CONTRIBUTION OF ERGONOMICS FOR OCCUPATIONAL HEALTH AND SAFETY AND ERGONOMIC RISK FACTORS

Prof. Aleksandar Zunjic

University of Belgrade
Faculty of Mechanical Engineering
Kraljice Marije 16 11000 Belgrade
Serbia
azunjic@mas.bg.ac.rs

1. INTRODUCTION

- *Limited Recognition of Ergonomics Experts:* In Serbia and many other countries, when occupational safety and health issues arise that company personnel cannot resolve, few would consider consulting an ergonomics expert.
- *Perceived Competence in Occupational Safety :* Most people believe that only persons competent to solve such problems are experts in the field of occupational safety and health, individuals with knowledge in the domain of industrial or occupational hygiene, as well as those working in the field of occupational medicine..
- *Misconception About Ergonomics Competence:* It is a mistake to overlook ergonomics experts for solving occupational safety and health problems, as they are equally capable in this field.
- *Equal Expertise in Ergonomics:* Individuals with expertise in ergonomics can effectively address most occupational safety and health issues, comparable to those in industrial hygiene and occupational medicine.
- *Potential Superiority of Ergonomics*: For certain occupational safety and health problems, ergonomics experts may even provide more successful solutions.
- *Neglect of Ergonomics Experts*: This presentation aims to explore the reasons why ergonomics experts are often overlooked in solving worker safety and health issues.
- *Advantages of Engaging Ergonomists :* It will be highlighted the specific areas of occupational safety and health where ergonomics experts can be effective, and will be illustrated the benefits and advantages of involving them in various situations.

2. DEFINING ERGONOMICS

- *Lack of Global Recognition and Awareness:* The role of ergonomics in worker safety and health is not widely recognized, and many people, including those in state institutions and ministries, are unaware of what ergonomics entails despite its daily relevance.
- *Need for Clear Definition:* To address this lack of understanding and for further discussion, it will be provided a precise definition of ergonomics as a science.
- *Varied Definitions of Ergonomics:* Over time, multiple definitions of ergonomics have emerged, differing based on their comprehensiveness and the aspects they emphasize or omit.
- *Author Bias in Definitions:* The differences in definitions are often due to authors focusing on specific areas of ergonomics they practice, leading to a biased understanding.

- *Essence of Ergonomics Defined.* To avoid this bias, the author of this presentation has created a new, comprehensive definition centered on the essence of ergonomics, which is work (since word ergonomics was derived from the Greek words ergon - work and nomos - law).

- *New Definition of Ergonomics*: "Ergonomics is a multidisciplinary science whose goal is to examine the impact of means of work, conditions of work, processes of work, and products as results of work on humans from the psychological, physiological, anatomical, biomechanical, sociological, organizational and physics aspect by applying the quantitative and qualitative research methods, as well as to adapt the design of the aforementioned elements to humans, with the aim of improving comfort, safety, efficiency and satisfaction, which are considered during their interaction with humans." (Zunjic A., 2017, A new definition of ergonomics, IETI Transactions on Ergonomics and Safety, Vol. 1 Iss 1., pp. 1-6)

- *Comprehensive Scope of Ergonomics Definition:* From this definition it can be seen that Ergonomics includes aspects of health and safety that emerge during employee work activities and human interactions with environmental entities.

- *Factors Affecting Health and Safety :* The definition also emphasize the impact of work tools, working conditions, work processes, and products on human health and safety.

3. SIMILARITIES AND DIFFERENCES BETWEEN ERGONOMICS, OCCUPATIONAL HYGIENE, AND OCCUPATIONAL MEDICINE

- *Connection to Occupational Hygiene and Medicine :* Understanding ergonomics' role in health and safety requires examining its relationship with occupational hygiene and occupational medicine, both of which are globally recognized in the field of occupational health and safety.

- *Complexity of Defining Differences:* While ergonomics, occupational hygiene, and occupational medicine share many similarities, especially regarding safety aspects, identifying their differences is complex but essential as these differences, though blurred, do exist.

- *Occupational Hygiene* has been an important part of occupational health since it first emerged after World War II as the science and art that deals with the anticipation, recognition, evaluation and control of human exposures to hazards in the working environment (Vincent J.H., 2005, Graduate Education in Occupational Hygiene: A Rational Framework, Ann. occup. Hyg., Vol. 49, No. 8, pp. 649-659).

- *Overlap Between Ergonomics and Occupational Hygiene :* Ergonomics and occupational hygiene have significant overlap, prompting an examination of their similarities and differences before considering their relationship with occupational medicine.

- *Limited Research on Comparisons:* Only one paper specifically addressing the similarities and differences between ergonomics and industrial hygiene has been published, in the Journal of the Ergonomics Society of Korea. (Park H.S., 2012, A Review on the Relationship of Ergonomics and Industrial Hygiene, Journal of the Ergonomics Society of Korea, Vol. 31 No.2, pp. 407-411)

- *Complementary Relationship'*. The author of the paper concluded that ergonomics and industrial hygiene are complementary fields, with many ergonomic-themed papers being published in leading occupational hygiene journals by professionals in the field.

- *Misunderstanding of Ergonomics by AIHA:* The American Industrial Hygiene Association (AIHA) has a limited view of ergonomics, focusing primarily on its role in addressing musculoskeletal disorders and their risk factors in the workplace.

- *Comparison with the Comprehensive Definition:* Comparing AIHA's statement "Ergonomics is a multidisciplinary science whose primary focus is on anticipating, recognizing, evaluating, and controlling musculoskeletal disorders and their risk factors in the workplace" (https://www2.aiha.org) with the comprehensive definition of ergonomics reveals significant discrepancies, highlighting a narrow interpretation by AIHA.

- *Limited Recognition by Other Organizations*: Other international associations, such as the Occupational Safety and Health Administration (OSHA), also emphasize ergonomics' role in preventing musculoskeletal disorders, while overlooking its broader contributions and possibilities.

- *Occupational Medicine*, previously called industrial medicine, specializes in the prevention and treatment of work-related illnesses and injuries (Wikipedia - Occupational_medicine).

- *Complementary Disciplines:* It can be considered that occupational hygiene and occupational medicine are complementary disciplines that work together to protect and promote worker health and safety.

- *Hygienists and Physicians:* Occupational hygienists aim to prevent occupational hazards, and occupational physicians diagnose and treat work-related health problems that occur despite preventive measures.

- *Occupational health* is an area of work in public health to promote and maintain the highest degree of physical, mental and social well-being of workers in all occupations (WHO -occupational health).

- *Ergonomics and Occupational Health :* The science and practice of occupational health involves several disciplines, such as occupational medicine, nursing, ergonomics, psychology, hygiene, safety and other (WHO - occupational health). From this statement by the WHO, it can be seen that ergonomics is related to the field of occupational health.

- *Ergonomics and Occupational safety:* Occupational safety focuses mainly on preventing injuries to personnel that can result from incidents associated with the job they perform in the workplace (Aloqaily A., 2018, Pipeline Process Safety Management, In: Cross-Country Pipeline Risk Assessments and Mitigation Strategies, Gulf Professional Publishing, pp. 171-180, ISBN 9780128160077.). Given that ergonomics also considers injuries that occur during the performance of work activities, the connection between ergonomics and the field of occupational safety can be seen from here.

- *Disputed Scope of Ergonomics' Contribution*: While the connection between ergonomics and occupational health and safety is evident, the extent and specific ways in which ergonomics can contribute to this field remain debatable.

We might ask, why is this so?

- *Simplified Definitions by Ergonomists:* Ergonomists have often simplified the concept of ergonomics for the general population, resulting in definitions that only partially capture its full scope, which has inadvertently harmed the perception of ergonomics as a comprehensive science.

- *Incomplete Definitions in Dictionaries and Encyclopedias*: Dictionaries and encyclopedias also contribute to the problem by providing incomplete definitions of ergonomics.

- *Non-Expert Definitions :* Definitions created by non-experts for personal use, which have become publicly available through the internet, further distort the understanding of ergonomics.

- *Superficiality in Professional Organizations:* The superficial understanding of ergonomics by individuals in organizations such as AIHA and OSHA has contributed to an incomplete picture of the field's possibilities.

4. ERGONOMIC RISK FACTORS

- *Ergonomic Risk Factors and Hazards:* Ergonomic risk factors refer to hazards that impact workers' health and safety, and understanding these factors is crucial for applying ergonomics to solve health and safety issues.

- *Diverse Perspectives on Ergonomic Risk Factors:* Just as definitions of ergonomics vary, different authors and institutions have varying views on what constitutes the risk factors that ergonomics should consider.

- *Ergonomics - Beyond Musculoskeletal Disorders:* Probably the best insight into this misconception about what the field of study of ergonomics is can be seen from documents that talk about ergonomic risk factors. In almost all cases, ergonomic hazards are equated with the causes of musculoskeletal disorders.

- *Another Example:* Under the title "Ergonomic Hazards," in the first sentence, the Australian Government - Commerce states that "An ergonomic hazard is a physical factor in the environment that impairs the musculoskeletal system" (Australian Government - Commerce, 2019, Ergonomic hazards).

- *One more example:* Occupational Safety and Health Administration, U.S. Department of Labor, created a document titled "Identifying and Addressing Ergonomic Hazards Workbook," where they present what ergonomic risks and hazards are. From this document, it can be clearly seen that they equate ergonomic risks with biomechanical risks.

- *NIOSH Example*: National Institute for Occupational Safety and Health in its publication titled "Elements of ergonomics programs" also treats as ergonomic risks only those risks that lead to musculoskeletal disorders.

- *Addressing Misconceptions About Ergonomics:* One of the aims of this paper and presentation is to highlight and correct wide present misconceptions about what ergonomics studies.

- *The Main Goal - Identifying Ergonomic Risk Factors:* By identifying ergonomic risk factors, the paper aims to show the areas where ergonomics can contribute to occupational safety and health.

- *Detailed Analysis of Ergonomic Risk Areas :* The presentation will cover eleven identified areas of ergonomic risk factors, providing precise definitions, typical risk factors, and their impact on both health and safety.

1. Ergonomic risk factors with a physical component

Ergonomic risk factors with a physical component are aspects of the work environment that interact with the worker during the execution of the work process and can, through their effect, impact their psychophysical state and health, and additionally can cause unsafe situations. Typical examples of ergonomic risk factors with a physical component are:

a. High noise levels

High noise levels (sound pressure) in interaction with the worker can cause damage to the sense of hearing, affect the cardiovascular system, digestive organs, and cause stress.

Additionally, noise increases the risk of miscommunication, can lead to nonperceiving auditory warnings, slow reaction time, affect distraction, all of which can manifest in the safety of task execution.

b. Effects of vibrations

Vibrations are most often transmitted to humans through interaction with tools. They can lead to damage to nerves and blood vessels, and can also cause vibration syndrome.

Additionally, vibrations increase the risk of reduced sensitivity in the hands, which can lead to loss of control over tools and unsafe situations.

c. Unfavorable and extreme temperatures

High temperatures in the work environment can cause dehydration, muscle cramps, dizziness, fainting, and other health effects. Low temperatures can cause shivering, hypothermia, frostbite, and fatal outcomes.

Additionally, unfavorable and extreme temperatures increase the risk of reduced concentration and errors, which can compromise safety.

d. Inadequate lighting

Low or high levels of lighting can lead to eye strain and headaches. The risk of vision problems also increases.

Additionally, insufficient lighting increases the risk of tripping and falling, can lead to not noticing hazards, but can also affect the precision of task execution, which can cause safety risks.

e. *Exposure to harmful particles or chemicals*

Harmful particles and chemicals are produced as a result of the worker's interaction with the work object during the work process. Dust particles and fumes can lead to respiratory problems, increasing the risk of allergies and occupational diseases.
Additionally, exposure to harmful particles or chemicals increases the risk of reduced visibility, can lead to distracting workers from their tasks, which can affect system safety.

f. *Inappropriate air humidity*

High levels of relative air humidity prevent the body from releasing heat through evaporation. In combination with a high temperature, it contributes to heat stress.
Additionally, high air humidity combined with high temperature contributes to difficult task execution, which can compromise safety.

g. *Slippery and uneven surfaces*

Slippery and uneven surfaces can, when it comes to floor surfaces, cause slips and trips, which can lead to joint injuries and increased risk of chronic pain in legs and feet.
Additionally, from a safety perspective, slippery surfaces can lead to loss of control over equipment or vehicles.

h. *Contact with sharp or hot surfaces*

Contact of workers with sharp surfaces can cause cuts, while contact with hot surfaces can cause burns. The risk of infections and scarring increases.
Additionally, contact with sharp or hot surfaces can lead to dropping work objects or tools, changing the trajectory of movement, which can lead to a change in safety status.

2. Ergonomic risk factors with a psychological component

Ergonomic risk factors with a psychological component are cognitive aspects of the work environment, workplace, and work tasks that affect a worker by inducing psychological and mental reactions that can impact their psychological health, as well as cause work errors that can compromise safety. Typical examples of ergonomic risk factors with a psychological component are:

a. *Information overload*
b. *Performing complex cognitive tasks*
c. *Sensory overload*
d. *Work monotony*

3. Ergonomic risk factors with a physiological component

Ergonomic risk factors with a physiological component represent aspects of the work environment, workplace, and work task that, through interaction with a worker, lead to changes in physiological parameters, which can lead to an increased risk of injury, illness, reduced work ability, and the occurrence of errors that can compromise safety. Typical examples of ergonomic risk factors with a physiological component are:

a. *High physical exertion*
b. *Improper work postures*

4. Ergonomic risk factors with an anthropometric component

Ergonomic risk factors with an anthropometric component are a set of potential hazards arising from the mismatch between workers' body dimensions and proportions and the design of the workplace, machines, tools, and equipment. This mismatch can lead to improper body positions, excessive use of force, or non-anatomical movements, resulting in an increased risk of musculoskeletal disorders, fatigue, permanent physical damage, and unsafe execution of work tasks. Typical examples of ergonomic risk factors with an anthropometric component are:

a. *Inappropriate seat and chair size and shape*
b. *Inappropriate handles and tools*
c. *Limited space for movement*
d. *Unadjusted monitor and screen height*
e. *Inappropriate size of protective equipment*
f. *Mismatch between workplace dimensions and workers' anthropometric characteristics*

5. Ergonomic risk factors with a biomechanical component

Ergonomic risk factors with a biomechanical component are defined as a set of potential hazards arising from the unfavorable interaction between mechanical forces acting on the worker's body and their musculoskeletal system during the performance of work tasks. These can lead to muscle and tissue overload, improper body positions, or movements beyond normal limits of feasibility, resulting in an increased risk of musculoskeletal disorders, injuries, fatigue, reduced work ability, and the occurrence of unsafe situations. Typical examples of ergonomic risk factors with a biomechanical component are:

a. *Repetitive movements*
b. *Prolonged execution of movements in inadequate body positions*
c. *Use of excessive force to perform a task*

6. Ergonomic risk factors with a sociological component

Ergonomic risk factors with a sociological component are defined as a set of potential hazards arising from unfavorable interactions between social aspects of the work environment and individual characteristics of workers. These can lead to psychosocial stress, reduced job satisfaction, impaired communication or teamwork, resulting in an increased risk of mental health deterioration, as well as the development of deviant behaviors that may compromise workplace safety. Typical examples of ergonomic risk factors with a sociological component are:

a. *Inadequate human-human communication*
b. *Disruption of work-life balance*
c. *Professional stagnation and lack of adequate rewards*

7. Ergonomic risk factors with an organizational component

Ergonomic risk factors with an organizational component are potential hazards that arise due to misalignment and maladjustment of organizational structures, work processes, and decisionmaking practices with the abilities, needs, and limitations of workers. This can lead to circumstances that may pose a risk to workers' health and safety. Typical examples of ergonomic risk factors with an organizational component are:

a. *Excessive load with tasks*
b. *Inadequate breaks and rest periods*
c. *Incomplete or inadequate training*

8. Ergonomic risk factors with a design component

Ergonomic risk factors with a design component represent potential hazards that arise from inadequate interaction between the design solution of workspace, equipment, tools, and products on one side, and the physiological, cognitive, and anthropometric characteristics of workers on the other. Typical examples of ergonomic risk factors with a design component are:

a. Unadapted control devices and interfaces
b. Unadapted displays
c. Deficiencies in the design of guards and protective devices
d. Non-ergonomic design of clothing

9. Ergonomic risk factors with a technological component

Ergonomic risk factors with a technological component are defined as a set of hazards arising from unfavorable interactions between technological systems where inadequately designed or implemented technological elements do not match the cognitive, physical, or sensory abilities and limitations of users. This can lead to increased mental load, physical strain, work errors, fatigue, or stress, resulting in health and safety risks. Typical examples of ergonomic risk factors with a technological component are:

a. Inadequately automated processes
b. Technology whose functioning or properties do not meet user expectations
c. Inadequate instructions for technology use

10. Ergonomic risk factors with a personal component

Ergonomic risk factors with a personal component are hazards that arise due to insufficient adaptation of the work environment, equipment, and tasks to the individual characteristics, abilities, and limitations of workers, which can endanger their health and safety. These factors are mitigated through a two-way alignment process - adapting work entities to humans, as well as training and selecting workers for better alignment with the inevitable job requirements. Typical examples of ergonomic risk factors with a personal component are:

a. Mismatch between work tasks and worker experience and skills
b. Mismatch between work hours and worker's circadian rhythm
c. Mismatch between work task and worker's age

11. Ergonomic risk factors with a discomfort component

Ergonomic risk factors with a discomfort component are aspects of the work environment, workplace, and work tasks that, through interaction with employees, can lead to discomfort and to some extent negatively affect their health and safety. Typical examples of ergonomic risk factors with a discomfort component are:

a. Lack of space for rest and relaxation
b. Prolonged discomfort of any kind

5. CONCLUSION

• *Broad Scope of Ergonomic Risk Factors:* The analysis reveals that ergonomic risk factors extend beyond the biomechanical component, encompassing multiple areas of health and safety.

- *Ten Additional Ergonomic Risk Areas*: In addition to the biomechanical aspect, ten other areas of ergonomic risks have been identified, each containing numerous risk factors commonly studied within ergonomics.
- *Validation through Ergonomic Theory and Practice :* The classification of these risk factors is supported by ergonomic theory and practice, with a substantial body of research addressing these factors since the formal establishment of ergonomics.
- *Interconnections with Occupational Hygiene andMedicine:* There are multiple interconnections between ergonomics, occupational hygiene, and occupational medicine in relation to occupational safety and health. Ergonomics emphasizes the identification of factors that can cause health and safety problems in interaction with humans, studies such interaction in a multidisciplinary manner, and provides suggestions for prevention and elimination of harmful consequences for health and safety.
- *Multidisciplinary Approach of Ergonomics*: The strength of ergonomics lies in its multidisciplinary approach, incorporating knowledge from medicine, psychology, engineering, and other fields to address health and safety issues.
- *Practical Solutions by Ergonomics Experts*: Ergonomics can offer practical design solutions, such as machine protection, which are beyond the scope of occupational hygiene and occupational medicine, demonstrating its unique contribution to solving health and safety problems.
- *Broader Scope Beyond Health Treatment:* While ergonomics does not extensively address the treatment of workers' health problems, it also considers the impact of ergonomic risk factors on work efficiency, productivity, comfort, usability, and satisfaction, making it versatile for solving additional industrial problems.
- *Equal or Greater Capability in Addressing Risks:* Based on the analysis, ergonomics is equally or more capable than occupational hygiene and occupational medicine in addressing health and safety risks from the work environment.
- *Raising Awareness About Ergonomics:* The ergonomic scientific and professional community should focus on increasing awareness of what ergonomics is and how it can solve various work-related problems, especially in health and safety.
- *Promoting Ergonomic Projects:* Spreading this awareness can help ensure that ergonomic project proposals in health and safety are accepted and valued, and that ergonomists are employed in relevant organizations.
- *Industry Engagement and Job Creation*: Familiarizing companies and the industry with the potential of ergonomics can lead to the creation of new job positions for ergonomics experts in the future.