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Impact of Ergonomics on Workers' Performance and Health

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***Abstract*—** *Ergonomics emerges as an essential scientific discipline, driving health, safety and increased productivity in work environments. This study aims to examine, based on the contributions of renowned authors, the application of ergonomics in Brazilian workplaces, highlighting its impact on the health and productivity of employees. The methodology adopted is a literature review from various official sources. Research has shown the relevance of physical and cognitive ergonomics in preventing musculoskeletal disorders and promoting well-being at work. It was clear that with the improvement in workers' quality of life, fatigue and stress are avoided, which improves the relationship between employees and employers, increasing productivity. The study shows the importance of applied research to strengthen ergonomic practices in organizations. The future of ergonomics is intrinsically linked to its ability to adapt and respond to new challenges, maintaining the commitment to promoting work environments that prioritize and cultivate human well-being.*

I. INTRODUCTION

According to Ferreira, Merino and Figueiredo (2017), ergonomics is the science of work, which studies interventions between human beings and other elements of the system, applying theories, principles, data and methods to projects to optimize human well-being. and overall systems performance.

Since among the factors that make up the work environment, ergonomic factors are those that significantly interfere with job satisfaction, in addition to being responsible for several issues that emanate from the workplace and need to be studied, ergonomic awareness now has , in this context, according to Gungor (2009), a substantial impact on the industry, organization, management, employees and general well-being of the system.

Nowadays, Mental Health practices in organizations coexist with pressure for increasing productivity, in a very competitive environment, in which the individual must always be ready for changes and adapt to market demands (VASCONCELOS; FARIA, 2008).

According to Vasconcelos and Faria (2008), in addition to working conditions, research showed that pressures resulted from the organization of work (division of tasks, repetition, cadence, hierarchy, command, control). For Dejours (1992), working conditions target the body, while the organization of work affects psychic functioning.

Sarmento and Villarouco (2020) show that ergonomics has consolidated itself as a key area for improving working conditions, adjusting the environment to meet the needs of workers. This approach underlies the first dimension of this research, focused on physical ergonomics and its importance in preventing musculoskeletal disorders and promoting work efficiency.

Additionally, studies such as Soares (2009) highlight that the benefits of ergonomics transcend individual well-being, positively impacting the organization by reducing absenteeism and increasing employee motivation. This perspective reinforces the relevance of understanding ergonomic practices as a strategic element for organizational development, an aspect explored in this work.

Ergonomics, understood as the science that seeks to optimize the relationship between workers and their work environments, plays a fundamental role in promoting the health, well-being and operational efficiency of individuals. In Brazil, the implementation of ergonomic principles faces particular challenges that reflect the need for detailed investigations into their effectiveness and adaptation to the national reality.

The ergonomics of the built environment, according to Sarmento and Villarouco (2020), provides valuable insights into optimizing spaces for health and efficiency, highlighting the importance of design and spatial configuration in the effective implementation of ergonomic practices.

The engagement of workers in the creation of ergonomic solutions, as pointed out by Soares (2009), is crucial to the success of these measures, ensuring that they are not only technically adequate, but also aligned with the expectations and needs of employees, an aspect that will be rigorously examined in this study.

This study aims to examine, based on the contributions of renowned authors, the application of ergonomics in Brazilian workplaces, highlighting its impact on the health and productivity of employees, contributing significantly to the field of ergonomics, suggesting strategies that maximize its benefits for workers and organizations.

The research presents a qualitative approach, which Gil (2019) highlights as important for investigations of lived experiences and Marconi and Lakatos (2019, p. 303) address that “the qualitative study develops in a natural situation, offering a wealth of data descriptive, as well as focusing on reality in a complex and contextualized way”.

Therefore, the research was developed in accordance with the principles of qualitative bibliographical research, through the search for already prepared material that discusses teaching through investigation and scientific literacy. Books and scientific articles were collected from databases such as: Scielo, Google Scholar, online repositories of universities and scientific journals.

Qualitative research in ergonomics, discussed by Palazzo and Diez-Garcia (2021), is essential for understanding the experience of workers and evaluating the effectiveness of ergonomic interventions. This study is dedicated to critically analyzing such perspectives, aiming to map perceptions about ergonomic practices and their concrete impacts on well-being and productivity.

II. FUNDAMENTALS OF ERGONOMICS

Ergonomics transcends mere spatial organization, involving a detailed analysis of the interaction between people, equipment and the environment. As Sarmento and Villarouco (2020) point out, this discipline is crucial to promoting well-being in multiple dimensions, encompassing not only physical comfort, but also mental and emotional aspects of workers. This holistic view allows for a broad understanding that employee well-being is influenced by a variety of factors, in addition to the physical, underpinning the importance of a properly designed work environment.

Furthermore, ergonomics continually adapts to new technologies and social transformations, highlighting the need for adaptability to meet the contemporary demands of work environments. Sarmento and Villarouco (2020) highlight that ergonomics must be a dynamic discipline, capable of responding promptly to the demands of today's workplaces, showing that ergonomics is a science in constant evolution, committed to offering relevant and effective solutions to the challenges of workers.

The interaction between different areas of knowledge, defended by Connor et al. (2023) and Jun et al. (2021), constitutes one of the foundations of ergonomic practices, highlighting the importance of multidisciplinary collaboration in creating healthy and efficient work environments. The fusion of different specializations contributes to the emergence of more complete and effective solutions, significantly improving well-being in the work environment.

Incorporating the contributions of Lima and Duarte (2014), it is understood that ergonomics, when acting from the initial design and engineering phases, can

significantly influence the final project solutions. By providing abstract "usage settings" that capture the essence of human interactions, ergonomists can guide design decisions in a more informed manner, ensuring that ergonomic aspects are integrated effectively from the beginning of the design process.

Furthermore, placing the human being at the epicenter of ergonomic considerations, as highlighted by Sarmento and Villarouco (2020), is essential to align employee well-being with the company's strategies. Person-centeredness in ergonomic practices ensures that actions are not only technically correct, but also strategically aligned with the organization's purposes and aspirations.

The implementation of ergonomic practices, highlighted by Connor et al. (2023) and Jun et al. (2021), demonstrates the company's commitment to the health and comfort of workers, establishing ergonomics as a competitive differentiator. This investment in human capital is recognized as an action that adds value not only to individuals, but also to the organization as a whole.

The ability of ergonomics to renew itself in the face of changes in the job market, as emphasized by Sarmento and Villarouco (2020), is also necessary to keep work practices aligned with innovations and best practices in the field. This dynamism ensures that ergonomics remain

relevant and effective, adapting to meet new technological and organizational demands.

Finally, the integration of ergonomic practices into corporate strategies, as emphasized by Connor et al. (2023) and Jun et al. (2021), highlights ergonomics as a preventive strategy that benefits all stakeholders. By adopting ergonomic principles, organizations not only respond to current challenges, but also prepare for a brighter future by cultivating a work environment that promotes innovation, health and sustainability.

III. ERGONOMICS AND ITS DOMAINS

The term Ergonomics is derived from two Greek words, ergon, which means work, and nomos, which translates as natural laws, which together define the science of work and a person's relationship with that work. According to the International Ergonomics Association, Ergonomics is technically defined as: the scientific discipline concerned with understanding the interactions between humans and other elements of a system, and the professional field that applies theory, principles, data and methods to design , in order to optimize human well-being and overall system performance (NAEINI; MOSADDAD, 2013).

According to Dul and Weerdmeester (2012), Ergonomics can be understood, more broadly, as the study of the design of a workplace, equipment, machine, tool, product, environment and/or system that considers physical, physiological capabilities , biomechanics and also psychological aspects of the human being.

Ergonomics science has three domains: physical, cognitive and organizational, the latter being a type of macroergonomics, through the understanding of organizational culture, work projects, human resource management, quality management and network and communication organization. According to Martins and Ferreira (2015, p.128), the three domains are:

> **physicist**— related to those that characterize the physical activities of the human body, such as anthropometric, biomechanical, anatomical and physiological aspects, thus studying posture at work, material handling, repetitive movements, work-related musculoskeletal disorders; cognitive — are focused on mental processes, involving perception, memory, information processing, reasoning and motor response, having mental workload, decision making, specialized performance, human-computer interaction, stress; organizational — related to the optimization of socio-technical systems, organizational structure, policy and process, such as communications, work design, temporal organization of work, new work paradigms, organizational culture, quality management.

3.1 Physical Ergonomics and Musculoskeletal Disorders

Musculoskeletal Disorders (MSDs) have a profound impact on the health and efficiency of workers, and it is essential to address them from an ergonomics perspective. Ramos et al. (2022) highlight the relevance of understanding and mitigating these conditions in the workplace, emphasizing that a detailed analysis can reduce the incidence of MSDs. Physical ergonomics is dedicated to adjusting the work environment to minimize these disturbances, providing effective solutions to improve employee health. Adaptations may include redesigning workstations, introducing ergonomic tools and promoting regular breaks for movement.

Low back pain, a common problem in work environments, illustrates the importance of preventive ergonomic strategies. Haeffner et al. (2018) highlight the need to adapt work spaces to prevent this condition,

showing that focused changes can significantly improve workers' lives. The causes of low back pain often include poor posture, inadequate lifting of weights and a sedentary lifestyle, and its impact on the work environment is significant, leading to absenteeism and reduced productivity. This focus on prevention is essential to avoid discomfort and maintain productivity, emphasizing adjustments to the height and ergonomics of workstations, as well as training on correct lifting and moving techniques.

In the fight against tendonitis, ergonomics is a key preventative tool. Ramos et al. (2022) suggest regular reviews of tasks and the layout of workstations to prevent movements that could trigger this condition. Tendinitis, inflammation of a tendon caused by repetitive movements or overexertion, can significantly impact work capacity, causing pain and limited movement. Ergonomic adjustments are, therefore, essential to avoid this and other diseases related to repetitive work, including the reorganization of tasks to evenly distribute muscular effort, and the implementation of tools that reduce the need for repetitive movements or excessive force.

Additionally, carpal tunnel syndrome also benefits from an ergonomic approach. Judicious adjustments to the work environment and the use of tools, as discussed by Magalhães et al. (2022), can reduce the risks of this syndrome, promoting a healthier and safer work environment. This condition, characterized by compression of the median nerve in the wrist, results in symptoms such as pain, numbness and weakness in the hand and arm. Strategies to mitigate risk include adopting ergonomic keyboards and mice, adjusting desk heights to ensure wrists maintain a neutral position, and performing strengthening and stretching exercises.

Bursitis, caused by repetitive movements or continuous pressure, is yet another condition where ergonomics can act preventatively. Interventions in the design of tasks and the physical work environment are recommended to prevent this and other conditions, as pointed out by Ramos et al. (2022), demonstrating the ability of ergonomics to address a diverse range of DMEs. Promoting a variety of movements and periodically changing tasks are practices that can help prevent overload in specific areas of the body, thus minimizing the risk of bursitis, which often affects shoulders, elbows and knees, causing pain and functional limitations.

Instructing employees in ergonomic and safety practices constitutes one of the main foundations of ergonomics in the workplace. Educational programs, such as those mentioned by Haeffner et al. (2018), play a vital role in alerting employees to the need to use work methods that protect their physical integrity. Such instruction must be comprehensive, covering recommended work practices and proposing knowledge about the signs and symptoms of musculoskeletal disorders, encouraging workers to seek early interventions to prevent the exacerbation of these disorders.

The rehabilitation of individuals affected by MSDs, emphasized by Haeffner et al. (2018), highlights the need for an integrated approach, which considers adjustments in the location and way of work to facilitate the safe return of the worker. These strategies may include adaptations to the workplace, flexibility in schedules, and the gradual introduction of tasks, ensuring that the return to work is beneficial for both the employee and the employer.

Finally, the effectiveness of ergonomic measures depends on continuous monitoring of work environments and collaboration between different professionals. Early identification and remediation of potential hazards is essential to preventing DMEs and ensuring a healthy and productive work environment. Multidisciplinary collaboration, involving ergonomists, healthcare professionals, managers and workers themselves, is essential to develop and implement effective strategies for preventing and treating musculoskeletal disorders.

3.2 Cognitive Ergonomics and Mental Health

Cognitive ergonomics is a crucial area that helps look after workers' mental health, looking at important issues such as how much they need to mentally exert themselves at work, the level of stress they face and how this affects their ability to concentrate. Beckert and Barros (2022) highlight how important it is to include this area in company policies, mainly because the The COVID-19 pandemic has heightened these challenges, making the work environment even more stressful for many.

When we talk about mental health at work, we are not just talking about emotional well-being, but also how this is reflected in the physical health of employees. The way work is organized, the complexity of tasks and even the environment in which they are performed can increase mental pressure on employees. Ramos et al. (2022) argue that adopting cognitive ergonomics measures can really make a difference, making the work environment more friendly to employees' minds.

Corrêa and Silva (2009) point out that taking care of workers' minds does not only mean helping them deal with stress, but also keeping their cognitive functions healthy. This can be done in a number of ways, such as changing the way work is structured, improving workplace design, or offering programs that provide psychological support.

Developing a work environment that supports mental health requires careful consideration of the structuring of tasks, the architecture of the workspace, and the style of feedback provided. Beckert and Barros (2022) emphasize the importance of making adjustments in these areas to minimize stress and enrich employees' mental health. There is a direct link between our mental well-being and professional performance.

According to Ramos et al. (2022), being mentally healthy allows employees to face the cognitive demands of their role, highlighting the importance of taking care of mental health to maintain satisfactory performance at work.

Observing how employees deal with mental pressure is essential to avoid mental disorders and promote a viable work environment. Carrying out constant checks, as Corrêa and Silva (2009) advise, is effective in recognizing difficulties and identifying the need for reformulations, whether in tasks or in business guidelines, to promote the health and efficiency of workers.

Working together – mental health experts, ergonomists and managers – is key to creating effective workplace interventions. This collaboration helps ensure that workers' needs are met and company objectives are achieved, all in an environment that promotes health and productivity.

Incorporating practices that improve well-being and offer psychological support, aligned with cognitive ergonomics, is crucial. Ramos et al. (2022) talk about the importance of creating a culture in the company that values mental health, providing an environment where the well-being of employees is a priority. Finally, the adoption of cognitive ergonomics practices appears as a powerful resource for promoting mental health and well-being in corporate environments. The experience of renowned organizations, such as Volkswagen do Brasil, illustrates the positive impact that such practices can have by establishing a more welcoming and motivating organizational climate. In this way, cognitive ergonomics is established as a pillar in the design of work spaces that value both productive efficiency and the psychological well-being of its members. Well-designed ergonomic strategies, what consider you aspects mental It is emotional of theemployees, are vital to organizational success and the perpetuation of a conducive and sustainable work environment.

3.3 Organizational Ergonomics and its Importance

Organizational ergonomics is a type of macroergonomics, through the understanding of organizational culture, work projects, human resource management, quality management and the organization of networks and communication, and the optimization of technical systems is among its main characteristics. , organizational structure, withLaw Suitand consolidated internal policy.

Organizational ergonomics is the structure and everything it encompasses in an organization, whether a company or institution, with regard to improving employees' working conditions. The most relevant factor in this area of ergonomics is communication between people, their policies, cooperation, networking and quality management in processes. Organizational ergonomics aims to optimize socio-technical systems, including organizational structures, policies or rules, and processes (FERREIRA; MERINO; FIGUEIREDO, 2017).

Thus, in the organizational context, it is essential that there is an accurate perception of the risks and ergonomic factors associated with work, whether in the countryside or in the city (RIO; PIRES, 2001). For Fernandes and Morata (2002, p. 706):

> Organizational stressors are factors related to work organization, such as shifts, rhythm and ergonomics, that is, the worker's relationship with their tasks. They alter the functioning of the entire organism and sleep, increase sensitivity to environmental stressors and, consequently, increase the risk of accidents at work. Combined, these stressors can have a range of effects on workers' health and well-being.

According to Martins and Ferreira (2015), among the different contexts in which Ergonomics can act, rural work is one of them. Agricultural activity is extremely important and also complex, and can result in a variety of accident and illness risks for rural workers. Such risks are present throughout the production process carried out in the field.

In this context, the Ministry of Labor and Employment, through Ordinance No. 3,214, of June 8, 1978 (BRASIL, 1978), created and is constantly reviewing regulatory standards (NR), which regulate and provide guidance on mandatory procedures related to Safety and occupational health. Among them are:

> NR 17 — Ergonomics, which aims to establish parameters that allow the adaptation of working conditions to the psychophysiological characteristics of workers, in order to provide maximum comfort, safety and efficient performance. Added to this, NR 31 — Safety and Health at Work in Agriculture, Livestock, Forestry,

> Forestry and Aquaculture — establishes the precepts to be observed in the organization and in the work environment, in order to make planning and work compatible development of agriculture, livestock, forestry, forestry and aquaculture activities, with safety, health and the work environment. According to this NR, rural or similar employers must plan health and safety actions aimed at preventing accidents and illnesses resulting from work in the rural production unit, taking into account the following order of priority: a) elimination of risks through replacement or adaptation production processes, machines and equipment; b) adoption of collective protection measures to control risks at source; c) adoption of personal protection measures. Still, it cites the need for employers to adopt ergonomic principles to improve comfort and safety conditions at work for their employees.

IV. MENTAL HEALTH AND ITS INFLUENCES ON ORGANIZATIONS

Mental health influences organizations and the lives of workers. In an organizational scope, that is, within companies, there is a notable influence exerted by the mental health of each employee within the organization, which consequently ends up affecting the level of productivity and profitability (SILVA, 2014).

According to Bergamini (1982, p19),

> "One of the aspects of human behavior whose study has been most encouraged today is that which seeks to understand how people live and solve their problems within their work context. Unlike technology, finance and commercialization, company management has made it clear that the human element is characterized as a preponderant factor in facilitating or compromising the achievement of organizational objectives".

Each organization is unique, each one has its own rules to be followed, objectives to be achieved by particular means to which they adhere, however they are all made up of even a small or large number of human beings in their composition.

According to Aguiar (1992, p 230),

> "The members of the organization group together to carry out organizational activities and relate to each other. As human beings, they bring their feelings, motivations, aspirations, values, skills, etc., to the organization. The organization develops its own culture, its behavior patterns, its beliefs and habits, common to all its members. All these factors interact. They are interdependent and influence each other. The organization, as a social environment, is a dynamic set of interacting factors, influencing the development of the individual characteristics of its members".

The influence exerted by organizations on their members is very strong, it does not influence everyone equally in the same way, but it ends up shaping everyone in some way. This influence conditions these members to add more ways to their personal ways of acting, often completely changing their way of being, or just leaving this new way as another optional way of acting on some specific occasion (SILVA, 2014) .

According to Silva (2014), within organizations, in the same way that one seeks to focus on the quality of the product or service offered, meet goals, increase sales, put pressure on employees, create a marketing plan, publicity, among others, one must Also focus on the progress of your employees' psychological condition. The psychological framework, the study of psychological theory is essential and is a requirement for an administrator or organization that has to deal with the most varied types of people on a daily basis.

According to Leavit (1972), studying mental health should be like rice and beans within organizations and for an administrator. Because with this added knowledge it is possible to see, predict and guard against problems caused by employees due to their mental states.

Companies are made up of human beings in their entire scope, each human being is unique, singular. There are days when someone is in a good mood, and other days when they are in a bad mood. These fluctuations in individual behavior directly interfere with the company's production. The correct and desired thing is for all employees to be proactive, to be leaders, to be diligent, to work hard, to sweat and to wear the company's shirt, body and soul. Every company aims to have an effective workforce, a framework in which all members of the organization have a good mental programming, which is the most conducive to generating good productivity (SILVA, 2014).

According to Brgamini (1982, p 24),

> A person becomes a problem within an organization whenever their behavior creates difficulties for the group of people in which they carry out their activities or in view of the

company's rules, including all business policies, whether administrative, technical or financial. . The problem employee draws attention for his atypical and often undesirable conduct, eventually causing a complaint about his way of acting. The "complaint" is therefore the current symptom, but to prove itself as such, the individual has gone through and accumulated a series of previous incidents. By exhaustively surveying these elements and studying their connection with the current complaint, it will be possible to formulate a diagnosis of the behavior and predict what future measures will be taken.

According to Silva (2014), among others, some of the negative influences of mental health on employees are: frustration, rationalization and fixation. The same author also cites some positive influences of mental health in the organization, such as the mental state of motivation and the mental state of leadership.

Mental health directly affects the decisions that human beings make on a daily basis. It can be said that everything that happens in the lives of human beings is what they attract to themselves. That is why it is necessary to take care of the mind, manage it effectively so that it does not lose control and end up being harmed.

The conditions and demands of the current job market impact workers' mental health in different ways. In addition to their immediate relationship with the work itself, what affects the psyche of workers are precarious work relationships, such as job instability, partial and/or temporary contracts, subcontracting, etc. Such precarious relationships are present in the reality of citrus workers, which requires a look at the connection between mental health and work, as the process of becoming ill is specific to each individual and involves their daily lives. It is important to highlight that, in addition, these workers suffer from exclusion from attention due to the failure to achieve actions developed by the worker health care network (SANTOS; MENTA, 2016).

V. INFLUENCE OF ERGONOMICS ON EFFICIENCY AND ORGANIZATIONAL PERFORMANCE

The incorporation of ergonomic principles in work environments goes beyond the mere promotion of the health and well-being of employees, having a significant impact on the efficiency and performance of organizations. Research carried out by Pinto, Tereso and Abrahão (2018) in the Metropolitan Region of Campinas shows how the implementation of effective ergonomics is directly correlated with increased productivity and improved performance in industries. This link highlights ergonomics not only as a preventive health measure, but also as a strategic vector for business growth and competitiveness.

The customization of workspaces, as addressed by Villarouco and Andreto (2008), emphasizes the ability of ergonomics to optimize organizational performance by adapting the environment to the specific needs of employees. This personalization enhances productivity, creating a work environment that motivates and inspires, while ensuring the health and comfort of employees. Thus, ergonomics presents itself as a valuable resource for promoting a stimulating and effective workplace.

Considering ergonomics as an interdisciplinary discipline that aims to adapt work to human beings, it seeks not only to prevent health problems, but also to optimize employee satisfaction and performance. Ilda (2005) reinforces this vision by demonstrating how well-planned ergonomic interventions contribute to a more engaged and productive workforce, highlighting ergonomics as a lever for continuous improvement in organizational performance.

Preventing workplace accidents and minimizing injuries are key components of ergonomics that have a direct impact on organizational efficiency. The guidelines provided by NR 17 (BRASIL, 2021) exemplify how the elimination of ergonomic risks contributes to a safer and, consequently, more productive work environment. This enhanced security not only protects employees, but also reduces operational costs related to sick leave and injury treatments.

Promoting quality of life at work through ergonomic practices is intrinsically linked to increased employee satisfaction. A healthy and comfortable workplace reduces stress and fatigue, which positively influences team motivation and efficiency. Therefore, ergonomics plays a key role in creating an environment that supports employees' physical and mental health, while boosting their disposition and performance.

Finally, the inclusion of employees in the development and implementation of ergonomic solutions ensures that interventions are practical and meet the real needs of workers. This direct involvement promotes not only the technical effectiveness of the proposed solutions, but also their acceptance and integration into the organizational culture, resulting in a more harmonious and productive work environment. Ergonomics, therefore, emerges as an essential strategic field for organizations that seek not only to increase their productivity, but also

to enrich the quality of life of their employees, demonstrating tangible benefits that range from employee well-being to substantial gains in efficiency. and market competitiveness.

VI. WORKPLACE ERGONOMICS IMPLEMENTATION STRATEGIES

The effective implementation of ergonomic strategies in work environments plays an important role in promoting health and increasing employee productivity. Recent research, such as Brasil (2020) and Thaís (2023), highlight success stories, such as Volkswagen do Brasil, where the adoption of such strategies resulted in a reduction in problems related to occupational health. The objective of ergonomics is to configure work to adjust to the capabilities and limitations of the human being, highlighting the relevance of a work environment that is both healthy and efficient. New approaches and studies in this field have expanded the understanding that well-planned ergonomic practices can lead to a substantial increase in well-being and organizational efficiency.

As pointed out by Oliveira et al. (2011), the Ministry of Labor and Employment highlights the importance of synergy between employers, employees and government entities. This synergy is essential so that ergonomic initiatives are not only implemented, but also sustained over time, integrating them effectively into occupational health and safety policies. The interaction between the various stakeholders guarantees a comprehensive and efficient approach to ergonomics in the work context, emphasizing the need for effective communication and mutual commitment to the success of the strategies adopted.

The effectiveness of ergonomic strategies also depends on the incorporation of cutting-edge technologies and validated methodologies, which must be adapted to the particularities of each work environment. In this sense, Filho and Lima (2015) emphasize that technological innovation in ergonomics can catalyze substantial improvements in working conditions, helping to prevent occupational injuries and illnesses. The integration of new digital tools and data-based solutions can enhance the application of ergonomic measures, making them more precise and personalized.

Furthermore, continuing education in ergonomics is essential to foster a preventive culture in work environments. Ferreira (2015) highlights that training and awareness in ergonomic principles and practices induce positive changes in work routines, mitigating risks and cultivating a safer and healthier working space. The expansion of these educational initiatives, covering different hierarchical levels of the organization, can reinforce the importance of ergonomics and encourage more active and informed participation from all employees.

The active inclusion of employees in the process of creating and implementing ergonomic solutions ensures that the measures adopted are relevant and effective. This participation promotes solutions that are not only technically appropriate, but also culturally resonant, harmonizing ergonomic interventions with the organization's reality and values. The development of communication channels that allow continuous feedback from employees can enrich ergonomic initiatives, ensuring that they are both innovative and aligned with employees' needs (FILHO; LIMA, 2015).

Integrating ergonomic considerations in the design of tools, equipment and spatial arrangements provides benefits that transcend the well-being of workers, and can also enrich the experience and safety of consumers. Natura's approach, mentioned in NATURA (2022), exemplifies how ergonomic design can constitute a strategic advantage. The company demonstrates a commitment to innovation by applying ergonomic principles not only in the work environment, but also in the development of its products, considering the well-being and experience of the end user.

Continuous evaluation and monitoring of ergonomic practices is vital to confirm their effectiveness and promote constant improvements. These periodic analyzes are essential to understand the impact of these practices on employee well-being and productivity, contributing to the durability of ergonomic initiatives. Implementing monitoring systems that use advanced technologies can offer more accurate and timely insights into the effectiveness of adopted ergonomic strategies (SARMENTO; VILLAROUCO, 2020; BRASIL, 2021).

In summary, the adoption and success of ergonomic strategies requires a multifaceted and integrated approach, which addresses both technical and human aspects, aligning with pre-existing health and safety policies. Dedication at all organizational levels and continuous adaptation to employee demands and feedback are crucial to ensuring an optimized and healthy work environment. The integrated and holistic approach, considering the interaction between individuals, tasks and the work context, is fundamental to the success of these strategies, positively reflecting on productivity and job satisfaction.

VII. ERGONOMIC ENGINEERING AND WORKPLACE DESIGN

The integration of ergonomic engineering and workplace design is critical to creating environments that promote worker health, safety and efficiency. Batagin (2017) and Lima and Duarte (2014) highlight the importance of incorporating ergonomic principles from the initial phases of design, allowing the anticipation and prevention of problems, thus avoiding later corrections. The Ergonomic Workplace Analysis (EWA) methodology, cited by Batagin, enables a systematic and detailed assessment, fostering continuous and sustainable improvements.

Ferreira's (2015) contribution enriches the dialogue on ergonomic engineering, highlighting Activity Ergonomics as an essential pillar to improve Quality of Life at Work. This methodology transcends the superficial analysis of the work environment, delving deeply into the interactional dynamics between the worker and all aspects of their work environment. This holistic approach takes into account not only physical elements, such as the arrangement of furniture and equipment used, but also investigates organizational structures, such as company culture, workflows and interpersonal relationships, in addition to social aspects, which they encompass social support, perception of role at work and occupational stress.

By focusing on Activity Ergonomics, an integration is proposed that goes beyond mere physical ergonomic adaptation, advocating for a work design that is intrinsically adapted to human characteristics, thus promoting environments that not only prevent occupational injuries and illnesses, but that also they catalyze job satisfaction, motivation and, therefore, productivity. This focus on an integral approach allows us to identify and shape working conditions so that they align with the needs, capabilities and expectations of workers, resulting in significant improvements in the quality of life at work, which are directly reflected in organizational efficiency and effectiveness (FERREIRA , 2015).

Lima and Duarte (2014) deepen the understanding of ergonomics in the work context by introducing the concept of "use configurations". This innovative approach is not limited to preventing occupational illnesses; it seeks to optimize the well-being and performance of workers. "Configurations of use" propose the creation of jobs that are adaptable to technological changes and developments in work practices, creating a dynamic environment that favors both the professional and personal development of employees.

The active participation of workers in the design of workstations is emphasized by Lima and Duarte (2014) as a pillar for the success of ergonomic interventions. This participation ensures that the solutions adopted effectively reflect the needs and preferences of end users, resulting in significant improvements in quality of life and productivity at work.

Batagin (2017) highlights the importance of universal design in the creative process, ensuring that workstations are accessible and usable by everyone, regardless of their physical capabilities or health conditions. This inclusive approach is fundamental to ensuring equity in the workplace.

On the other hand, Ferreira (2015) highlights the relevance of cognitive ergonomics and its impact on reducing cognitive load and improving the psychological well-being of workers, expanding the understanding that quality of life at work transcends physical aspects.

Lima and Duarte (2014) offer a comprehensive vision when integrating sustainability into workplace design, arguing that this incorporation is not just an environmental necessity, but an extension of ergonomics itself. By establishing a direct connection between workers' well-being and environmentally responsible practices, the authors argue that a truly sustainable work environment goes beyond environmental conservation, also addressing social and economic sustainability.

In this context, sustainability in jobs is seen as a triple commitment that includes economic viability, social equity and environmental protection. By integrating these three pillars into ergonomic design, Lima and Duarte (2014) propose a work environment that is not only healthy and productive for workers, but also contributes to the preservation of environmental resources and promotes social justice.

The approach suggests that jobs designed with sustainable considerations can result in benefits such as reduced waste, lower energy and resource consumption, as well as fostering a more positive organizational climate, where workers feel valued and part of an ethical business culture. is responsable.

Another important point to consider is the continuous monitoring and adaptation of workstations, which are essential to maintain the relevance and effectiveness of ergonomic interventions in the face of technological changes and new work dynamics, as discussed by Batagin (2017), Ferreira (2015) and Lima and Duarte (2014).

Continuous training in ergonomics, as highlighted by Ferreira (2015) and Lima and Duarte

(2014), is a key element in the development and maintenance of jobs that are not only safe and efficient, but also adaptable to rapid and constant changes. in the world of work. This continuous learning process allows ergonomists and other professionals related areas understand and apply the latest research, technologies and methods in the design, evaluation and improvement of work environments.

By committing to ongoing education, ergonomics professionals can better respond to new questions arising from technological advances, organizational changes, and new understandings of occupational health and worker well-being. This includes staying abreast of the latest trends in analytical tools, ergonomic simulation software, as well as new industry regulations and standards.

Ferreira (2015) and Lima and Duarte (2014) argue that such training not only benefits individual ergonomists, but also organizations and their employees, as it promotes more adaptive, productive and, crucially, more humane work environments. By staying up to date, the ergonomist can effectively advise on modifications to the work environment that promote not only health and safety, but also worker engagement and satisfaction.

Continuing training also prepares professionals to proactively address emerging ergonomic risks, rather than reacting to them after they become problems. This translates into a more strategic and less costly approach to managing occupational health and safety, aligning work practices with long-term organizational sustainability and efficiency goals.

VIII. WORK SYSTEMS AND HUMAN-MACHINE INTERFACE

In Civil Engineering, work systems and human-machine interfaces have evolved significantly, driven by the advancement of technologies and the need to optimize processes, increase safety and improve the quality of constructions.

The integration of information and communication technology (ICT) on construction sites, as discussed by Oliveira and Serra (2017), transforms significantly the management of safety equipment in civil engineering. The use of RFID technology, as exemplified in the control of security equipment, illustrates the ability of ICTs to automate and optimize processes, reducing the incidence of human errors and increasing operational efficiency. This technology allows for precise, real-time monitoring of resources on the construction site, promoting more effective and proactive management in the maintenance and use of safety equipment. Figure 1 illustrates the components of an RFID system. The reader emits radio signals continuously at a given frequency. When a Tag, previously adjusted to identify the working frequency in use, interacts with these signals, it is activated and establishes communication with the reader through modulation of transmittance frequencies. The reader, in turn, captures and interprets this data, forwarding it to the system to which it is linked, allowing it to recognize the communication protocols on a computer.

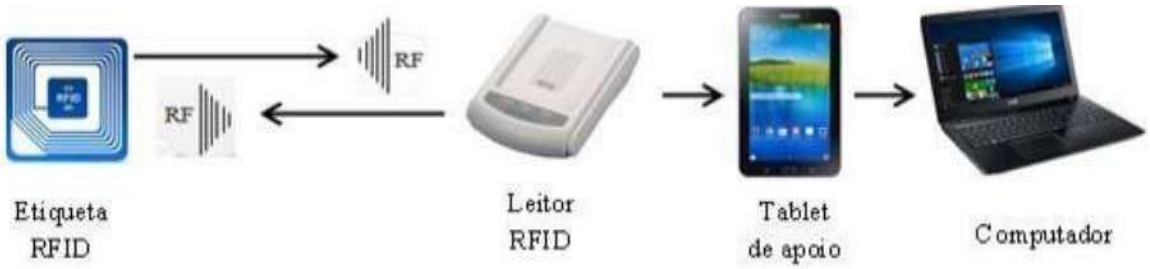

Fig.1 – RFID System Components. Source: OLIVEIRA et al. (2011)

By detailing the implementation and benefits of the RFID system on construction sites, the study reveals how ICT can contribute to better organization, tracking and management of resources, fundamental elements for safety and productivity in construction. Technology allows you to quickly identify the location and status of equipment, providing essential data for immediate and strategic decisions, emphasizing the relevance of adapting such technological innovations to improve conventional practices in the sector (OLIVEIRA et al., 2011)

The article by Oliveira et al (2011) highlights the application of RFID technology (Radio Frequency Identification) in monitoring and controlling safety equipment on construction sites. The implementation of this technology allows for more effective equipment management, contributing to safety and productivity. By

automating tracking and control, human errors are reduced and the use of resources is optimized, demonstrating a significant advance in human-machine interaction in civil engineering.

On the other hand, ergonomics, as discussed by Soares (2009), plays a fundamental role in designing safer and more efficient work environments. The integration of ergonomic principles into work systems and human-machine interfaces in civil engineering not only improves worker well-being, but also increases operational efficiency. Ergonomics considers human limits and capabilities, aiming to adapt work, equipment and the environment to people, which results in greater productivity and fewer workplace accidents.

The interaction between humans and machines is increasingly mediated by digital interfaces, which allow more precise and intuitive control of equipment. These interfaces are designed with usability in mind to ensure that they are understood and used efficiently by operators, regardless of their level of familiarity with the technology.

The research by Prysthon, Schmidt and Silveira (2006) reinforces the idea that engineering produces solutions that are used by society, highlighting the importance of applied research in solving concrete problems. In that context, the human-machine interface in civil engineering is not limited to the construction site, extending to project management, planning and design, where data-driven decisions and information modeling build a bridge between theory and the practice.

The integration of Augmented Reality (AR) in civil engineering, as discussed in the article by Silva et al. (2020), offers a wide range of benefits and possibilities, particularly in improving ergonomics in the workplace. AR, by combining elements of the real environment with data and virtual models, provides a more intuitive and efficient interaction between professionals and the project or construction they are working on.

The application of AR in civil engineering can significantly improve spatial understanding and technical details of projects, allowing professionals to visualize structures, facilities, and potential problems in a more immersive and interactive context. This not only facilitates the identification and resolution of problems more quickly and effectively, but also contributes to reducing the risk of errors and accidents in the workplace, thus promoting a safer and ergonomically optimized environment (SILVA et al., 2020).

Additionally, AR can be used to simulate different construction scenarios, allowing engineers and builders to visualize changes and adapt their plans before physical implementation. This results in more flexible and adaptable work processes, which can better respond to workers' ergonomic needs, minimizing unnecessary efforts and improving overall efficiency (SANTOS, 2023).

The training and training of professionals also benefit greatly from AR, as it allows them to simulate complex or dangerous work situations in a controlled and safe environment. This can improve workers' preparation and response to real working conditions, increasing safety and promoting ergonomically favorable work practices (SALGADO et al., 2020).

Therefore, the integration of AR in civil engineering represents a significant advancement in the way projects are visualized, planned and executed, offering a powerful tool to improve ergonomics, safety and efficiency in the workplace. The possibilities that open up with the use of this technology have the potential to fundamentally transform the construction industry, aligning it with the principles of ergonomics and maximizing the well-being and productivity of workers (RAIZ, 2024).

IX. CIVIL CONSTRUCTION AND ERGONOMICS

Civil construction is one of the industry sectors where workers are most exposed to various risk factors, as well as to accidents at work, that is, they are more prone to occupational risks (SILVA et al., 2016).

> Silva et al. (2016, p.39) defines occupational risks as those where:
>
> > Professionals will be exposed to dangerous and unhealthy activities, having a direct relationship with working conditions, methods used and risk agents to which they are exposed, such as chemical, physical, biological and mechanical agents, subjecting them to possible adverse health effects of the worker.

For the good performance of construction work in an ergonomic manner, it is necessary to consider NR 17. This regulatory standard provides guidelines so that there are adaptations in working conditions to the psycho-physiological characteristics of workers, while ensuring comfort, safety, quality life and efficient performance.

NR nº 17 establishes standards for work activities regarding transport, furniture, equipment, environmental conditions and work organization. According to the NR 17 application manual, it is necessary to provide adaptations to the working conditions and environment, considering the psycho-physiological conditions of the

worker, ensuring that they carry out their activities in a comfortable way and that ensures physical well-being and quality of life.

9.1 Some innovations in the construction industry

We can say that the more technology advances, the greater the opportunities for ergonomics, as such innovations result in less effort, greater adaptation and, consequently, better working conditions.

Below are some innovations that are already in use on construction sites here in Brazil. These are creations that a few years ago would have been something out of a science fiction film, but that today are already contributing to faster, cheaper and, obviously, more ergonomic constructions:

a) Mechanical leg: The equipment is nothing more than legs similar to those we used when we were children (Figure 2). The worker goes through a period of training until he is able to balance safely and from then on the gains are incredible, as the work can be done much faster, without the need for ladders or scaffolding.

Fig.2 – Mechanical legs used in civil construction. Source: ERGOTRIADE (2021)

b) Floor leveler: That scene of 10, 20 men squatting or kneeling with trowels leveling large areas of floor is already a thing in many construction companies. Using a single operator and only 10% of the time, this machine levels large areas of flooring. The equipment was developed in the United States and is already in use in Brazil (Figure 3).

Fig.3 – Floor leveler used in construction. Source: ERGOTRIADE (2021)

c) Plastering and plastering machine: Using compressed air, this invention is capable of plastering up to 30 m^{two} per hour. In addition to guaranteeing time savings, it avoids manual work which, in this activity, usually

represents an ergonomic risk (Figure 4).

Fig.4 – Plastering and plastering machine used in construction. Source: ERGOTRIADE (2021)

d) Painting equipment: This is the evolution of compressed air painting systems (Figure 5). In addition to representing important gains in productivity and ergonomics, it also prevents the dispersion of paint in the air, which significantly reduces risks to worker health.

Fig.5 – Painting equipment used in construction. Source: ERGOTRIADE (2021)

X. THE IMPORTANCE OF ERGONOMICS FOR THE HEALTH OF THE COMPANY AND ITS EMPLOYEES

Understood as a discipline that harmonizes the work environment with human needs, ergonomics goes beyond preventing health problems, also aiming to increase employee satisfaction and performance. In this context, Ilda (2005) strengthens this concept by illustrating that carefully planned ergonomic actions not only encourage team engagement and productivity, but are also effective tools for constantly increasing organizational efficiency. Therefore, ergonomics is established as an integral approach, which not only protects the well-being of employees, but also contributes significantly to business evolution and success.

The incorporation of ergonomics from the initial stages of design and planning of work spaces appears as a crucial strategy, which can prevent the need for future modifications, which are often more costly and less effective. Furthermore, organizational engagement with Ergonomics needs to be intensified, requiring leaders and managers to recognize its value not only for the health of employees, but also for the performance and sustainability of companies.

The development and expansion of educational programs in ergonomics are fundamental and must cover all hierarchical levels of organizations. Promoting understanding about ergonomics and its relevance must be an essential component in the training of all employees, from senior management to operational levels.

Advances in cognitive ergonomics signal a future where mental health will receive as much attention as physical health. Organizations will need to be prepared to implement strategies that consider both aspects, ensuring a holistically healthy work environment.

Research in ergonomics, aimed at discovering new spheres and facing recent challenges, is essential for the evolution of this science. The integration of varied fields of study, such as psychology, design, engineering and public health, can significantly increase the quality of ergonomic interventions, making them exceptionally comprehensive and creative. By adopting participatory ergonomics strategies, which include employees in the development and evaluation of ergonomic measures, not only an increase in their effectiveness is expected, but also an increase in engagement and acceptance on the part of employees. Legal and regulatory factors will also continue to exert a significant influence on the fate of ergonomics, with compliance with current legislation and active contribution to the creation of standards that favor healthier work practices being essential.

XI. GENERAL CONSIDERATIONS

The study carried out shows the importance of applied research to strengthen ergonomic practice in organizations. The future of ergonomics is intrinsically linked to its ability to adapt and respond to new challenges, maintaining the commitment to promoting work environments that prioritize and cultivate human well-being.

In short, ergonomics must remain focused on the human element, ensuring that technological innovations and organizational changes are consistently evaluated considering their impacts on the health, well-being and efficiency of workers.

It is important that managers, from all sectors, are aware that providing an occupational health and safety program and investing in ergonomic projects in the organization is not just a legal obligation. This measure can increase the productivity and performance of workers, reducing the rates of absences due to occupational illnesses.

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