Zarządzanie Przedsiębiorstwem. Enterprise Management
Volume 24 • Number 3–4 • December 2021 • pp. 8–13
DOI: 10.25961/ent.manag.24.03.02

INFLUENCE OF WORK AND WORKING CONDITIONS ON THE SPINAL DISEASES

Eleonóra Bigošová[1], Ľuboslav Dulina[1], Miroslava Barbušová[1], Dariusz Plinta[2], David Strnad[3]

[1] *Department of Industrial Engineering, Faculty of Mechanical Engineering, University of Zilina, Slovakia*
[2] *Department of Industrial Engineering, Faculty of Mechanical Engineering and Computer Science, University of Bielsko-Biała, Poland*
[3] *Institute of Logistics and Transport, Faculty of Mining, Ecology, Process Control and Geotechnologies, Technical University of Kosice, Slovakia*

Corresponding author:
Eleonora Bigosova
Department of Industrial Engineering
Faculty of Mechanical Engineering
University od Zilina
Univerzitna 1, 010 26 Zilina, Slovakia
phone: (+421) 41 53 2722
e-mail: eleonora.bigosova@fstroj.uniza.sk

Abstract
Musculoskeletal disorders are the most common work-related health problem in Europe. They affect the health of individual employees and increase the financial and social spending of European companies and countries. From a biomechanical point of view, the spine is the most stressed part of the human body. Back pain is one of the most common diseases of civilization. Excessive loading of this part of the body in the work process can lead to the emergence of serious diseases. The article provides an overview of the course of diseases of the musculoskeletal system in Slovakia. It also describes the available methods for assessing the load on the spine, as the most stressed part of the body, of employees in industrial enterprises.

Keywords
Musculoskeletal disorders, risk of spinal diseases, proactive ergonomics.

1. Introduction

Pain, discomfort, and loss of function of the neck, back, upper, or lower limbs are common among working people. Such ailments are collectively referred to as diseases and damage of the musculoskeletal system. As many as 80 percent of the population will experience problems related to the musculoskeletal system of various origins during their lifetime [2].

Musculoskeletal problems are the most common work-related problem in the EU. These problems affect employees in all sectors of industry. In addition to the negative effects on the health of employees, they lead to high costs for businesses and society. The European Agency for Safety and Health at Work publishes studies that provide an accurate picture of musculoskeletal problems across Europe. This study combines and analyzes existing data and information from major surveys and administrative data in the EU [2].

The European Agency for Safety and Health at Work has identified the disorders and issues of the musculoskeletal system at European level as a problem that should be addressed without delay [3].

In Fig. 1 shows the percentage of workers who had musculoskeletal problems in 2015.

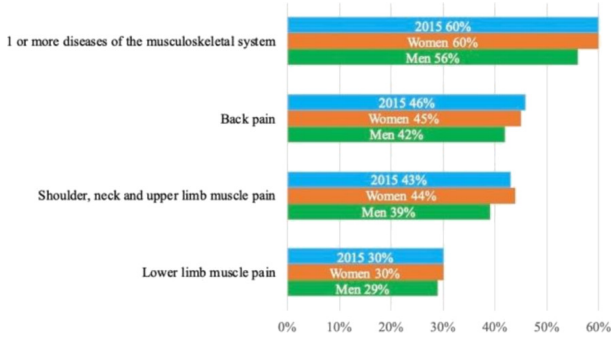

Fig. 1. Percentage of individual types of diseases in 2015 in both men and women [3].

Figure 1 shows that in 2015, up to 60% of the EU population experienced at least one disease of the musculoskeletal system. 45% of the population suffered from back pain.

Of the many health problems, spinal disorders are among the most important. According to a survey of EU countries, approximately 23% of employees in each country suffer from muscle pain and, on average, up to 25% of employees suffer from back pain. The spine is one of the most important structures in the human body. It supports and stabilizes the upper part of the

body and is the center of our musculoskeletal system which gives movement to the body. Without the proper functioning of the spine and back muscles, which support it, we cannot fully perform any work activity. Back pain is a current problem mainly because it contributes to a high percentage of the onset and long duration of incapacity for work (on average two days more than the average length of all diseases). In the general practitioners' practice, back pain represents more than half of the treated patients, in orthopedic clinics it is more than one quarter of treatments [3].

1.1. Analysis of diseases of the musculoskeletal system in Slovakia

At present, work activities characterized by frequent repetition of the same movements with demands for high movement coordination are coming to the fore. In many cases, workers must carry out their work for a long time at a forced pace and with excessive static and unilateral loading not only of the limbs but also of the spine. Such overload, if not avoided in time, leads to staff turnover, incapacity for work and later to occupational diseases [10].

The number of diseases of the musculoskeletal system and connective tissue, as reported in the Health Yearbook, is shown in Fig. 2.

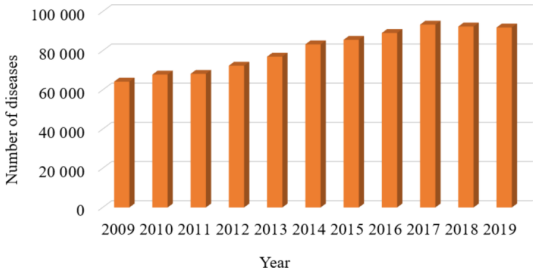

Fig. 2. Number of diseases of the musculoskeletal system in Slovakia (2009–2019) [11].

In 2019, 91 882 cases of hospitalization of people in Slovakia were reported. Compared to 2018, this is 493 (0.53%) fewer cases but their number is still very high compared to 2009 [10].

Diseases of the skeletal and muscular system and connective tissue are shown in Fig. 3. Arthropathy (ongoing degenerative and destructive processes on the joints) and diseases of the spine and back have the largest share in diseases of this category.

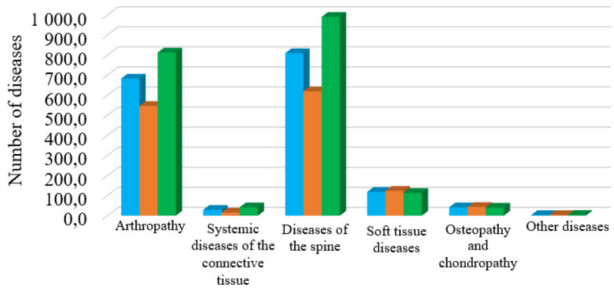

Fig. 3. Diseases of the musculoskeletal system and connective tissue.

From the analysis of diseases of the musculoskeletal system in Slovakia, it shows that the number of these diseases is still high. However, their number is not only high in Slovakia, but also in other European countries [11].

1.2. Risks affecting the development of spinal diseases

The number of spinal diseases is still very high. An accompanying feature of every activity performed is risk. When performing work activities, the risk may be based on the work positions to which employees are exposed at work, but in combination with other undesirable factors affecting humans, they create discomfort for employees and increase the risk of spinal diseases (Fig. 4) [5].

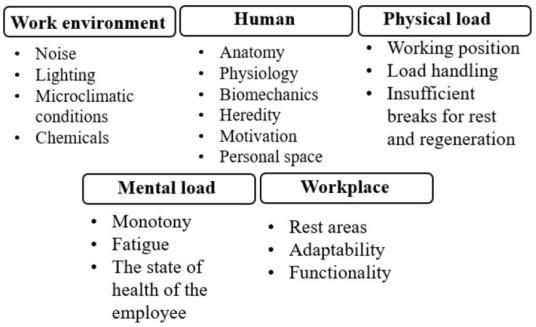

Fig. 4. Labor factors affecting humans [authors].

The factors of physical activity in combination with the personal characteristics of a person and the characteristics of the workplace are the main contributors to the development of spinal diseases. The basic anatomy and physiology of the body work together to withstand different types of biomechanical loads. Exceeding the body's physical ability to handle such a load results in pain and physical injury [4, 8].

1.3. Risks arising from the working position

The job position is one of the most important factors that affects employee performance. When performing their work activities, employees should move in such a way that they do not have any work discomfort and undue stress on individual parts of the body. Long-term work under the influence of unacceptable working positions leads to incorrect posture, and thus to the development of spinal diseases [7].

Standing and sitting are the most common working positions. In both types of working positions various health problems can occur, mainly affecting the spine. The working position has a significant effect on the load on the spine due to pressure. Figure 6 shows the different positions of the workers in the standing position and the action of pressure on the intervertebral discs when handling the load, compared with respect to the natural position of the human being, which is the upright standing [7].

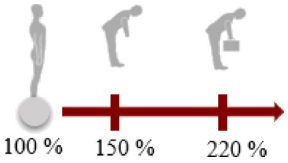

Fig. 5. Pressure acting on the intervertebral discs in standing position [14].

While in the upright position the pressure on the intervertebral disc will be 100%, in the working position in which the torso is tilted, the pressure on the same intervertebral disc will be 50% higher. If a worker were to handle a load in this working position, the pressure acting on the intervertebral disc would be up to 120% higher than in an upright position. Under such a great pressure, the intervertebral disc can be damaged, causing great pain and incapacity for the employee [12].

The second most common working position is sitting. Upright sitting is a physiological working position. Because it is not a natural position for humans, there is an incorrect posture and thus an increased risk of spinal damage. Figure 7 shows the different sitting positions and the effect of pressure on the intervertebral discs with and without handling the load. Again, they are compared with respect to a person's natural position (upright position) [12, 14].

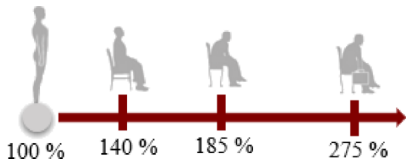

Fig. 6. Pressure acting on the intervertebral discs in sitting position [14].

While in the upright position the pressure on the intervertebral disc is 100%, in the working position of an upright seat the pressure on the same intervertebral disc is 40% higher. If an employee leans forward in a sitting position, the pressure will be 45% higher than in an upright sitting position. If an employee in a sitting position with a forward bend had to manipulate the load, the pressure would increase by up to 135% compared to an upright sitting position. As in the case of standing position, even in sitting, the intervertebral disc would not be able to withstand such a large load and would be damaged and consequently in pain [9].

1.4. Risks arising from handling loads

Another important factor that is largely involved in the development of spinal diseases is load handling. Manual handling of loads is handling which, due to the characteristics of the load or unfavorable ergonomic factors, poses a risk of damage to health or the spine of workers. Handling means any [1]:

- transfer or carrying of burdens (including people and animals) by one or more employees,
- lifting a load,
- load support,
- load storage,
- pushing and pulling the load, and others.

To prevent the risks of damage to the health of employees from manual handling of loads, Government Regulation no. 281/2006 Coll. on the minimum safety and health requirements for the manual handling of loads, specifies the indicative weight limits for the handling of loads, which are given in Table 1.

When working in a sitting position and lifting a load with one hand, the weight of the load must not exceed 5 kg. Loads weighing 10–15 kg can be lifted continuously for 10 minutes, loads weighing 5–10 kg can be lifted for 15 minutes. Breaks between lifting periods must not be less than 10 or more 15 minutes is recommended.

1.5. Risks arising from the design of workplaces

Ergonomic principles of workplace and work environment design are the key to creating the best possible conditions for the work of employees and thus ensuring their health. The design of workplaces will improve the quality of working conditions and thus ensure the protection of health and increase the quality of life of employees. A properly designed workplace should meet these ergonomic requirements [13]:

- clear,
- comfortable,
- arranged,
- hygienic,
- aesthetic,
- safe.

Table 1
Weight limits for lifting and carrying loads [6].

Age	Conditions of manipulation	Max. load weight [kg]		Max. weight for the whole working time [kg]	
		Men	Women	Men	Women
18–29	Favourable Unfavourable	50 40	15 10	10000 8000	6500 5500
30–39	Favourable Unfavourable	45 40	15 10	7500 7200	6500 5500
40–49	Favourable Unfavourable	40 35	15 10	6500 6000	6000 5500
50–60	Favourable Unfavourable	35 30	10 5	5500 5000	5000 4000

When designing workplaces in compliance with ergonomic principles, it is necessary to focus on the following factors:

- anthropometry of employees,
- functional and dimensional parameters of the workplace (height of the working plane, handling space of the upper limbs, handling space of the lower limbs, visual space).

All the risks described in this section can adversely affect spinal health. There are currently several methods, whether approximate or medical, to identify these risks. A list of these methods is given in the following section.

2. Methods of evaluation of the musculoskeletal system with a focus on the spine

The number of employees suffering from musculoskeletal problems and back pain is still growing. The solution for businesses would be to identify the factors causing the problems in a timely manner through an appropriate backbone assessment method or system. The parameters that need to be monitored to eliminate the consequences of work on the health of employees are:

- anthropometric properties – gender, age, weight, height,
- load handling – load weight and handling conditions,
- working positions – working position and operation time in a working position,
- workspace – handling, pedipulation, visual.

In this section I did a survey of available methods focused on the diagnosis of the spine (Fig. 7).

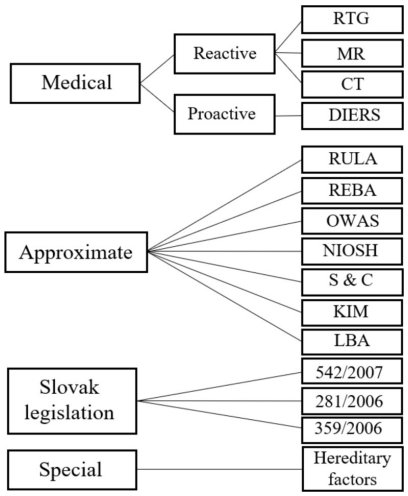

Fig. 7. Methods used to diagnose the spine [authors].

Based on the analysis of methods used for the diagnosis of the spine, I compiled a table (Table 2), which contains a comparison of individual methods with respect to the parameters needed to monitor to create a predictive system to eliminate the occurrence of work-related diseases.

It can be seen from Table 2 that none of the methods for assessing spinal load is satisfactory from the point of view of ergonomics for companies. It is therefore necessary to create a system for evaluating the load of the spine, which will consider all the parameters listed in the table, which is key to achieving a more detailed evaluation of the spine (Fig. 8).

Table 2
Comparison of methods with respect to the monitored parameters [authors].

Parameter category	Parameter	Medical methods				Approximate methods							Legislation		
		RTG	CT	MR	DIERS	RULA	REBA	OWAS	NIOSH	S&C	KIM	LBA	542/2007	281/2006	359/2007
Anthropometric properties	Gender	✓	✓	✓	✓	👎	👎	👎	👎	✓	✓	≈	👎	✓	👎
	Age	✓	✓	✓	✓	👎	👎	👎	👎	👎	👎	👎	✓	✓	✓
	Weight	👎	👎	👎	✓	👎	👎	👎	≈	≈	👎	≈	👎	👎	👎
	Height	👎	👎	👎	✓	👎	👎	👎	≈	≈	👎	≈	👎	👎	👎
Load handling	Load weight	👎	👎	👎	👎	≈	≈	≈	✓	✓	✓	✓	👎	✓	✓
	Handling conditions	👎	👎	👎	👎	≈	≈	👎	✓	👎	✓	👎	👎	✓	✓
Working position (WP)	Working position	✓	👎	👎	≈	≈	≈	✓	👎	👎	✓	≈	✓	👎	≈
	Time in WP	👎	👎	👎	👎	≈	≈	✓	👎	✓	✓	👎	✓	👎	≈
Workspace	Handling space	👎	👎	👎	👎	👎	👎	👎	👎	👎	👎	👎	✓	👎	✓
	Pedipulation space	👎	👎	👎	👎	👎	👎	👎	👎	👎	👎	👎	✓	👎	✓
	Field of view	👎	👎	👎	👎	👎	👎	👎	👎	👎	👎	👎	👎	👎	👎

✓ include
≈ partial includes
👎 do not include

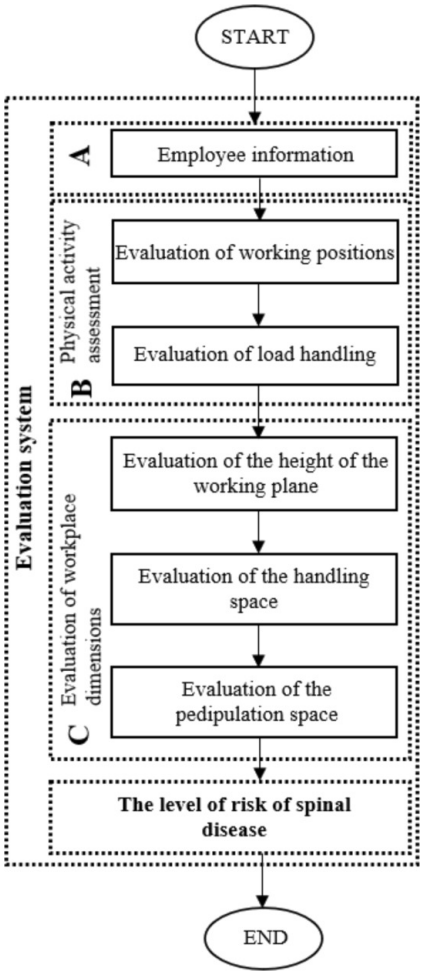

Fig. 8. Evaluation system to the level of risk of spinal disease [authors].

The proposed evaluation system considers all parameters listed in Table 2. The system has the character of an evaluation tool. The evaluator will monitor the employee directly during the performance of his work and record the input data into the system. Subsequently, the system will process this data and the result will be to determine the level of risk of damage to the spine of the evaluated employee. Input data to the predictive system are personal characteristics of the employee such as gender, weight, height, age, health, as well as selected factors of work affecting a person during work activities, which are working positions, load handling, work plane height, handling space and a pedipulation space.

After identifying the level of risk of spinal cord injury by the predictive system, corrective action can be considered to prevent the predicted condition.

3. Conclusions

At present, the number of work activities is increasing, in which the same movements are repeated frequently and require high movement coordination. From the analysis of diseases of the musculoskeletal system, these diseases have an increasing trend and are one of the ten causes of hospitalization of people not only in Slovakia but also in other countries of the European Union.

Musculoskeletal disorders are among the most common disabilities associated with the work performed. Up to 46% of these diseases are back pain.

The onset of spinal disease, as already mentioned in the work, results from not only the position of the torso but also other parts of the body in combination with the handling of the load or the design of the workplace. At present, there is no method for a comprehensive assessment of the load of the spine due to the performance of work activities. Spine assessment is only a partial (supportive) part of some approximate methods used to assess the load during repetitive activities, load handling or work position assessments.

Based on previous knowledge, a comprehensive evaluation system has been created, which is using not only approximate methods but also legislation able to determine the level of risk of spinal diseases. At the same time, it serves as a control tool for companies, thanks to which it is possible to prevent the health problems of employees as well as economic losses, due to the reduction of work performance and incapacity for work of employees.

This work was supported by the Slovak Research and Development Agency under the Contract no. APVV-16-0488.

References

[1] Asadi F., Arjmand N., *Marker-less versus marker-based driven musculoskeletal models of the spine during static load-handling activities*, Journal of Biomechanics (WoS), 112, 110043, 2020.

[2] European Agency for Safety and Health at Work (EU-OSHA, 2019a, online: https://osha.europa.eu/sk/publications/msds-facts-and-figures-overview-prevalence-costs-and-demographics-msds-europe/view.

[3] European Agency for Safety and Health at (EU-OSHA, 2019b, online: https://osha.europa.eu/en/publications/summary-msds-facts-and-figures-overview-prevalence-costs-and-demographics-msds-europe.

[4] Furmann R., Plinta D., Čechová I., *Use of RFID in medical facilities*, ProIn: Productivity and Innovation, Žilina (Slovakia): CEIT Central European Institute of Technology, p. 40–43.

[5] Fusko M., Bučková M., *Workers in Industry 4.0*, National Maintenance Forum 2019 Proceedings, 1st ed., Žilina: University of Žilina, p. 185–193.

[6] Government regulation of The Slovak republic n. 281/2006 Z. z.: 2006: Regulation of the Government of the Slovak Republic on minimum safety and health requirements for manual handling of loads.

[7] McGill S., *Back mechanics* [*Mechanika zad*], Europrint a.s., Praha, 2017.

[8] Michnik R. et al., *The effect of the pelvis position in the sagittal plane on loads in the human musculoskeletal system*, Acta of Bioengineering and Biomechanics (WoS), 22, 3, 33–42, 2020.

[9] Nachemson A., *The load on lumbar disks in different positions of the body*, Clin. Orthop. Relat. Res., 45, 107–122, 1966.

[10] National health information center – Occupational diseases or Occupational Disease Treats in The Slovak Republic, 2019a, online: http://www.nczisk.sk/Documents/publikacie/2017/zs1806.pdf.

[11] National health information center – Statistics of the hospitalized in The Slovak Republic, 2019b, online: http://www.nczisk.sk/Documents/publikacie/2017/zs1825.pdf>.

[12] Saiklang P. et al., *An Evaluation of an Innovative Exercise to Relieve Chronic Low Back Pain in Sedentary Workers*, Human Factors The Journal of the Human Factors and Ergonomics Society (WoS), 2020, doi: 10.1177/0018720820966082.

[13] Svitek R., Krajčovič M., Martinkovič M., *Balancing of assembly operations and detailed design of workplace in software environment*, Industrial Engineering, p. 145–152, 2019.

[14] The Back Clinic, 2015, online: http://www.backclinicinc.com/2015/07/27/pressure-on-back-in-static-positions/.