should include:

- Introduction and general information about ergonomic program.
- Musculoskeletal problems and their symptoms.
- Reporting procedures about symptoms at workplace.
- Information regarding competent person employees could report risks.
- Proposals for possible adjustments and new procedures which could be useful for employees in order to eliminate MSDs risks.

Trainings regarding MSDs prevention for ergonomic team members, employees responsible, health and safety at work, supervisors. They should include the information mentioned above for employees working in production and following additional information:

- How to recognise potential MSDs risks during workplace inspection and correctly use ergonomic tools and analyses for their identification?
- How to react in case employees report problems, pain or discomfort that might lead to musculoskeletal problems?
- How to eliminate, check or even completely remove MSDs risks at workplace?

### 2.4.9. MSDs prevention plan

Selection process and MSDs check implementation is mainly implemented to manage already existing risks. However, it is important to prevent potential risks before creating workplace itself, implementing new work process or before buying new machines and facilities. MSDs risks might of-ten be removed already in a planning phase, design, purchase or installation phase. In most cases, cheaper and less time-consuming remedial measures are proposed.

#### Planning phase

If process or Product Board wants to implement a new project in a company, it is already possible to eliminate potential MSDS risks in that phase. Therefore, it is advised to discuss how proposed new product, machine or tool is related to an employee and how much these can influence problems related to musculoskeletal system.

#### Proposal phase

Everyone who is involved in new design creation should have knowledge about potential MSDs risks and find a way how to eliminate them in initial phases. This is possible if we take into account the following:

- Way new employee will use the new proposal and will work with it.
- Proposal's functionality.

Steps which must be included in the proposal phase:

- Everyone involved in the new proposal must undergo a training related to MSDs risks and problem solving.
- Develop own procedures and standards focusing on MSDs risk elimination.
- Provide cooperation with producers and suppliers so that both sides are informed in case of new technology proposal change and alternative materials that could have caused the emergence of MSDs risks.

#### Purchase phase

Majority of workplace equipment is bought from suppliers as a ready product. Therefore, it cannot be adjusted anymore. Before purchasing the product, it is advised to implement the process of „inspection“ and assess potential MSDs risks. This process will be more effective if staff will be trained in order to assess potential MSDs risks. It is recommended to set standards for frequently purchased goods, considering MSDs factors.

Additional steps to be considered:

- Support buyers to accept decisions eliminating risks for employees, even though they can be a bit more expensive.



- If there a plan to buy more new items, there should be a test before their purchase, assessing its use and showing whether employees will be exposed to risks during this item’s usage.

**Installation phase**

In case installation has been done properly, for example, purchased item was not placed correctly, it may lead to unsuitable employee’s position at work. Employees providing installation should have information available regarding MSDs risk prevention. Regular inspections during installation should guarantee the purchased item will be installed in a way that eliminates exposition of any kind of danger.

**2.4.10. MSDs risk recognition**

MSDs risk recognition as well related problems should be done based on reactive and/or proactive approach (Fig. 2.20.). Ideally, it should only be based on proactive approach. In most cases, company usually starts with the effort to prevent MSDs by mainly focusing on workplaces that experienced musculoskeletal problems in the past. If there are not real records of risk occurrence at particular workplaces, concerns and discomforts of employees, possible risks should be regularly checked at workplaces.

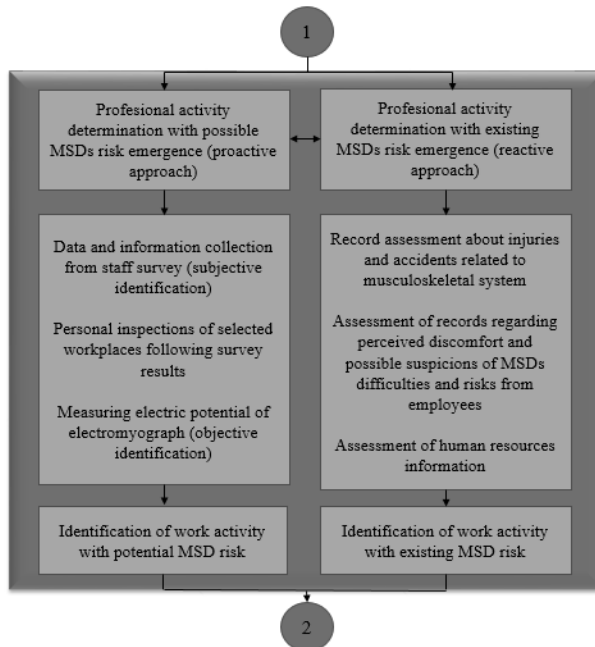


Fig. 2.20. Key steps of implementing Ergonomics prevention programs – current state analysis and MSDs risk recognition [own elaboration]

Even though it may seem as unproductive activity, with proactive approach or in other words early identification and risk management it is possible to prevent problems related to musculoskeletal problems and also avoid costs such as administration, health check, paid overtime and other charges. Together with reactive approach application, records and statistics about injuries related to musculoskeletal system should be looked into. This examination will help identify work activities where MSD risk already exists. (Fig. 2.20.)

**2.4.11. Professional activity determination with possible MSDs risk emergence (proactive approach)**

Everyone at workplace should be trained in order to recognise risks and in order for workplaces with MSDs risk occurrence to be more effective. This will ensure that every employee will look for ways how to perform work more effectively or propose changes to eliminate risks of musculoskeletal system.

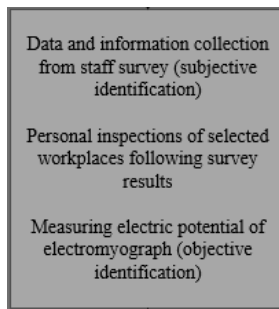


Fig. 2.21. Ways to recognise MSDs risks based on proactive approach [own elaboration]

Fig. 2.21. shows proposed changes which could be used to recognise work activity where there is a probability of MSDs risk emergence.

**Data and information collection from staff survey (subjective identification)**

It is important to realise that true experts who can identify ergonomic risk factors and also opportunities for improvement are employees themselves, performing work every day. They have true work experience. Staff surveys are very effective in getting overview about ergonomic risks at workplace. That is why employees should be information key source about requests, work hardship and potential MSDs risks at workplace. It is also recommended to regularly follow potential employee concerns and their objections to work demands, used machines and facilities or workplace arrangement itself. This information can be recorded.

When changing work conditions.

- During meetings.
- Via proposals for improving box from employees.

- Via direct messages from supervisors, ergonomic team members and Health and Safety at Work employees.
- Or via formulas regarding work requirements, musculoskeletal problems, discomfort or concerns related to health and carried out work with used aids.

One of the ways to gain data for current state analysis is to use various types of formulas. These should include the following requirements:

- Logical structure harmonised with data and database character.
- Necessary material provision for ergonomic analysis.
- Possibility of easy search.
- Clarity (maximum equivalent extent of both-sided printed page, A4 format).
- Simple and clear questions.
- Clear answer alternatives.

### **Personal inspections of selected workplaces following survey results**

Results from collected and evaluated data from formulas are used as primary information for next step implementation, which is personal workplace inspection. It is possible to focus on particular risk workplaces or groups of employees which could be considered risky based on formula evaluation. During personal inspection, it is necessary to set priorities of problem solving based on intensity and severity of musculoskeletal problems. It is recommended to conduct targeted dialogues with employees, provide them with information and process a video documentation which could be used during training when implementing ergonomics prevention program. Employees should also participate in risk factor inspection and participation in problem areas in risk management and Health and Safety at Work. Also, it is necessary to inform company management about MSDs symptom analysis results and applied physical effort at selected workplaces. Analyses should be carried out via mentioned formulas and after it is important to bring next approach of creation and ergonomic prevention program implementation in a company.

### **Measuring electric potential of electromyograph (objective identification)**

For objective identification of potential MSDs risks it is possible to use electromyograph (EMG). It is a device thanks to which group of muscle fibre activities are measured, activity of individual neural pathway is checked and excitement speed in nervous system is also measured (Keller, 1999). This is scanned by electrodes transferred into a process, processed and registered on a screen in a form of EMG curve. Electromyograph is usually with 2 or 3-channel EMG scan head and the maximum number of channels could be 6. Properties of each scan head's channel is given by character requirement of scanned signal, properties of used scanned electrodes a way of scanning.

### 2.4.12. Professional activity determination with existing MSDs risks (reactive approach)

Fig. 2.22. shows recommended activities based on which it is possible to set work activities where MSDs risks already exist. It is also possible to implement all recommended activities to recognise existing risky work activities at the same time or at least some of them.

#### **Record assessment about injuries and accidents related to musculoskeletal system**

Workplace analysis should start with company record examination based on which type and character of already existing injuries which could still represent danger for musculoskeletal system can be identified. Examination of these records is recommended at least once a year and also in cases, if:

- There have been changes in a product line.
- Workplace has changed its place.
- Configuration has been changed (settings) at workplace.
- Company has bought new machines and facilities for the workplace.
- Work procedures and methods have changed.

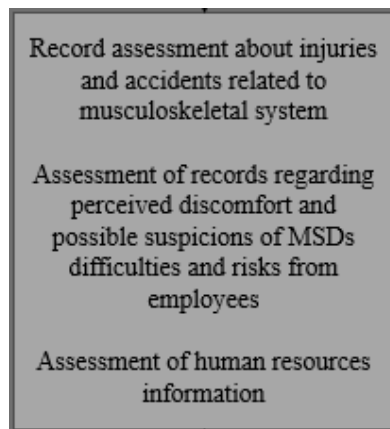


Fig. 2.22. Way of distinguishing MSD risks based on reactive approach [own elaboration]

Record examination is advised before and also after the implementation of the above-mentioned cases due to better imagination of whether these changes have caused health problems or not. Also, this step helps to maintain ergonomic prevention program and is one of the ways that evaluates its success after the implementation. However, requirements and needs of a company should be considered when selecting the type of record. All ergonomic team members and participants should be aware that some of these records contain confidential information. Therefore, it is necessary to provide personal data protection as outlined in the law of National Council of the Slovak republic no. 428 from 2002, amount 167. Some types of records are mentioned below.

These are mainly used to specify a problem related to MSD at work.

- OSHA 300 Log (form for work injury record and occupational diseases).
- Records about debt compensation to employees.
- Records from first aid premises.
- Emergency situations and accidents records.
- Reports from meetings related to Health and Safety at Work.
- Hygienic evaluation reports, so-called workplace audit.
- Work activities description.
- Instrument condition evaluation, machines and equipment.
- Remarks, potential employees' complaints.

#### **2.4.13. Risk factor determination by using check lists**

Check lists are used for ergonomic risk factor evaluation including artificial positions, repeating movements, pressure and hand, repetitive collisions, lifts and vibrations. Check list is used as a screening tool to determine work activities with possibility of MSDs risks when applying proactive or even reactive approach. If no work act is identified as risky or there is no danger of employee getting hurt, work is considered to be safe and no box is ticked. However, on the other hand, positive findings in a check list indicate steps to prevent or eliminate risk should be taken soon (or in case of danger).

#### **2.4.14. Risky professional activity determination for other activities**

Data and information collected according to previous steps could help select a specific workplace for further steps such as detailed risk analysis, its management and check. Therefore, it is important to select priorities based on which order of workplaces will be chosen in order to implement further steps. One of the priorities could be MSD risk presence itself and its confirmation, reports about employees' worries and uncomfortable feeling, ergonomic team member reports, overtime reports, absence, work dissatisfaction, poor quality or decreased productivity. There a proposed a described tool in the following part. This tool could be used to set priorities at workplace where problems related to musculoskeletal system exist and could be demonstrated – reactive approach (Tab. 2.5.), but also for workplaces with the probability of MSDs problem occurrence – proactive approach (Tab. 2.6.). There are two tables stated thanks to which priorities after considering some factors could be set.

Tab. 2.5. Priority determination for workplaces, with MSDs risk occurrence – reactive evaluation [own elaboration]

Reports about existing MSDs occurrence <sup>1</sup>		Report of perceived discomfort or concern about MSDs		Possible risks defined by the control record		Recommended priority
yes	no	yes	no	yes	no	
x		x		x		Very high <sup>2</sup>
x			x	x		
x		x			x	High <sup>3</sup>
x			x		x	

<sup>1</sup> Reports about existing MSDs occurrence causing employee's incapacity for work or production delay.

<sup>2</sup> If more workplaces are selected with a very high priority recommending immediate implementation of other activities, it is important to focus on those workplaces, which have reported discomfort or musculoskeletal system problems.

<sup>3</sup> If more workplaces with high recommended priority are selected it is again necessary to proceed in the same way as in the previous case and focus on those which have reported discomfort or musculoskeletal system problems.

Tab. 2.6. Priority setting for workplaces, where reports about MSDs do not exist – proactive evaluation [own elaboration]

Reports about existing MSDs occurrence <sup>1</sup>		Report of perceived discomfort or concern about MSDs		Possible risks defined by the control record		Recommended priority
yes	no	yes	no	yes	no	
	x	x		x		Medium
	x		x	x		Low <sup>4</sup>
	x	x			x	No further action is required to continue monitoring
	x		x		x	

<sup>4</sup> If more workplaces with a low priority are selected, during next monitoring, it is necessary to focus on those professional activities which have reported discomfort/MSD problems. Check list is an ordinary list identifying risks related to professional activity that is carried out and very often it is mainly reports from employees that might reveal this risk.

Recommended priority:

- Very high – find out and examine MSDs risks, propose a way of checking and implement remedial measures.
- **High** – find out and examine MSDs risk, propose way of checking and implement remedial measures after workplaces with a very high priority will be sorted out.
- **Medium** – decrease probability of MSDs risk spreading in the future after workplaces with a high priority will be sorted out.
- **Low** – decrease probability of MSDs risk spreading in the future after workplaces with medium priority will be sorted out.

**2.4.15. MSD risk identification and its evaluation**

In order to identify MSD risk of a particular professional activity, it is necessary to have a clear idea about elements of a workplace, professional activity and factors possibly supporting negative impact of risk factors. MSD risk identification process itself and its evaluation (Fig. 2.23.) might help to identify the source problem related to the emergence of musculoskeletal system problem and therefore solve the main cause of this problem. Thanks to this process it is possible to:

- Prevent similar types of problems in the future by implementing standards.
- Ensure the proposed solution will not create new and unexpected problems in the future.



Fig. 2.23. Key steps of implementing Ergonomics prevention programs – implementing MSD risk evaluation [own elaboration]

Removing risks causing musculoskeletal system problems does not need to be time and money consuming. Many causes usually occur during identification of a problem itself. If it is possible to identify a root problem and all interested parties agree on this, it is not necessary to carry out a detailed evaluation. However, if it is not possible to identify root cause exactly, detailed evaluation is then necessary. Therefore, there might be 2 evaluation approaches: approach based on a simple MSD risk evaluation and second approach based on a detailed quantitative risk evaluation. (Fig. 2.24.)

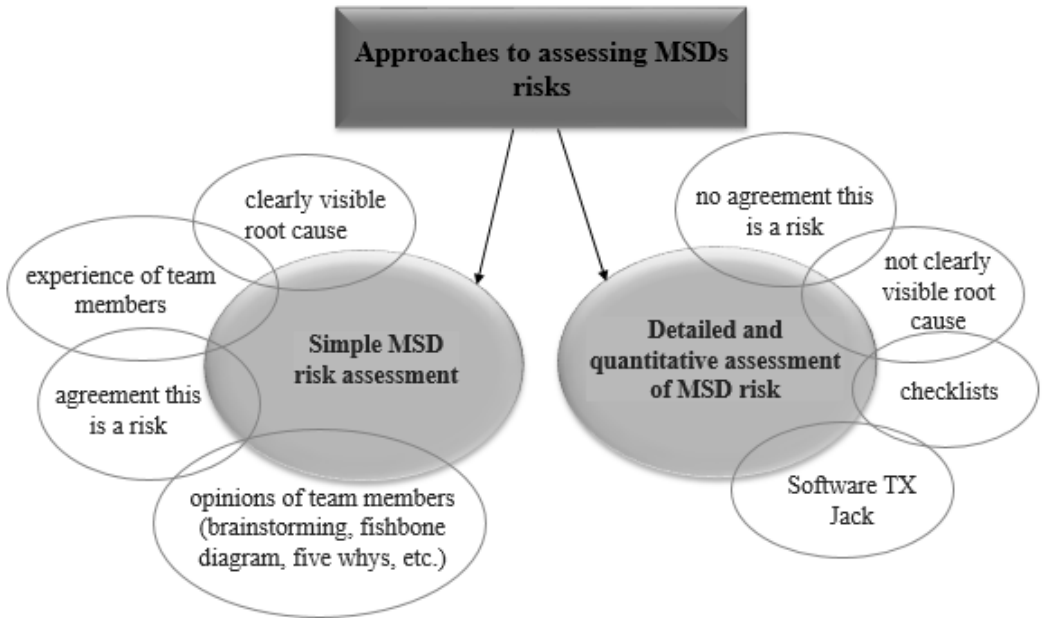


Fig. 2.24. Effective use of possible MSD risk evaluation approaches [own elaboration]

**2.4.16. MSD risk management way and implementation of proposed ergonomic solution**

After MSD risk identification and evaluation which already exists and causes musculoskeletal system problems or a potential risk which might cause musculoskeletal problems in the near future, selection phase of managing risk identification and proposed solution implementation follows. Early risk management and its immediate check can partially or completely eliminate possible employee's exposure to risk factors. Effective risk management does not always have to be complicated and expensive. Simple change in a work process, organisation or change in tool could be effective. If more complex solution (time and money consuming) is needed, it is possible to implement it in stages, in a way, smaller changes will be implemented step by step. Risk management selection and proposed solution implementation is shown in the fig. 2.25.





Fig. 2.25. Key steps of implementing Ergonomics prevention programs – MSD risk management selection and a proposed solution implementation [own elaboration]

#### **2.4.17. Result communication and a success evaluation of implemented ergonomic solution**

Result communication and success evaluation of implemented ergonomic solution is in its subjective but mainly objective evaluation. This is possible to implement after the proposed and implemented solution has been running for a certain time and after processes have been stabilised. In creation methodology and ergonomic prevention program implementation evaluation by both ways is proposed. Their detailed description could be found in the following sub-chapters.

#### **2.4.18. Subjective evaluation of implemented ergonomic improvements**

After implementation of ergonomic improvements in a company, it is advised to get feedback from employees, in order to find out whether further adjustments are necessary. It is possible to use a short and simple survey which would reveal employees' opinions, working in the workplace where ergonomic improvement was implemented.

Thanks to the scale below, it is possible to calculate the level of physical effort before and after ergonomic changes (Fig. 2.26.). Scale uses range from 1 – 5, where:

- 1 – represents minimum physical effort.
- 2 – represents low level of physical effort.
- 3 – represents medium level of physical effort.
- 4 – represents high level of physical effort.
- 5 – represents very high level of physical effort (bordering on physical possibilities).

Furthermore, it is also possible to assess the physical effort level before and after ergonomic improvement.

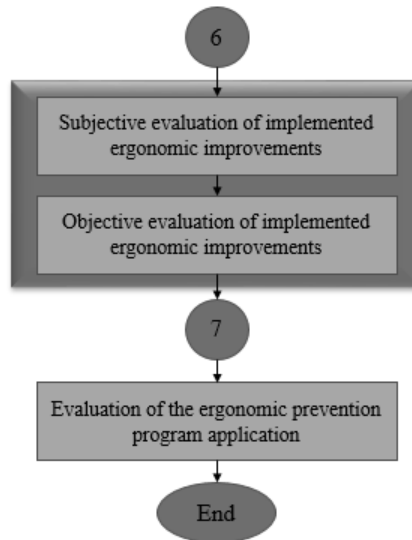


Fig. 2.26. Key steps of implementing Ergonomics prevention programs – result communication and success evaluation of implemented ergonomic solution [own elaboration]

**2.4.19. Objective evaluation of implemented ergonomic solution**

If we want to ensure ergonomic prevention program is implemented successfully, we must implement inspection and result measurement in the improvement process. Apart from gaining subjective information from employees, it is also necessary to perform a continuous objective ergonomic evaluation through which risk factor decrease or elimination should be demonstrated. Also, it is possible to perform it based on the original ergonomic evaluation. By using same evaluation tools and methods which have been used, it is necessary to repeat work act evaluation which has been previously specified as critical or risky. This will allow for objective comparison and enable to quantify reduction of MSD risk.

#### 2.4.20. Prevention ergonomic program evaluation and its implementation

After a complete implementation of all previous steps, final creation and ergonomic prevention program implementation phase follows and that is evaluation of its implementation. All information collected during creation process and ergonomic prevention program implementation, which aims to reduce or eliminate the level of risk exposition causing musculoskeletal problems, is key to a non-stop improvement of ergonomics in a company. By implementing all proposed steps of ergonomic prevention program is important due to following reasons:

- **Non-stop improvement** – it is possible to use data collected during the non-stop ergonomic improvement process realised through ergonomic prevention program implementation. Thanks to these, it will be easier to understand where risk factors occur, which might be the reason of musculoskeletal problems and they can also set priorities for the following months.
- **Value demonstration** – real measurement results enable to show ergonomic prevention program value, number of injuries reduction, elimination of injury gravity, cost reduction related to incapacity for work and other factors. It is possible to gain more support from management and other employees, through particular numbers.

Monthly statement and yearly audit of whole ergonomic improvement process in a company implemented via ergonomic prevention program could be used for the evaluation of preventive ergonomic program implementation and its current state. Monthly statement is a report, related to progress achieved during the last month. It should include information regarding:

- **Early intervention:** monitor total number of new reports suspecting problems related to MSDs.
- **Education:** monitor number of formal meetings, related to education and trainings from the field of ergonomics in the past month.
- **Ergonomic improvements:** monitor number of recorded ergonomic opportunities and implemented ergonomic improvements.

Annual audit aims to examine results of implemented ergonomic program in a previous year. Its task is to check whether each proposed key element of ergonomic prevention program fulfils its task effectively. Seven elements stated below should be checked:

- **Management's commitment when creating and implementing ergonomic prevention program:** there should be a long-term vision in a company, related to ergonomics. Also, there should be an annual ergonomic plan with measurable targets, sources and draft budget, responsibility role and duty matrix of individual ergonomic team members.
- **Employees' involvement:** employees should be informed about implemented ergonomic processes and they should also know what they carry responsibility for.

They should know how to identify and early report musculoskeletal symptoms. Moreover, their participation in identification and risk elimination causing MSD problems should be monitored.

- **Evaluation:** ergonomic prevention program effectiveness and planned target and result achievement should be evaluated annually. Proposed and implemented ergonomic improvement should be documented and all employees should be informed about them.
- **Analysis of risky professional activities:** ergonomic risks should be identified based on study of accessible injury/illness reports and also from implemented surveys among employees. Same tools and methods for ergonomic risk quantification should be used in a company.
- **Implementation of solutions:** There should be a plan of solution implementing in a company: implemented solutions should be checked and applied as possible in the whole company.
- **Education:** trainings should be provided to employees thanks to which they would understand ergonomic principles and proved work procedure early in order to identify symptoms which might cause musculoskeletal problems.
- **Ergonomic prevention program development with doctor's assistance:** possible ergonomic risks at workplaces should be evaluated based on employees' reports who should be, if needed, monitored under doctor's supervision.

It is recommended to calculate real costs of implemented solution at the end of this phase. This should mitigate exposition or eliminate risk factors causing musculoskeletal problems to an employee. In fact, this phase allows to compare planned creation and implementation schedule of prevention program with real schedule. In case planned costs have not been estimated correctly and individual step length implementation, it is necessary to analyse deviations and identify causes. Based on this information, company management and ergonomic team members will be able to learn and avoid similar types of mistakes when analysing the current state and MSD risks again. Therefore, in other words, it is a continuous process of ergonomic improvement focused on mitigating exposition and MSD risk elimination which might cause problems to employees. Therefore, it might result in productivity decrease and costs for the company. Procedures that have been correctly proposed should be registered so they could be implemented in the future.

## 2.5. CONCLUSION

Nowadays, along with the advanced technology development, it is also important to put emphasis on employees' health. In order to increase effectiveness of human work in companies in Slovakia, particularly by decreasing MSD risk exposition level, it is recommended to use ergonomic preventive programs. They could improve work conditions through ergonomic rationalisation by using methods of group problem solving. Synthesis among questions related to employees' health protection and

economic questions could be achieved through their implementation. In my opinion, ergonomic prevention programs should be a part of company culture, but it is important to keep in mind their implementation requires a corporate approach. First, it is necessary for companies to be aware of their responsibility towards their employees. By implementing it, they will eliminate musculoskeletal problems and mainly thanks to respecting employees' requirements for musculoskeletal system. Moreover, costs for incapacity for work are reduced as they contribute to overall company costs. Based on study, literature and current knowledge of ergonomics we can conclude there are actually no fixed steps preventing and following use of accessible ergonomic analyses used to determine ergonomic risks. This chapter has mainly focused on 2 approaches. First is the proactive approach (MSD risks are not recorded and musculoskeletal problems of employees are suppressed). Second is the reactive approach (MSD risks are recorded). These 2 approaches are considered by the stated creation and implementation methodology of ergonomic prevention programs, described by the basic development diagram which is divided into 6 stages. The main steps (stages) of the proposed methodology describe creation and implementation of company ergonomic prevention programs in general. Depending on their consistency and application, they might be beneficial for the company and its employees.

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