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Analysis of the impact of ergonomics on office workstations

Análisis del impacto de la ergonomía en los puestos de trabajo de oficina

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Abstract— The ergonomic design of office workstations will have the function of avoiding injuries and occupational diseases, since it will have the purpose of designing the space with the necessary ergonomic characteristics to take care of the posture, light, tools, place, among other aspects that make the workplace more pleasant. If organizations choose to design and adapt the workstations with an ergonomic approach, they will have a balance between the worker and the tools, benefiting them with greater comfort in their workplace, which will provide both for the worker and for the organization, better health and safety, reliability, quality, productivity, efficiency, and job satisfaction. Therefore, this literary research seeks to know the impact that ergonomics has on office workstations, highlighting the importance of including this ergonomic concept in organizations. In this way, the aim will be to provide a satisfactory conditioning of the working conditions, to the psychic and physical qualities of the employee, with the objective of protecting their physical health and emotional well-being, improving in turn the effectiveness, efficiency and safety at work.

Keywords— Ergonomic design; office workstations; working conditions; ergonomic impact

Resumen— El diseño ergonómico de puestos de oficina tendrá como función evitar lesiones y enfermedades laborales, ya que tendrá como fin diseñar el espacio con las características ergonómicas necesarias para cuidar de la postura, la luz, las herramientas, el lugar, entre otros aspectos que hagan más agradable el lugar de trabajo. Si las organizaciones optan por diseñar y adecuar los puestos de trabajo con un enfoque ergonómico, tendrán un equilibrio entre el trabajador y las herramientas, beneficiándolos con un mayor confort en su puesto de trabajo, lo que proporcionara tanto para el trabajador como para la organización, una mejor; Salud y seguridad, fiabilidad, calidad, productividad, eficacia, y satisfacción en el trabajo. Por lo tanto, con esta investigación literaria se busca conocer el impacto que tiene la ergonomía en los puestos de oficina, destacando la importancia de incluir este concepto ergonómico en las organizaciones. De esta forma se tendrá como fin proporcionar un acondicionamiento satisfactorio de las condiciones laborales, a las cualidades psíquicas y físicas del empleado, con el objetivo de proteger su salud física y bienestar emocional, mejorando a su vez la eficacia, eficiencia y seguridad laboral.

Palabras clave— Diseño ergonómico; puestos de oficina; condiciones laborales; impacto ergonómico

I. Introduction

A job title is a position within an organization in which a person is expected to manage certain specific tasks and functions in relation to the work he/she will perform in the company, positions may vary depending on the industry, organization and geographic location. In addition, each job position usually has a detailed description of the responsibilities, skills and experience requirements expected of the person filling that position. Therefore, it is necessary for workplaces to be ergonomically designed, as they increase productivity, worker satisfaction, feel comfortable and safe while performing their daily tasks. Likewise, a safe and healthy work environment can also reduce the costs associated with work-related injuries and illnesses, as well as medical expenses and lost productivity.

Ergonomics is a discipline that focuses on the relationship between people, work and context, and is increasingly relevant in a world where technology is changing the way we work, and where employee health and well-being are considered key factors for the success of organizations.

In this sense, it is important that the current working conditions ensure the safety of workers, since companies must take care of the mental and physical health of its members to perform their functions in the best possible way, the lack of interest and little use of these safety standards can cause illness and human losses in the worst case [1].

The adequacy of ergonomic workstations is essential to prevent injuries and occupational diseases, for this reason it is essential to reduce fatigue and stress, to increase productivity, health and quality of work.

This research was done with the objective of identifying and eliminating possible risk factors that may cause musculoskeletal injuries or disorders, such as repetitive movements, awkward postures or heavy loads. At the same time, this analysis on the ergonomic impact on office workstations will allow the university and us as students to contribute scientific knowledge in the field of ergonomics and occupational safety, it also serves to inform policies and work practices around the world, while fostering collaboration and can be used by other researchers and practitioners to improve the well-being of workers.

II. Materials and methods

This project was developed through a systematic literature review, defined as an observational and retrospective research design, which synthesizes the results of multiple investigations [2].

> Investigation can be conceptualized as "a process by which an attempt is made to find the answer to a research question or the solution to a problem in a systematic way and with demonstrable facts [3, p. 16].

In order to carry out this research, a bibliographic review was carried out to gather scientific information on the ergonomic impact on office workstations. The search was conducted through the university repository, digital library and databases (Scopus) of the Universidad Cooperativa de Colombia. At the same time, digital channels such as academic Google were used, where scientific articles, academic papers and scientific journals were found. Likewise, some web pages were analyzed just to clarify some concepts. Then the most relevant information was selected according to criteria or keywords, such as ergonomics, office positions, occupational disease, among others. Taking into account the information in an eight-year timeline. And, finally, the selected information is organized, presented in the document, and an analysis and discussion of the results with their respective conclusions is made.

III. Conceptual framework

- *Ergonomics*: Ergonomics seeks to improve work systems or any human activity, in order to adapt it to the characteristics, abilities and limitations of each person, seeking to obtain an efficient, comfortable and safe performance [4]. The international association of ergonomics defines this concept as a scientific discipline related to the understanding of interactions between human beings and other elements of a system, and also as the profession that applies theoretical principles, information and methods of a design in order to optimize the welfare of man and the performance of systems as a whole [5].
- *Productive efficiency*: It can be defined, in a technical sense, as a characteristic of productive processes that implies the use of the least possible amount of inputs to obtain a target output [6]. This concept focuses on whether the company is being efficient from the production point of view, i.e., it will be considered efficient if it operates according to the production function, i.e., if it obtains the maximum yield from the productive factors used, without wasting resources [7].
- *Job performance*: The total value that the company expects with respect to the discrete episodes that a worker performs in a given period of time [8].

- *Ergonomic office workstations*: An ergonomic office workstation is one that allows workers to perform their work with a minimum risk of acquiring occupational diseases due to poor handling and adequacy of work tools. Office ergonomics seeks to design an adequate work environment and reduce risks related to the type of activity performed, correcting inadequate posture, poor lighting, mobility difficulties, among others, and avoiding negative repercussions on the employee's health and well-being, such as musculoskeletal injuries in the neck, hands, wrist, shoulders, circulation problems, and visual impairment [9].
- *Job stress*: It is the harmful psychobiological response, which occurs when the obligations of a job do not match the capabilities, resources or needs of the worker. The cause may be directly related to the job, such as workload, limited decision-making possibilities, etc., or it may be related to the work environment, due to poor communication and interpersonal conflicts. It can also be related to difficulties in balancing work and personal life. Work stress has caused various negative effects on physical and mental health, becoming a problem for employees, companies, and occupational health areas, thus causing absences from work, among other affectations [10].
- *Musculoskeletal disorders*: Can be defined as a consequence of muscle overload associated with poor posture, strength, repetitive movements and the frequency and duration of work activities [11].

  Occupational health problems affect both workers and employers and cause discomfort, pain, reduced productivity and can lead to disability.
- *Safety and health*: Safety and health arose from unexplained events that caused injuries or deaths in the work environment [12]. It plays a valuable role today in supporting the recognition, evaluation and control of risk factors and their associated risks. Occupational health and safety management systems are not only about defending the worker against a threat of occupational risk [13], but also that it seeks a positive outcome of health promotion and integrity, for personal development.

IV. Theoretical Framework

Performing jobs for long periods of time can cause them to become monotonous and be performed mechanically and without critical thinking, which can generate musculoskeletal disorders in workers due to repetitive postures and movements. This, in turn, can affect the quality of life and well-being of workers. To address this problem, the science of ergonomics has been developed, which seeks to reduce the negative effects of the work environment both physically and psychologically, in order to ensure optimal safety and work environment. To this end, various evaluative methods are used to determine the problems that can be generated by routine work.

In recent years, several researches have been published on ergonomics in the workplace, and I will mention some studies related to the present research, such as:

In research developed in Ecuadorian universities, whose general objective is to analyze ergonomic development through forced postures in routine work [14]. The methodology used consisted of documentary and bibliographic research. The results obtained were based on the analysis of the characteristics of ergonomics, ergonomic risks and methods of evaluation of awkward postures. As a conclusion, it was determined that the implementation of studies that evaluate the loads executed by workers based on standards such as OWAS and REBA [14], what they seek is to evaluate through observation, the forced postures of individuals in their workplace, as well as to obtain a quantitative qualification of the movements they perform when having a certain workload.

In another study, conducted between universities in Mexico and Colombia, whose objective was to know the criteria and standards of illumination levels and thermal comfort in office workers working in front of data display screens, the results showed that there are no permanent effects on vision due to computer use [15]. However, visual fatigue can reduce workers' performance. At the same time, they offer recommendations for those who occupy positions with data display screens to reduce the problems derived from the exposure of the display screens and to make positions more in accordance with the capabilities of the people and their interaction with the environment, screen, chair and work plans. This will also reduce worker complaints and increase quality, productivity and well-being. However, they also point out that lighting levels and thermal comfort for offices should be evaluated taking into account the type of task and geographical context for workspaces and taking national and international standards as references.

Research has been conducted in Australia on the effectiveness of injury prevention counseling tailored according to the Stage of Change (SOC) approac [16]. Managers of 25 workgroups from medium and large companies in various occupational sectors were assigned to receive standard or tailored ergonomic counseling according to the workgroup's SOC. After 12 months, semi-structured interviews were conducted with each manager. In a multivariate model,

it was observed that those who received tailored advice implemented more recommended changes and more —additional— changes compared to those who received standard advice. Qualitative analysis identified that the main barriers and facilitators to implementing changes were related to workers' resistance to change and senior managers' attitudes toward health and safety. In conclusion, the results suggest that adapting ergonomic counseling to SOC principles can improve the implementation of ergonomic recommendations.

Turkish scientists determined the effect of ergonomic intervention on the health complaints of office workers using the survey method, as well as ergonomic observations of the participants and their work environment [17]. Ergonomic trainings were carried out in a general way and proved to reduce the risk factors at work, at the end of the intervention it was determined a better working posture and in the use of equipment. Also, as a result, the proportion of participants with musculoskeletal and eye complaints decreased from 81.2% to 62.5% and from 52.5% to 28.7%, respectively. These results demonstrate the need for this type of program to be carried out in organizations for all risk groups by occupational health and safety units.

A critical analysis of the current urban paradigm carried out in Chile states that the concept of ergocity arises from a systematic approach to ergonomics and its correlation with criteria such as comfort and wellbeing applied to the city [18]. The methodological approach used here allowed them to characterize, identify and describe the public space and the factors that have a negative impact on its quality and on the valuation that people give them, through physical and perceptual indicators that make it possible to integrate their vision and their relationship with objects, the environment, the design and urban planning, concluding in the emergence of a new critical knowledge related to the improvement of public space in order to guarantee the adaptability of people and their way of inhabiting the spaces and incorporating the mechanisms of planning and development of our cities and territories, avoiding the continuous adaptation of people to the built environment.

A systematic approach is needed to increase the impact of ergonomics in organizations, and it is precisely intended to present the results of an ergonomic macro-diagnosis carried out in five Colombian organizations using the Ergonomics Maturity Model (EMM), which evaluates the capacity of an organization to introduce, implement and develop ergonomics [19]. The model evaluates a set of —influencing factors— that allow a systematic analysis of the organization and classify it into one of five possible maturity levels. The results showed that the organizations evaluated were at the lowest maturity level of the MME: "lack of knowledge", this is due to the lack of trained personnel, the lack of a responsible work team in the ergonomics area, a reactive approach to problem solving, the lack of ergonomic alignment with the organizational strategy and poor risk assessment, among other factors. In conclusion, this research shows that macro ergonomic aspects are poorly considered, which is reflected in the low level of maturity achieved.

In a randomized controlled trial (RCT) conducted in the Netherlands, which aimed to examine the effectiveness of the StayWork Participatory Ergonomics (PE) program in preventing low back and neck pain, 37 departments were randomly assigned to either the intervention group (PE) or the control group (no PE) [20]. During a six-hour meeting, the work groups followed the EP steps and developed ergonomic measures to prevent low back and neck pain, which were subsequently implemented in the departments. The prevalence, intensity and duration of low back and neck pain were assessed by questionnaires at baseline and at 3, 6, 9 and 12 months follow-up. The primary outcomes were prevalence of low back and neck pain, and the secondary outcomes were pain intensity and duration. After 12 months, the analysis revealed that the intervention was no more effective than in the control group in reducing the prevalence, intensity and duration of low back and neck pain. PD did not increase the likelihood of preventing low back pain, nor neck pain. However, PD increased the probability of recovery from low back pain, but not neck pain. In summary, PE did not reduce the prevalence, intensity and duration of low back and neck pain, nor was it effective in preventing low back and neck pain. However, PE was more effective in the recovery of low back pain.

In addition, it should be noted that nowadays the study of the negative impact of ergonomics is increasingly relevant in industrial plants, due to the cause-effect relationship, since it can bring problems for both workers and the company itself. The main objective of another systematic review study conducted in Peru was to identify the negative impact [21]. For this purpose, databases such as ProQuest Ebook Central and Peruvian and Spanish standards were searched, with priority in Spanish language sources and years after 1998 until 2018. The review of different research focused on the origin of the impact of ergonomics, the standards that regulate such impact and the consequences of exposure to dysergonomic risk factors. As a result, it was found that the nega-

tive impact of ergonomics can be physical (exposure to noise, temperature, etc.), chemical (exposure to dust, fumes, etc.) and ergonomic (handling of loads, forced postures and repetitive movements), which can cause occupational diseases, these diseases when evaluated and compared with existing regulations can allow managing improvements in industrial plants by early identification of health problems of workers, which in turn benefits the industrial company.

In this case, Musculoskeletal Disorders (MSDs) are known as one of the main problems affecting the health of industrial workers and can lead to lost work days, functional incapacity and waste of an organization's financial resources. Studies conducted in Iran aimed to evaluate the effect of ergonomic interventions on the reduction of MSDs and the improvement of working posture in workers in a foundry industry [22]. These studies involved 117 male workers who were divided into four different groups: a control group, a group with specialized ergonomic training, a group with on-the-job intervention, and a group simultaneously subjected to training and on-the-job intervention. The 4 groups were evaluated during an initial follow-up period, at 6 and 12 months. The Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) and direct observations of work postures using the Quick Exposure Check (QEC) method were used to evaluate the results.

The results showed that the interventions were effective and that the difference in final score was significant between the different groups. In addition, the interventions led to a significant decrease in QEC scores and musculoskeletal symptom scores in the neck, shoulder, lower back, knee, and lower leg regions among the different groups. In the end, it was determined that workstation modification and workstation training and intervention simultaneously had a greater effect on MSDs and work posture improvement compared to training alone.

Researchers from Indonesian Universities examined the effects of an ergonomic intervention on workers in a traditional metal foundry who manually pour molten metal into molds [23]. Workers often complain of musculoskeletal complaints, which have activity, physical, and motivational aspects. To conduct the study, stratified random sampling was used and the subjects ($n = 127$) were divided into three groups: the Process Cement Department (PCD) group, the Loam Department (LD) group, and the Black Sand Department (BSD) group. Musculoskeletal complaints and fatigue were assessed by questionnaires one month before the intervention, as well as one month and eight months after. The results indicated that the LD group experienced a smaller reduction in musculoskeletal complaints and fatigue compared to the other groups. In addition, positive effects of the ergonomic intervention were observed on the workers' back, waist, left thigh, right knee, right ankle and left foot ($p < 0.05$). The intervention also had a positive impact on activity-based fatigue was no longer felt in the body and legs, and the feeling of wanting to lie down decreased. Physical and motivational fatigue experienced by workers manifested as headaches, back pain, thirst and malaise, difficulty concentrating, thinking and controlling behavior ($p < 0.05$). In summary, ergonomic intervention can reduce musculoskeletal complaints and fatigue, especially through a morning briefing, the use of ergonomic ladles when pouring molten metal into the molds, and the consumption of nutritious food during breaks.

An analysis carried out at a certain Peruvian university was aimed at improving the productivity of the logistics area of Eurosport & Performance S.A.C. [24]. A quasi-experimental research design was carried out with a quantitative approach and a sample of 15 employees. For the initial diagnosis, surveys were conducted with company representatives, field observations and physical inventories, invoices, work orders and database were counted. Software such as Microsoft Excel and SPSS, and tools such as the Problem Tree, Ishikawa Diagram and Pareto Diagram were used. Several indicators were analyzed, including cognitive ergonomics, productivity, physical ergonomics, efficiency, effectiveness and profitability. The results showed that the implementation of ergonomics can improve productivity, achieving an overall average increase of 28.82%. However, during the implementation of ergonomics, limitations were found, such as the lack of training of workers in active breaks and ergonomics, the health emergency situation due to COVID-19 and the availability of company representatives. Despite these limitations, the management model managed to significantly increase the company's efficiency, effectiveness, profitability and productivity.

A Mexican journal on Industrial Engineering published a study carried out for the ergonomic evaluation of a workplace in a company of the metal-mechanic sector, with the objective of identifying the musculoskeletal risk factors of the workers and determining their risk level [25]. Two evaluation methods were used: the method of the National Institute for Occupational Safety and Health (NIOSH), which allows evaluating tasks involving lifting loads and provides the maximum recommended weight; and the OWAS method (Ovako Work Posture Analysis System), which is based on the observation of the different postures adopted by the worker in his back, arms and legs, in addition to the weight of the load during the development of his task.

The results have shown that the postures adopted during the task have the potential to cause damage to the operator's musculoskeletal system, and that there is a high risk due to the lifting of loads. Consequently, it is concluded that preventive measures are required to reduce the risk of musculoskeletal injuries in this specific workplace.

On the other hand, research carried out in the city of Cagua, Venezuela, focused on the identification of the risks of musculoskeletal injuries in the job "Low pressure table assistant" [26]. A sample of 10 men was used in phase I and two in phase II: high school graduates, sedentary, 31 years old on average, working in rotating shifts from Monday to Friday, and the tasks of boxing, removing sheets, positioning, crating, transferring and palletizing were evaluated. MODSI methods and the NIOSH equation were used to identify the risks of musculoskeletal injuries, and it was found that the tasks of packing and removing sheets present a —medium— level risk, while the tasks of positioning, packing, transferring and palletizing present a high risk. In addition, positioning and transferring tasks presented a —very high— risk due to prolonged standing, torsional movements of the trunk, extension of shoulders, elbows and arms, lateralization of the wrists, flexion of the back and neck, and relative strength. To reduce the risk of musculoskeletal injuries, it is suggested that a plan be implemented to reduce the number of rejected bottles, design hand tools to uncork bottles, install a chair for alternating postures, a preventive plan for musculoskeletal disorders and active breaks, provide personal protective equipment, expand work spaces, and incorporate mechanical aids appropriate to the characteristics of the tasks and the needs of the workers.

IPB University emphasize the importance of considering ergonomic issues at work [27]. MSDs were examined using the Nordic Standardized Questionnaire and the Wong-Baker Pain Rating Scale. Physical-mental-social fatigue was measured by the Cumulative Fatigue Symptom Index (CFSI), and job satisfaction was assessed from eight variables, such as salary, employment, accessibility, health services, living conditions, work equipment, training and social services. It was found that most workers suffered from severe musculoskeletal disorders in various parts of the body, indicating the need to improve the ergonomic conditions of work tools and techniques. In addition, the most common fatigue symptoms were found to be physical in nature, suggesting the need to address physical working conditions to reduce fatigue and improve workers' health and well-being.

A. Fundamental theoretical contexts

The workplace is the space where each individual performs his work functions within the organization, its efficiency will depend on the adequacy of the position and the tools it has. Designing a workstation is a necessity, not only for the organization, but also for each individual in the company. Because, if the workstation is not adequate, but on the contrary is uncomfortable, exhausting, dangerous, or even unpleasant, this will detract from quality and productive efficiency. On the other hand, if the employee has a safe, comfortable, stimulating workplace, designed according to his or her functions and needs, it will provide physical and emotional satisfaction, thus bringing greater efficiency, quality and work performance [28].

The importance of workplace design is fundamental for the employee, because it can have a direct impact on their performance and effectiveness in the development of their activities, bringing non-monetary and economic benefits [29]. Likewise, they can provide income, increase self-esteem, help interpersonal relationships and create meaningful life experiences, and in the opposite case, it can be a source of physical and mental harm, stress and anxiety for its occupants.

It is here where you can see the importance of including ergonomics in the design of workstations, let's keep in mind that ergonomics is a science, which aims to find balance between man and tools. It seeks to achieve greater comfort for workers.

Ergonomics studies the factors that influence the reciprocal relationship between man-tools (machine), impacted by the environment. This relationship complements each other for a better performance; the individual reasons and acts, while the tools must be coupled to the needs of man, both in handling and in appearance and communication. Ergonomics aims to give the indications that the designer must use for the optimization of the work to be performed by the individual-machine composite. The individual is understood as the person who manipulates the tools (machine), and the environment as the physical and social environment that surrounds the man-machine combination [30].

The Human-Machine system is considered as a set of elements that establish a synergic communication following a series of rules, in order to achieve the established goals, and whose performance is the result of the interaction and joint work of all the elements involved [31].

The ergonomics is a science that encompasses different disciplines responsible for studying the relationship between the person and the machine, analyzing their needs, capabilities and competencies of individuals, focusing on those specific points that

impair the work environment, process quality, production efficiency and product quality [32]. The object of study of ergonomics is to optimize the unnecessary efforts of the worker, to improve his capacity and performance in productivity and efficiency.

The contextualization of ergonomics is evolving with a systemic approach aimed at an appropriate balance between the economy, society and the environment [33]. The goal of ergonomics is to prevent injuries and illnesses in the workplace. Performing activities on a computer constantly and with a bad position or posture during a long working day increases the risk of many chronic diseases. According to Law 1562 of 2012 [L1, art. 4], occupational disease is that acquired by the high level of exposure to risk factors related to their work activity or to the work position in non-ergonomic conditions that have been imposed on the worker to develop their tasks [34]. Office workplaces have a series of factors that make possible risks that affect the well-being and health of employees.

Some of the most frequent illnesses in office work are thigh-skeletal disorders, due to certain postures adopted, causing back pain, hand and wrist pain, tension, etc. On the other hand, we have eye discomfort due to continuous work on screens such as the pc, poor lighting, or lack of natural light. Depression, stress, anxiety, discouragement and restlessness also become some diseases that can occur in office jobs, due to pressure, lack of active breaks in the workplace, and deficiency in the structure of the organization. And finally, contagious diseases can be contracted due to poor ventilation in overstaffed offices, facilitating the spread of viruses and bacteria [1].

There are different pathologies that are diagnosed in Colombia as occupational diseases, among the main ones we can find the following: numbness and tingling in the hand and arm, shoulder tendinitis, lumbar pain, inflammation of tendons and tendinitis of the wrist and hand, stress and anxiety disorders, among other injuries caused by a poorly conditioned workplace.

It should be noted that some medical conditions do not manifest themselves or are not diagnosed instantaneously, but are progressive diseases, i.e., over time the signs and symptoms appear first, and then the pathologies. Depending on the time and the level of risk factors to which the worker is exposed, the development of the pathology can be accelerated or reduced [35]. For this reason, it is of vital importance that, from the design of the workstations, the risks and needs to which each individual will be exposed at the time of exercising their position are taken into account. In addition, the occupational health and safety department must ensure appropriate monitoring in the management and control of risk factors that may directly or indirectly harm workers.

On the other hand, a work climate with distractions, noise, bad environment, among others, has a negative impact on the health and well-being of workers, but if, on the contrary, they have adequate facilities that allow better communication, concentration and contact with nature, this will provide a healthy workspace [36]. In a survey of 2 000 office workers carried out for this article, these workers expressed a preference for plenty of natural light, access to outdoor spaces, peer support, private spaces and collaborative spaces.

In addition to the size of the space, the way of distribution directly influences the functionality of these, determining that not only the amplitude of the place allows a better functionality, but also the way of distribution, and use of tools and work surfaces, will help us to have a good performance and productive development in the workplace [37].

V. Discussion

The analysis of job satisfaction also revealed that salary and work situation significantly influence job satisfaction, suggesting that improving working and economic conditions could have a positive impact on workers' satisfaction and well-being. In general, it is recommended that occupational safety and health measures, such as the use of personal protective equipment and improved work techniques, be implemented to reduce the risks of injury and fatigue among workers. It is also suggested to promote safe behavior and provide training and professional development opportunities for workers to improve their job satisfaction and well-being at work.

An innovative solution to evaluate ergonomics in a rod bending process is presented in a research conducted in a Mexican construction company [25]. The proposed automated system uses the Microsoft Kinect sensor to capture and process information about the postures and movements of the operators during the process. The software processes the information captured by the device and uses the OWAS method to evaluate the ergonomics of the workers' postures and movements.

The results of the study show that the automated system is highly reliable and effective in ergonomic assessment. It was statistically proven (95% confidence) that the automated system provides ergonomic assessments with results similar to those of a traditional expert assessment. In addition, the automated system is capable of performing assessments in real time, which means that problems can be identified and corrected quickly and efficiently. This presents an important contribution to the improvement of occupational health and safety, as it offers an automated and reliable tool for the evaluation of

ergonomics in industrial processes. The application of this technology can help companies reduce the risk of work-related injuries and illnesses, which in turn can improve the productivity and well-being of workers.

Chinese researchers describes the assessment of different body postures required for operations in the garment sewing industry (positioning, aligning pieces, sewing, straightening, depositing garments in a suitable location) which were observed in nine different workplaces using the REBA and OWAS methods to assess the strain present at work and the need for workplace design interventions [38].

It is noted that garment sewing is an industry with closed-type workplaces in which workers continuously perform similar operations. The work requires sitting at a sewing machine, and the worker uses hands and performs machine hand operations. The hands and upper body manipulate the actual fabric and the feet/legs operate the sewing machine at short intervals which, when repeated throughout the workday, strain the worker. The actual operations depend on the type and character of the garment, as well as the technological performance of the sewing machine and the worker's aptitude for the job.

The results indicate that strain is present in all the workplaces studied, thus necessitating intervention in workplace design. Workplace redesign also implies a correct design of the overall work system (man-machine-environment) in line with the static and dynamic anthropometric characteristics of individual workers, as well as the application of the most favorable work process to ensure less strain and less fatigue.

Ultimately, it is suggested that measures be taken to improve ergonomics and reduce stress in garment sewing work, with the aim of improving the health and well-being of workers and increasing efficiency and productivity in the workplace.

MSDs are a very common ailment among employees working in Small and Medium-Sized Enterprises (SMEs) and large industries. A study conducted in manufacturing SMEs in Indonesia aimed to examine the risk of MSDs among workers in the SME manufacturing sector using two ergonomic approaches: self-report (SR) and observation method (OM) [39].

The Self-Report (SR) approach used the Nordic Body Map (NBM) to assess the level of comfort and complaints reported by workers. On the other hand, the Observation Method (OM) used the Rapid Upper Extremity Assessment (RULA) to evaluate the working posture of the operators.

The self-report assessment based on the NBM revealed the main concerns related to the upper body, such as the back, neck, hips and buttocks. Meanwhile, the RULA-based assessment found that workers' posture scored a 6, indicating the need for further analysis and urgent changes.

Based on the results of the RULA assessment, it is recommended that ergonomic measures be implemented in the workplace to reduce MSD problems and create more relaxing work environments. After making the necessary changes, the new workplace scored 3 on the RULA assessment, indicating a satisfactory posture.

In conclusion, the Self-Report (SR) method is beneficial to perform a preliminary assessment before carrying out the subsequent assessment using the Observation Method (OM). It is crucial to perform follow-up assessments to provide recommendations based on the ergonomic risk assessment.

Unilibre studies determine the prevalence of musculoskeletal pain and associated factors in teachers of a technical and technological educational institution in Colombia [40]. Using a cross-sectional methodology in a population of 103 workers, where sociodemographic, physical and labor data were collected through interviews and the application of the Nordic Kourinka Questionnaire. The results showed that the highest prevalences of musculoskeletal pain in the last 12 months were neck pain, low back pain and back pain. A statistically significant association was found between back pain with female gender, low back pain, knee pain and ankle/foot pain with physical activity of less than 150 minutes per week, ankle/foot pain with extra-occupational activity and shoulder pain with seated working hours. In conclusion, it was determined that the prevalence of musculoskeletal pain in teachers in this population is important and some relationships with statistically significant association between biomechanical risk factors and musculoskeletal pain were found.

Brazil and USA jointly conducted a systematic review study focused on exploring the effects of job rotation programs on the prevention and control of MSDs and psychosocial factors in the manufacturing industry [41]. The researchers conducted a comprehensive search of several peer-reviewed journal databases MEDLINE, EMBASE, Business Source Premier, ISI Web of Knowledge, CINAHL, PsyINFO, SCOPUS, and SciELO and examined 71 full-length studies for relevance and methodological quality. Of the 14 studies included in the systematic review, only one was rated as being of good methodological quality.

The results indicate that there is currently weak evidence to support job rotation as a strategy for the prevention and control of MSDs in the manufacturing industry. Although job rotation does not appear to reduce exposure to physical risk factors, positive

correlations have been observed between job rotation and increased job satisfaction. Worker training is described as a crucial component of a successful job rotation program, and a number of metrics used to implement and measure job rotation programs have been identified.

In summary, although job rotation may have some benefits for job satisfaction, there is currently no strong evidence to support its effectiveness in the prevention and control of MSDs in the manufacturing industry. More rigorous studies are needed to better understand the full impact of job rotation on production and worker health.

Institutes in Sweden investigated upper airway response and physical workload following airborne and ergonomic exposure to aerosols used by cleaning workers, who are often exposed to chemicals and high physical workload that can cause airway problems and pain [42]. The researchers conducted a survey of professional cleaning workers to learn about the use of cleaning aerosol and its effects on eyes, respiratory tract and musculoskeletal pain. Subsequently, a human chamber exposure study was conducted with 11 professional and 8 non-professional cleaning workers to investigate airborne exposure, acute effects on the eyes and respiratory tract, and physical burden during cleaning with aerosol sprays, foam application, and microfiber cloths pre-moistened with water. All cleaning products used were free of bleach, chlorine and ammonia.

The medical evaluation included ocular and respiratory tract parameters, inflammatory markers in blood and nasal lavage, as well as technical records of physical load. In addition, it was revealed that 77% of the 225 professional cleaning workers used aerosols frequently. The chamber study showed that switching from a spray nozzle to a foamer decreases exposure to airborne particles and Volatile Organic Compounds (VOCs), thus reducing eye and respiratory effects without increasing ergonomic burden. The use of foam was found to reduce the effects on peak nasal inspiratory flow compared to the use of aerosol and technical records showed a high physical workload regardless of spray or water cleaning.

The results indicated that the use of foam is preferable to the use of spray to improve the work environment for cleaning workers, especially if the use of cleaning products containing bleach, chlorine and ammonia cannot be avoided.

Ecuadorian studies describe how the agro-industrial pineapple processing company AGROEDEN decided to carry out an evaluation to improve workers' working conditions, productivity and the quality of its services. [43]. To this end, the levels of ergonomic occupational hazards were analyzed qualitatively and quantitatively in two work processes: planting and packing, the workstations, forced postures and ergonomic comfort were evaluated, and proposals for improving the work environment were issued.

The evaluation has identified that the organization is at a —Moderate— level by analyzing musculoskeletal symptomatology in 10% of the workers, due to postural habits and efforts derived from the activity they perform during the workday. The assessment has also provided information to prepare a qualitative occupational risk matrix, which establishes that the jobs with the highest level of occupational risk are those of planting and packing, due to forced postures and repetitive tasks. This ergonomic evaluation allows the company to know the occupational risks to which workers are exposed and, consequently, to establish measures to improve working conditions and prevent musculoskeletal injuries and other work-related health problems.

In the Garo Hills region of Meghalaya, India, tea picking is carried out in a traditional way, which increases the risk of musculoskeletal disorders in female workers, especially in those who have been doing this activity for a longer time, in which a sample of 40 female workers with more experience in tea leaf picking was selected [44]. A 5-point scale was used to record musculoskeletal pain, ranging from mild pain (1) to very severe discomfort (5), to measure the strain on the muscles used in the work. Correlation coefficient was used to explore the relationship between age, years of activity, Body Mass Index (BMI) and musculoskeletal problems in women. In addition, analyses of upper extremity discomfort were performed using a Rapid Upper Extremity Assessment technique (RULA) and whole body discomfort using a Rapid Whole Body Assessment technique (REBA).

The results showed that, during tea picking, workers experienced severe discomfort in the head (4.5), neck (4.3), both fingers (4.2), upper and lower back (4.3 and 4.4) and feet (4.3). The RULA analysis yielded a high score of 7, indicating the need for immediate changes. Also, the REBA score was 11 for all parts of the body, suggesting that the workers were under great physical strain.

In conclusion, severe musculoskeletal disorders can lead to permanent disability in workers, preventing them from returning to work or performing simple daily tasks. Therefore, it is necessary to provide rest periods, ergonomic interventions and personal protective equipment to minimize discomfort in the tea picking activity by female workers.

The objective of research conducted by Belgium and China was to document the distribution of joint loads on the human body during different occupational tasks in order to improve ergonomic recommendations and prevent work-related musculoskeletal disorder [45]. Ground reaction forces and 3D motion capture were measured in 20 participants while performing ten different occupational tasks. A detailed musculoskeletal model was used to calculate internal joint loading in terms of contact forces and compared to external loading approaches commonly used to assess injury risk. The results showed that lifting 10 kg from the ground imposed the greatest internal joint load on the whole body, while lifting 10 kg from hip height to shoulder height imposed the least internal joint load. Furthermore, it was observed that only during tasks involving an upright standing posture did the load proxies correlate well with internal joint loading. In summary, this study suggests that the information obtained through this modeling workflow may be useful for optimizing load distribution across different anatomical regions and improving ergonomic recommendations in the workplace.

Accident rates for work-related musculoskeletal disorders have been observed to vary widely among companies, even when they belong to the same industries and have similar sizes. US researchers set out to identify common risk factors for back, shoulder, hand/wrist and knee MSDs in the manufacturing sector [46]. It also sought to characterize biomechanical workplace exposures and work organization practices among companies with high and low rates of MSD claims, so that sector-specific intervention strategies could be developed.

The researchers used historical workers' compensation data to divide manufacturing companies into two matched groups (low and high in the bottom 25% and top 75%, respectively). A total of 432 workstations in 16 companies were evaluated to determine the levels of biomechanical workplace risk. In addition, management and worker representatives from 32 matched companies were interviewed to indicate possible differences between management strategies and management-worker relations. A total of 39 injured workers were also interviewed to collect information on self-reported causes of injury and suggested preventive measures.

The results indicate that companies with a high MSD accident rate have more jobs with high biomechanical exposure than companies with a low MSD accident rate. More jobs were found to have higher risk levels of prolonged standing and heavy lifting in high accident rate companies than in low accident rate companies. No elevated biomechanical risk factors associated with jobs were found in companies with a high shoulder accident rate. High repetition rate, pinch force and strain rate were associated with companies with a high hand/wrist MSD accident rate. High work pace and work stress were common in companies with a high MSD knee accident rate. There were no statistically significant differences in organizational factors between companies with high and low MSD accident rates. Injured workers identified heavy lifting, fast work pace, high hand/wrist repetition, high hand force, and forced shoulder postures as the main contributing factors.

In conclusion, it was found that companies with a high MSD accident rate have more jobs with high biomechanical exposure than companies with a low MSD accident rate. Available job evaluation methods for low back and hand/wrist are satisfactory for quantifying risk levels in manufacturing jobs, while more sensitive job evaluation methods for the shoulder and knee need to be investigated.

Finally, studies from the Netherlands analyze how interventions aimed at reducing exposure to work-related physical risk factors to prevent MSDs are highly recommended [47]. The study "A first step towards a framework for interventions for individual working practice to prevent work-related musculoskeletal disorders: a scoping review" also says that in addition to interventions targeting organizations and the workplace, interventions also target workers' behavior, the so-called Individual Work Practice (ITP) and as there is currently no conceptual framework for ITP interventions, this study is a first step towards creating such a framework.

In the review, databases such as Ovid Medline, Ovid Embase, Ovid APA PsycInfo and Web of Science were used to find intervention studies addressing worker exposure to physical ergonomic risk factors. The content of these interventions was extracted and coded for ITPs to arrive at distinctive and general categories of these interventions. We included 110 intervention studies describing 810 topics for ITP.

From this, eight general categories of interventions for ITP were identified: job adaptation, variation, exercise, use of aids, occupational skills, occupational manners, task content and organization, and motor skills. These categories are a starting point for developing and evaluating effective worker-delivered interventions to prevent MSDs. However, an international expert consultation is needed to reach a consensus on these categories. In summary, the study offers insight into how work-related MSDs can be addressed and provides a basis for developing effective interventions in ITP.

VI. Results

Within this systematic analysis, scientific information has been collected from authors with an ergonomic approach, where a bibliographic and applicable contribution on the subject of ergonomics in office workstations is intended. Accordingly, literary results were obtained on the subject, where the different factors that influence the impact of ergonomics in office workstations are described.

Within these factors, we find the need that companies currently have to prevent injuries caused by occupational hazards and the importance of an ergonomic workplace design, identifying the benefits it brings to the worker and the company. In view of this, it is important to know how to design and know the characteristics of an ergonomic workstation.

One of the functions of ergonomics in an organization is to create a sustainable work system, recognizing the employee as a key factor in the work environment, establishing solutions that facilitate the performance of work activities, with maximum performance for the employee and for the company. That is why the main thing to create a healthy work environment, is the proper design of the workplace.

As mentioned in NTP:242 [48], for this ergonomic design in office workstations, three factors will be taken into account:

- *Workstation dimensions*: It is of vital importance that the workstation be adapted to the employee's body dimensions, thus allowing natural movements and postures for effective work.
- *Working posture*: An office job requires a prolonged position in a chair, which can cause health problems, especially back problems. To achieve a correct posture, the following factors must be ergonomically adapted: A functional work chair, a work table that facilitates the proper development of tasks, including footrests and armrests. Providing a better comfort to the employee.
- *Environmental comfort requirements*: The work environment also influences the productivity and well-being of the employee. That is why three factors are taken into account: lighting, noise and temperature.
- Having a luminous environment will generate satisfaction and avoid visual problems. As for the sound environment, for office work where concentration and frequent communication are required, there must be adequate noise levels. And, finally, we have the thermal environment, since office workstations are usually very closed, it is important to have a temperature that allows to condition the place in a correct way, avoiding dissatisfaction and fatigue to the employee.

Other factors to be taken into account for an ergonomic workstation design are [49]:

- Involve workers in improving the design of their own workplace.
- Ensure that smaller workers can reach controls and materials in a natural posture.
- Ensure that larger workers have enough room to comfortably move their legs and bodies.
- Locate the most frequently used materials, tools and controls within easy reach.
- Allow workers to alternate sitting and standing during work as much as possible.
- Provide workers with good adjustable chairs with backrests.
- Make office workstations that require data display screens (DSPs) adjustable by workers.
- Provide eye examinations and appropriate eyewear to workers for regular use of equipment with a Data Display Screen (DSP).

VII. Conclusions

Ergonomics is an important topic and one that should be taken seriously by companies and workers alike. The literature reviewed in this paper demonstrated that ergonomic problems in the workplace can have negative effects on the health, productivity and quality of life of workers. However, it has also been shown that the implementation of appropriate ergonomic measures can significantly improve working conditions and prevent injuries.

It is important to note that the implementation of ergonomic designs can be a great challenge due to the changing and complex nature of work, different aspects such as adaptability, comfort and safety in the workplace must be taken into account. Continuously improving ergonomic designs can have a significant impact on reducing and preventing workplace accidents.

It is essential that companies are committed to providing a safe and comfortable work environment for their employees. This involves investment in ergonomic furniture, ergonomics training for workers and the implementation of policies that promote wellness. For their part, workers must take into account their own health and well-being, be attentive to signs of fatigue and pain which may be related to poor posture or an inadequate work environment.

In short, ergonomics, especially as applied to office workstations, is an issue that requires attention and action by all parties involved. Therefore, it is suggested that companies seek advice and guidance from ergonomics experts to ensure that the designs imple-

mented are effective and appropriate for the type of work performed in each sector. If the right measures are taken, a healthy and productive work environment can be achieved that benefits both employees and companies.

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