



TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering  
Vol. 65, Issue Special III, November, 2022

## SAFETY WORKPLACE: FROM OF POINT OF VIEW OF ERGONOMICS AND OCCUPATIONAL BIOMECHANICS

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***Abstract:** Since more studies about the workplace and occupational health appeared, the research has escalated hugely. However, the relationship between biomechanical factors in the workplace remains the subject of considerable debate when is about what is a comfortable workplace. This paper evaluates the available data about the established definitions which according to ergonomics and biomechanics are related to the workplace to define what is the relation between a “healthy and safe workplace” from the point of view of the ergonomic side. As a result, is defined that the lack of biomechanical factors during workplace design are the main cause for musculoskeletal disorders related with work illnesses and is established the priority requirements name or not a workplace as “healthy & safe”.*

***Key words:** Healthy workplace, Muscle fatigue, Kinetics and kinematics in workplace, Motion analysis, Ergonomic workplace, MSD, WMSD*

### 1. INTRODUCTION

Since more studies about the workplace and occupational health appeared, the literature has escalated hugely. On the web, about ergonomics and occupational illness, there have been almost 6,000 research papers written on workplace ergonomics, all of that related at the same time with biomechanics [1, 2].

There is a continuous challenge to achieve an ergonomic workplace, putting at first the task of identifying quantitatively the types of motions that a worker makes in its workplace (Kinetics and Kinematics of workers) and how much these motions contribute to the risk of occupational illness [3]. That is where occupational biomechanics appears, as an interdisciplinary field in which information from both the biological sciences and engineering mechanics is required to quantify the forces present on the body during work [4, 5].

Any position, from the standpoint of biomechanics, can produce stress and

exhaustion if sustained for lengthy periods of time. Standing, for example, is a normal bodily position (in theory we can call it: mechanical equilibrium), that offers no health risks in and of itself [6–8]. Working in a standing position for lengthy periods of time, on the other hand, might result in aching feet, general muscular tiredness, and low back pain, because during this "equilibrium" there are forces acting to maintain the position. To remain in a state of rest, the muscles make a force opposite gravity all time [9–11].

All these motion analyses of workers can be discussed and selected from different papers and studies, investigated and understood from different flanks, but the research question is: How are related the biomechanics with to what can be considered a healthy workplace?

The rest of the document is structured as follows. Section 2 Related works. Section 3 Method. Section 4 Results. Finally, Section 5 Conclusions.

## 2. RELATED WORKS

Even with all the effort to studying workplace safety an impressive quantity of information about ergonomics has resulted plagued by a lack of theory, weak methodology to improve it; as it is mentioned by M. S. Christian, J. C. Bradley, J. C. Wallace, and M. J. Burk in 2009, on the research about behaviorally oriented occupational safety [12].

The ergonomics on the workplace has been widely explored, some researches are mainly are about technical and organizational aspects in the companies, industries, or any institution which can be a place to work [13, 14]. Many of the related works have delved into analyzing or proposing methods to improve workplace working conditions directly related with ergonomics [11, 12, 15]

Joan Burton in 2010 in her publication for the World Health Organization: Healthy Workplace Framework and Model [16] gives a document that can be followed as practical guidance to a general point of view of a healthy workplace mentioning a properly physical environment (correct ergonomic) as starting to get a safe workplace.

## 3. METHOD DESCRIPTION

The method is divided in two different steps. First Step achieves to define the occupational biomechanics in a healthy workplace [17–20]. Once defined the occupational biomechanics, second part achieves to identify the main risks factors related with biomechanics in a workplace.

The methodology, in both cases, consists in applying a technique of evaluation, at first making research and evaluation of the available data about the established definitions which according to ergonomics are related to the workplace with the purpose of identifying and making a summarization of them. For gathering the information, the Derived/Compiled Data collection method was applied to make a systematic assessment of it.

According to define occupational biomechanics in workplace it was selected the next eligibility criteria: the definitions shall be focused on motion analysis as well as in the

position of the workers. In the second part, the biomechanical factors to consider, which are directly connected to occupational health in the workplace and ergonomics; and has been selected those are mentioned repetitively in the official internationally occupational health organizations. Subsequently, the organizations for identifying the main risks were chosen according to their members' number: World Health Organization (WHO 197 members), International Labor Organization (ILO 187 member states), and European Agency for Safety and Health at Work (OSHA EU Agency 22 states plans).

### 3.1 Occupational biomechanics in workplace

As starting point, it has been proven that if a position is held for an extended amount of time, it can produce discomfort and exhaustion [9]. Discomfort in workplace is directly connected with physical and psychosocial work environment, both suggested as prior need to fulfill as a challenge for getting a healthy workplace [16, 21].

Even if it can be affirmed that if a worker makes their job in the natural bodily position, the postures on its own it will present health hazards because hours of work continues to be around 8 hours per day [22, 23].

But what happens if at this problem it is added inappropriate layout of work areas or certain tasks where the workers must use an unnatural standing positions? [9].

Therefore, it is inferred that repetitive movements and the sitting position work present more hazards in a workplace. Here is where the biomechanics of the worker appears on the scene like the main actor to follow the track into a workplace.

Taking a quick look, the biomechanics knowledge on workplace situations achieves to reduce mechanical traumas.

This knowledge aims to be converted into information useful that allows design a workplace able to avoid discomfort on the workers.

Improving comfort in the workplace can be used as a key to preventing the causes of possible musculoskeletal injuries and disabilities [24].

### 3.2 Biomechanical factors recognized a risk in workplace.

Once defined the occupational biomechanics, second part achieves to identify the main risks factors related with biomechanics of workers. As it was mentioned in the first part even in a "natural position" there are forces acting outside and inside of the human body to remain in the position, and long periods of work can produce hazards [25].

Thus, OSHA establishes although even there are different positions of work (each one with different hazards and preventions) such as: working in a sitting position and working in standing [26]; all represents threats that point to cause Work-related Musculoskeletal Disorders.

Trying to dive into the existing information, more and more publications converge to point out that musculoskeletal disorders (MSDs) are a result of biopsychosocial and biomechanical influences acting upon the individual.

And at the same time, MDSs are recognized as an occupational etiologic factor since the beginning of the 18<sup>th</sup> century [2].

### 3.3 Biomechanical Analyses

After identifying the main risks in workplace is necessary to evaluate the task during the performance time, for this purpose qualitative and quantitative biomechanical analyses shall be used, Table 1 presents the steps to evaluate the task and make an intervention.

Table 1

Phases for analyzing a task		
Phase number	Phase Name	Description of the phase
1	Preparation	Develop a theoretical framework of the most effective technique to reach the goal in mechanical terms
2	Observation	Observe the actual activity performance
3	Evaluation / Diagnosis	Evaluate a novice performance
4	Instructions / intervention	Communicate with the performer.
		Correct the error.
		Repeat the analysis

Formulas for the workplace analysis

Table 2

OSHA Recordable Incident Rate	IR	$IR = \frac{\text{Number of OSHA Recordable Cases X 200,000}}{\text{Number of Employee labor hours worked}}$
Lost Time Case Rate	LTC	$LTC \text{ Rate} = \frac{\text{Number of Lost Time Cases x 200,000}}{\text{Number of Employee Labor Hours Worked}}$
Days Away/Restricted or Job Transfer Rate	DART	$DART \text{ Rate} = \frac{\text{Total Number of DART incidents x 200,000}}{\text{Number of Employee Labor Hours Worked}}$
Severity Rate	SR	$SR = \frac{\text{Total number lost workdays}}{\text{Total number of recordable incidents}}$

During the qualitative part is necessary to record and measure incidents and employee injuries occurring on the job to create a culture that improves injury prevention, in this sense Table 2 shows the data required for analysis.

The Incident Rate shows the total incidents related to the workers, the Lost Time Case Rate exhibits cases that contained lost time, Days Away/Restricted or Job Transfer Rate indicates the number of lost workdays while Severity Rate gives the restricted days or job transfer due to work-related injuries.

## 4. RESULTS

MSDs (musculoskeletal diseases) are a range of painful conditions, these diseases make a reference to a very big group of degenerative and painful illnesses for muscles, skeletal system, nerves, and blood vein [9, 27].

With all the efforts to improve the workplace to prevent risks, nowadays, almost nobody is unfamiliar or at least has been heard with the most popular ones, such as carpal tunnel syndrome, tendonitis, thoracic outlet syndrome, and tension neck syndrome[28,29]. Notwithstanding, deepen this essential topic of workplace health, the MSDs also include more tendon tenderness and associated illnesses like bursitis, tenosynovitis, or epicondylitis, it also includes nerve compression disorders producing carpal tunnel syndrome or sciatica, and others for example osteoarthritis, these disorders can cause sign myalgia, back pain, and other regional pain syndromes which cannot be attributable to a certain pathology [9, 27-31].

From a perspective of motion analysis and ergonomics in the workplace, MDSs mostly

affect the low back, neck, shoulder, forearm, and hand (but the lower extremities has gotten more importance in recent times: work using the legs can lead to WMSD of the legs, hips, ankles, and feet); and is well known, almost all work requires the use of the arms and hands, MDSs become the most common affection between workers, and today represents the main source of work-related illness, which are directly related with to workplace health and its comfort [27-29, 32].

Trauma to the musculoskeletal system is produced by different causes, some of them, directly related to workplace selection

comfortable layout, or at least avoid cause discomfort to avoid causing an MDS. Therefore, evaluation of WMSDs includes identifying workplace risks and at the same time include fulfilling whole the healthy/safe workplace itself [9, 10, 33].

The diversity of the biomechanical traumas found in the workplace could be, primary factor prevention methods which in many cases eliminate completely the risk [34, 35]. Besides, the workplace experts have rarely been trained in human behavior to anticipate adverse human implications of poor worker-workplace systems and are a lot less focused on its comfortability.



Fig. 1: Biomechanics topics directly related to getting a healthy/safe workplace

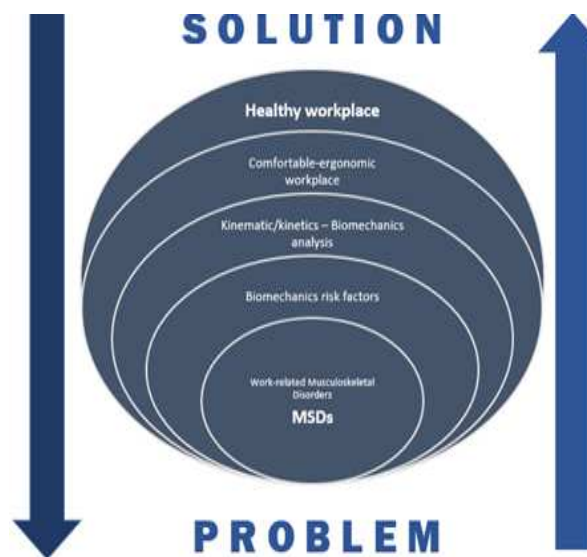


Fig. 2: Overview of effect-cause relation of Healthy workplace and biomechanics



**Fig. 3:** Identified needs concern to achieve a healthy workplace

In such a manner, the biomechanics topics to manage directly related to getting a healthy/safe workplace can be classified as the more relevant as is shown in the Figure 1: i) Analysis for manual materials handling, ii) Analysis for seated work, iii) Analysis for extended arm reach, iv) Analysis for avoiding cumulative trauma disorders of the wrist [24, 32].

## 5. CONCLUSIONS

OSH establish The Strategic Framework on Health and Safety at Work 2014-2020 to the MSD risk factors and ergonomics as main challenges to address accordance to get a safety workplace. OSHA EU points mainly to prevent risks factors at workplace can cause MSD and ergonomic related illness, such as: physical and biomechanical factors, organizational and psychosocial factors, individual and personal factors [29, 36–38].

Therefore, OSHA recognize about a “safety workplace” will be one that: i) do not impair/prevent impair the health and well-being of workers, as well as the potential influence on the neighboring communities and the environment; ii) have psychological and social well-being and the ability to conduct a socially and economically productive life [38].

The biomechanical factors are established as the main a risk in workplace; making an overview of effect-cause as is shown in Figure 2; it is clear that if a MSD is the undesired effect in a healthy workplace the leading cause where try to find a solution is into the knowledge of occupational biomechanics [39].

Any organization has specific necessities concern to achieve a healthy workplace. These needs are summarized on their common points as: i) Physical work Environment: in the physical work environment health and safety concerned; ii) Psychosocial Work Environment,

as is shown in the Figure 3; where Physical Work Environment is directly related to the biomechanics of the workers and the other three issues are connected and can be used as a prevention to reduce biomechanical risk factors in the workplace [16, 40].

## 6. ACKNOWLEDGMENTS

This work was developed under co participating Higher Technological Institute 17 July.

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### **Siguranța la locul de muncă din punctul de vedere al ergonomiei și biomecanicii ocupaționale**

**Rezumat:** Odată cu apariția unui număr tot mai mare de studii despre locul de muncă și sănătatea ocupațională, cercetarea în domeniu s-a dezvoltat semnificativ. Cu toate acestea, relația dintre factorii biomecanici la locul de muncă rămâne subiectul unei dezbateri considerabile când este vorba despre ceea ce înseamnă un loc de muncă confortabil. Lucrarea de față evaluează datele disponibile despre definițiile stabilite care, conform ergonomiei și biomecanicii sunt legate de locul de muncă, pentru a defini care este relația dintre un „loc de muncă sănătos” și „un loc de muncă sigur” din perspectivă ergonomică. Ca urmare, este discutat cazul neconsiderării factorilor biomecanici în timpul proiectării locului de muncă, care reprezintă principala cauză a viitoarelor tulburări musculo-scheletice, precum și cerințele pentru securitatea și sănătatea locului de muncă.

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