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Ergonomic practices in a group of industries in the Metropolitan Region of Campinas: nature, management, and actors involved

Práticas ergonômicas em um grupo de indústrias da Região Metropolitana de Campinas: natureza, gestão e atores envolvidos

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Abstract: This study aimed to identify and understand the ergonomic practices adopted in the industries in the Metropolitan Region of Campinas (RMC), according to their nature, management, and social actors involved. We applied questionnaires in order to find which industries conducted ergonomic practices and analyses. Following this, we selected four large sized industries that conducted ergonomic practices and analyses as defined by their main offices or individual branches, which were available for taking part in a case study. The main findings in this study demonstrated that many of the professionals in charge of ergonomics work in health and occupational safety engineering fields. Inspection and regulation compliance are relevant drivers in the conduction of ergonomic initiatives in industries. The study showed the acknowledgment of the contribution from ergonomists in the conception of work. The ergonomic improvements that were implemented are closely related to the physical aspects of work, often because these are easier to be identified by the actors involved. The actors involved consider that the ergonomic practices in the industries improve the affairs related to health, safety, productivity, and quality at the workplace. There are some difficulties in convincing managers to undertake ergonomic improvements, with the need of justifying the economic value in these initiatives. Ergonomics experts are understood to use different methods, tools, and strategies, which they can resort to in order to understand work, with the responsibility of carrying out ergonomic initiatives according to the specific characteristics of an organization, its activities, and its workers. Ergonomic practices allow understanding a certain activity, establishing a dialog between the actors involved in the various hierarchical levels, and contributing to changes and improvements that aim to preserve the health and safety of workers. These changes and improvements enrich the performance of organizations.

Keywords: Ergonomics; Ergonomic analysis; Management; Industry.

Resumo: *O presente estudo procurou identificar e compreender as práticas ergonômicas adotadas nas indústrias da Região Metropolitana de Campinas (RMC) de acordo com a sua natureza, gestão e os atores sociais envolvidos. Foram aplicados questionários para identificar quais as indústrias que possuíam análises e práticas ergonômicas e posteriormente foram escolhidas quatro indústrias de grande porte que realizavam análises e práticas ergonômicas definidas pela matriz ou pela própria filial e com disponibilidade para a realização de estudo de caso. Os principais resultados encontrados na pesquisa demonstraram que os profissionais responsáveis pela ergonomia em grande parte estão alocados nas áreas da saúde e engenharia de segurança do trabalho. A fiscalização e o cumprimento das normas são motivadores relevantes para a realização das ações ergonômicas nas indústrias. Evidenciou-se o reconhecimento da participação do ergonomista na concepção do trabalho. As melhorias ergonômicas implementadas estão muito ligadas aos aspectos físicos do trabalho, muitas vezes por serem os mais fáceis de serem reconhecidos pelos atores envolvidos. Os atores envolvidos entendem que as práticas ergonômicas nas indústrias melhoram questões ligadas à saúde, segurança, produtividade e qualidade no trabalho. Convencer os gestores a realizarem melhorias ergonômicas é difícil, sendo necessário provar o custo/benefício dessas ações. Conclui-se que o especialista em ergonomia utiliza-se de diferentes métodos, ferramentas e estratégias à sua disposição para o entendimento do trabalho, com a responsabilidade de desenvolver as ações ergonômicas de acordo com as características da organização, de suas atividades e de seus trabalhadores. As práticas ergonômicas promovem a compreensão da atividade, estabelecem*

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uma interlocução entre os atores envolvidos nos diferentes níveis hierárquicos e contribuem para transformações e melhorias no sentido de preservar a saúde e a segurança dos trabalhadores. Essas transformações e melhorias promovem um melhor desempenho da organização.

Palavras-chave: *Ergonomia; Análise ergonômica; Gestão; Indústria.*

1 Introduction

Many challenges have arisen as a result from economic globalization, such as the high level of competitiveness through cutting edge technology, the economic value that is required by managers, the ever increasing needs of consumer in regards to product quality, and the importance of environmental awareness and the preservation of natural resources. Considering this, the production processes must be made more efficient and flexible, in order to ensure quick delivery of products and higher productivity with less people, which often causes work to be intensified - which generates negative conditions to workers. Brazil's managers are concerned with the country's jeopardized production, high absenteeism levels, high medical care costs, high costs as a result from leaves of absence, high judicial compensation awards, costs with reinstatement of workers – they are actively searching for solutions to these problems, which have high social and financial impacts (Silva & Bertoncello, 2010). Besides that, Brazil's work regulatory standard 17 requires the conduction of ergonomic workplace analyses in companies, in order to investigate whether their occupational conditions properly match the psychological and physical characteristics of their workers, including lifting, transporting and unloading tasks, furniture requirements, equipment, the environmental conditions of jobs, and the work organization. This standard points towards the responsibility of employers in conducting ergonomic workplace analyses, and highlights that work-related accidents and diseases are predictable, and therefore avoidable. The industries are nowadays responsible for minimizing and solving the problems they identify through ergonomic practices. Improving the understanding of how a company sees the ergonomic workplace analyses they carry out and how they use these is a great challenge. "Which are the ergonomic practices adopted?", "who manages these practices?", "what are the scope and limitations of these practices?" are issues that have been little explored.

Implementing ergonomic measures in industries is carried out in different ways, depending on the type and policies of an organization (Hägg, 2003). According to Marras & Allread (2005), ergonomy is considered as a process rather than as a special program inside a company that has a defined beginning and end. This process must be viewed as any other, such as production, maintenance, or safety processes, in which there is a commitment to continuous improvement.

Considering the need for industries to adapt to the requirements of the Brazilian legislation and the difficulty in finding research that reports related initiatives, it is highly relevant to know the universe of the ergonomic practices that were adopted in the industries in the Metropolitan Region of Campinas (RMC), according to their natures (employed schools of thought and methods), management (how they are implemented and managed), and social actors involved (their background and perceptions).

RMC is one of the most dynamic regions in the Brazilian economic scenario. This region is characterized by a very important industrial park and comprises nineteen cities: Americana, Artur Nogueira, Campinas, Cosmópolis, Engenheiro Coelho, Holambra, Hortolândia, Indaiatuba, Itatiba, Jaguariuna, Monte Mor, Nova Odessa, Paulínia, Pedreira, Santa Bárbara do Oeste, Santo Antônio da Posse, Sumaré, Valinhos, Vinhedo.

This study sought to understand how ergonomic practices have been developed and the theoretical foundations and strategies that were used by a group of industries in the Metropolitan Region of Campinas, by identifying: the motivation for implementing ergonomic practices; the schools of thought and methods used; the ergonomic practices carried out, and the strategies adopted for their implementation; the involved actors and their perceptions.

In the universe of ergonomics, there are several methodologies that can be chosen, according to the nature of the proposed issue and the deadlines and available resources (Wisner, 2003).

The so-called human factors ergonomics (HF) school of thought is rooted in Anglo-Saxon countries and focuses on the relationship between man and technology; in the interface among components, materials, and human factors, considering the general characteristics of man, in order to better adapt machines and technical devices to their operators (Mascia & Sznelwar, 1997). Meister (1999) describes human factors as physical, cognitive, and motivational. Thus, it mainly aims at increasing the productivity of the men who interact with machines and at increasing the safety/comfort that is experienced by men while operating machines. The school of thought studies the operator's anthropometric characteristics, the biomechanic effort (oxygen intake, load transportation), the environmental factors (heat, cold, noise, vibration, toxic agents), the psychological and physiological

characteristics of the workers (sight, hearing, touch, time of reaction, perception, cognition), and also the characteristics of circadian rhythms. The effectiveness of the HF recommendations depends on the acceptance from teams in the engineering and development of systems. The ergonomists use analysis tables, measurement instruments, publications, norms, among other evaluation tools, aiming to demonstrate the ergonomic risks to managers (Montmollin & Darses, 2011).

Another school of thought is human activity ergonomics, which gained momentum in Europe after World War II, considering the need for reconstruction and improved working and production conditions. This school, also known as francophone ergonomics, started focusing on analyzing the activity in real-life working conditions; that is, in its technical and organizational contexts and in the relationships between production constraints (Mascia & Sznelwar, 1997). Work is analyzed as a process in which an operator (who is capable of initiatives and reactions) and his technical and dynamic environments interact (Falzon, 2007). Such research is no longer conducted in laboratories, but rather by analyzing the activities of operators in specific activities (Montmollin & Darses, 2011). This clinical approach of human activity hinders the generalization of findings, but identifies the patterns related to the limitations in the studied situation and the strategies that are developed by workers. Organizational issues are fully included in the analysis, as well as the strategies adopted (regulation, anticipation, among others) by a worker in order to be able to perform the task (Guérin et al., 2001). The methodological approach that was proposed by the activity analysis is structured into several stages that are connected to each other in order to understand and transform work (Abrahão et al., 2009). The stages require ergonomists to explore the functioning of an organization, its technological base, the processes conducted, its population of workers, and the tasks each worker is assigned with, in order to, instead of producing generic knowledge on work, understanding work as it is performed in a certain company (Vezzá, 2005).

Montmollin & Darses (2011) understand that Human Factors Ergonomics and Human Activity Ergonomics somehow complement each other. If on one hand, human activity ergonomics does not allow establishing catalogs of general data that can be directly used in the creation of technical devices as recommended by HF, on the other side it is conducted where production managers need it the most, in the critical situations in which the skills of operators are able to prevent workplace incidents and accidents from happening. According to the authors, no hierarchy needs to be established by the two schools.

Macroergonomics is a sub-discipline of ergonomics that deals with the technology in the human-organization interface. According to Bugliani (2007), the principles of macroeconomics are based on the articles by Hendrick, which were published between 1991 and 1995 in the Ergonomics journal. This school has the technological sub-system, the personal sub-system, the external environment, and the organizational architecture and its related interactions as its scope. It is a sociotechnical (which deals with the technological component, the personal component, and work, which consists in the organizational structure and processes), top-down (through a strategic approach), bottom-up (as it adopts a participatory approach), and middle-out (due to its focus on the process) approach. It provides a better guarantee of optimal functioning and effectiveness in the system, including the aspects of productivity, quality, health, safety, psychosocial factors of comfort, intrinsic motivation, commitment and perceived workplace quality of life. Macroergonomics uses participatory ergonomics by engaging people in the planning and control of a significant share of their working activities, with enough knowledge and power to both influence processes and results, in order to establish the desirable goals. People can take part in several ways: in quality circles, in their company committees, in self-managed activities, and individually (Hendrick & Kleiner, 2006).

Larson et al. (2015) selected eighteen case studies among 166 projects that had been submitted to the verification process of a large multinational company. They showed the successful interventions in both reducing the risk of work-related musculoskeletal disorders and in improving operation, through the use of a macroergonomics - based program coupled with a participatory approach.

Iida (2005) classifies ergonomics in four categories. Design ergonomics is applied in designing products, machines, environments, or systems. Corrective ergonomics is applied in real situations in order to solve problems related to safety, fatigue, diseases, quantity and quality of production. Awareness ergonomics is the one that trains workers to identify and solve everyday problems. Finally, participatory ergonomics is the one that tries to involve the workers/operators in the solution of ergonomic issues.

According to Falzon (2007), ergonomic practices must be thought of as diagnostic activities (in which analyses are carried out in order to understand work), intervention activities (in the sense of correcting already existing situations), and conception activities (through which new work methods are developed).

According to the International Ergonomics Association (IEA, 2017), ergonomic practices may be related to different specialty fields, such as physical ergonomics, cognitive ergonomics, and organizational ergonomics. Physical ergonomics is related to the anatomical,

anthropometric, physiological, and biomechanical activities of man in regards to physical activity, and it comprises work postures, the handling of objects, repetitive movements, musculoskeletal problems, workplace layout, safety, and health. Cognitive ergonomics is related to mental processes such as perception, memory, reasoning, as well as cognitive load, decision-making processes, specialized performance and men - machines interaction. In turn, organizational ergonomics is related to optimizing sociotechnical systems, including their organizational structure, rules, and processes, in a way to comprise communication, management of groups, the conception of work, the conception of work schedules, teamwork, cooperative work, organizational culture, virtual organizations, teleworking, and management through quality.

The physical, organizational, and cognitive aspects of work do not exclude each other. Changing one of them generates possible transformations in the other aspects. According to Menegon (2003), every work activity contains a physical dimension, which indicates a need for mobilizing a person's biological body. It also contains a cognitive dimension that is associated with the knowledge and reasoning required for performing work. It also has an organizational dimension that is characterized by the social nature of work, in a relationship of interdependency with other activities, with which it interacts and complements itself. The work activity represents the intersection of these three dimensions, being irreducible to one or another.

To Guérin et al. (2001), ergonomists are in charge of understanding work for transforming it. According to Montmollin & Darses (2011), understanding work means to observe and analyze based on concepts and methods; to transform means to intervene. These two core aspects of the work of an ergonomist may vary according to the different contexts and methodological, theoretical, and deontological choices of this ergonomist, who does not intervene in an isolated manner, but rather in collaboration with others. Daniellou & Béguin (2007) state that an ergonomist is able to identify the other actors involved and to direct his/her action in regards to the actions of these other parties, thus favoring his/her mission. This dimension of intervention is called "social construction". Ergonomists are transforming agents who carry out ergonomic practices at companies. They may be people without ergonomics degrees (designers following rules), people who have complementary education in ergonomics (physicians, design engineers), and also qualified ergonomists.

According to Bouyer (2014), an ergonomist can never disregard the subjective dimension of their activity. The practice of analyzing and understanding work to fully consider the subjective dimensions opens up a path for improving this professional's activity models. It is necessary to create spaces for autonomy, regulation, and provision of acceptable room for manoeuvre to perform a task, in a way to allow workers to use their bodies and minds in an implicitly safe way that covers all steps from the creation of a job and the task itself.

Throughout their careers, ergonomists are involved in a range of types of activities such as: consultancy in regards to risk factors, design, evaluation, redesign, and productivity; they influence different ways to look at things and share their views with their clients, in order to get the interested parties to see work in a different light. Ergonomists are facilitators who have a proactive role of promoting the application of ergonomics in organizations (Theberge & Neumann, 2010).

Ergonomists are committed to promoting the construction of work situations that are adapted to the highest possible number of workers, according to the objectives to be fulfilled, to the context in which they perform, and to the different work stages they face. Ergonomists must formulate concrete contributions whose validity is recognized through the results they achieve and the effects that are observed as a result of them (Chistol, 2004).

Ergonomics faces the challenge of seeking results to improve performance (productivity, efficiency, effectiveness, quality, innovation, flexibility, reliability, sustainability) and wellness (health, safety, satisfaction, pleasure, learning, personal development).

According to Dul et al. (2012), ergonomics has a great potential to contribute to the design of all kinds of systems with people; however, this field faces challenges to provide a high-quality application. This application must have a systemic approach that is conducted by the project, which focuses on performance and wellness, seeking to train technicians, managers, and all the remaining people involved. A good strategy is to raise the awareness of managers of resources and decision-makers, and to promote the education of ergonomics specialists.

According to Sznelwar & Hubault (2015), several studies in the field of ergonomics support the importance of knowing what people really do at work to meet production goals, especially considering there is always a gap between what was proposed and considered in the conception of a task and what happens in the real-life situation. When work situations are brought together through an ergonomic analysis, it is possible to obtain evidence from the activities of workers and to propose alternatives, based on a participatory approach. This knowledge must be considered as a source for strategic decisions, in order to improve reliability, productivity, and quality, as well as to provide conditions to improve health and safety.

From a more recent perspective, not only do ergonomists aim effectiveness at work, but also the

constant and collective development of operators and organizations; from an ergonomist's stance, it is about effecting a dynamic development situation, putting a dynamic development situation in practice, integrating the strategies of organizations, in order to allow for continuous and sustainable knowledge development. This point of view is classified as constructive ergonomics (Falzon & Mollo, 2009).

According to Gonçalves (2014), while a series of models of ergonomic initiatives in companies has been published, it is not clear how these models can be implemented. The small number of studies on the implementation of ergonomic practices may lead to an opportunity to increase the knowledge in the field, taking into account the occupational health context and improvements in working conditions. Ergonomic practices may be understood as activities performed by the actors involved in the sense of observing, analyzing, understanding, intervening, mediating, transforming, and conceiving work, considering it physical, organizational, and cognitive aspects.

Driessen et al. (2010) implemented a participatory ergonomic program in companies with different work demands, involving 81 workers, in order to reduce lumbar and neck pain. Kogi (2012) evaluated participatory ergonomic programs in small urban and rural companies in different places in the world, based on quick training sessions, aiming to examine the practices which led to a reduction in occupational risks, increased productivity, and improved working conditions. Souza (2012) evaluated 105 consultancy companies, in order to identify the main tools used in the preparation of ergonomic analyses. This study concluded that these instruments were insufficient to analyze work during an ergonomic intervention, as these mostly focused on evaluating factors regarding the physical dimensions of work, with no references to the instruments about participation and confrontation.

Based on these considerations, this study aimed to identify the different methods and strategies adopted by the industries in the region of Campinas, in the implementation of ergonomic practices, according to the organizational characteristics of companies and professionals involved.

2 Materials and methods

According to the classification by Gerhardt and Silveira (2009), this study has a qualitative approach; concerning its nature, it is applied; and in regards to its objectives, it is an exploratory study. With respect to the procedure adopted, this is a case study, as it is an empirical investigation that studies a contemporary phenomenon within the real context (Yin, 2001).

This study was developed in two stages. The first stage started with the development of a questionnaire, which aimed at identifying the industries in RMC – limited to manufacturing industries and agroindustries – that adopted ergonomic practices. This questionnaire contained open and closed-ended questions, and it was divided in two parts. Its first part had more general questions, with the aim of characterizing the industry. The second part comprised questions that were more related to ergonomic practices and analyses.

We contacted two groups of human resources (HR) professionals from industries that were representative of RMC. Both groups were connected to 45 industries each. Besides these groups, we contacted the Organizational Human Development Department of CIESP CAMPINAS (São Paulo State Industry Center – regional Campinas unity), which nowadays encompasses 594 member companies that are distributed in 19 municipalities in the region, most of which in RMC. Both groups were willing to take part in the research and to answer the questionnaire. The groups tied to human resources were available to answer the questionnaire via e-mail. The group of CIESP agreed to answer it during one of its on-site meetings.

After we identified the contacts that were suggested by the HR groups in these industries and their respective e-mails, we sent 90 questionnaires via e-mail to both HR groups. However, only 19 industries answered the questionnaires via their representatives. In regards to the group of CIESP, the questionnaires were distributed in a meeting with 10 industries, with 8 representatives having answered the questions.

Among the total 100 questionnaires distributed, 27 were answered. The data were arranged in a table and a simple statistical analysis was conducted. It guided the identification of the companies to be studied.

The criteria used to choose the industries that would take part in the second stage were: being large-sized; conducting ergonomic practices and analyses as defined by their head office or individual branches; being available for the study.

Fifteen large-sized industries were initially selected; among these, 13 conducted ergonomic practices and analyses. We made phone calls to all of the 13 questionnaire respondents in order to verify if their industries were willing to take part in the study. These professionals submitted research proposals to their respective hierarchical superiors. At the end, 4 industries were shown to be willing and available to the study. Two of them carried out practices as defined by their headquarters and the other two followed instructions from individual branches.

In regards to the procedures, we made visits in order to made agreements with the industries and their actors; to analyze the documents submitted, in order to know the organizational structures that were connected to the ergonomic initiatives and tools used by the involved professionals; and semi-structured interviews, whose script was developed to guide this

study. This script sought to identify the respondents' data (such as job/position and length of service at their companies) and the following items: characteristics of chosen industries, history, construction, motivation for implementing ergonomic practices; professionals in charge of ergonomics (background, formal or outsourced employment, duties performed); actors and areas involved in ergonomics; schools of thought and ergonomic models adopted; ergonomic strategies and practices adopted; perceptions from actors involved in regards to the difficulties they faced and the positive aspects from ergonomic practices.

In the industries 1, 2, and 4, the whole research was supervised by their ergonomists and, in industry 3, by their occupational physician. At least 140 hours were dedicated to the interviews and document analyses in the industries, along a period of four months.

3 Results

In the first stage, the questionnaires revealed that 44% of the respondent industries were located in Campinas, and the others were located in the other cities in RMC. In regards to their fields of activity, only one of the companies was in the agricultural sector. The remaining ones were manufacturing industries.

In regards to their origins, 19 were multinational and 8 companies were national. In regards to their size, according to the criterion from Brazilian Micro and Small Business Support Service (SEBRAE, 2017), 16 industries were large-sized, 5 were medium-sized, and 6 were small-sized, with 21 of them conducting ergonomic practices and analyses.

In regards to the professional training of those who dealt with ergonomics in the industries, most professionals involved were verified to be part of health care services or occupational safety engineering. Among the professionals involved with ergonomics, 10 called themselves ergonomists.

Chart 1 presents the practices that were implemented by the industries and the number of industries that adopted these practices.

The classification of the practices in relation to their ergonomics specialty fields showed that 57% of them were related to physical ergonomics, 42% to organizational ergonomics, and 1% to cognitive ergonomics.

In regards to the motivation for implementing ergonomic practices, the respondents were able to check more than one alternative. Thus, the motivation was the adoption of a preventive policy for 21 industries. Seven of these companies were influenced by their headquarters, and 12 of them were influenced by inspections carried out by labor prosecution offices and regional labor authorities.

The answers to the open-ended questions were distributed in two large groups. For the first group, the difficulties reported included comments in two categories: the first one was related to the lack of compliance to the schedule of required ergonomic initiatives; to the lack of implementation of initiatives that generated costs; to the difficulty in proving the economic value of improvements to be implemented; to the absence of specific funds for ergonomic improvements. The second category is related to issues in organizational culture changes, such as the interference on production, lack of willing to accept improvements implemented, the lack of participation from upper management, and resistance to change. In the second group, among the positive aspects, two other categories were noticed: the first one related to health and occupational safety issues, such as reduction of complaints, diseases, absenteeism; reduction in accidents and risk factors; increase in workers' satisfaction, improvement in quality of life, motivation for proper postures, and practice of physical activity. The second category was related to

Chart 1. Ergonomic practices implemented by the industries.

Implemented practices	Number of industries
Changes in production stations, machines, and devices	19
Layout changes	18
Changes in offices	12
Cognitive load reduction	2
Visual fatigue reduction	8
Reduction of overtime	6
Increase in training	12
Inclusion of breaks	12
Improved autonomy to workers	2
Workplace exercises	17
Improved relationship with managers	8
Participation of workers in improvements	8
Rotation of tasks	17
Participation in the conception of new production stations	18
Participation in ergonomy committees	2

productivity aspects, such as increased productivity, quality, reduction of costs with processes, improvement in performance in processes, improvement in the workplace environment, and participation from production managers.

Chart 2 shows the data obtained in the second stage of this study, which relate to the main characteristics in the four industrial units selected and in the practices adopted.

3.1 Characterization of the industries, motivation for implementing ergonomic practices, and actors involved

Industry 1 (I1) is a chemical multinational, which has been operating in Brazil for over 60 years. Its products are destined to be used in industrial, domestic, and hospital applications. It has over 2400 workers in its plant at the Metropolitan Region of Campinas, the location in which Brazil's corporate team is based. The implementation of ergonomic practices in Brazil started in 2002 as a result from an inspection made by labour authorities. An outsourced company was contracted to analyze the ergonomic risks. However, the analysis was not continued. In 2004/2005, according to the headquarter's strategy, three professionals from the occupational safety sector were certified to apply EJA the Ergonomic Job Analyzer (EJA) tool. From 2005 to 2009, the occupational hygiene manager also coordinated the ergonomic initiatives, albeit with a very modest enforcement. In 2009, they decided to have a person in charge of their corporate ergonomics in Brazil, when a new phase started in a more organized and focused way. The professional in charge of ergonomics was a materials engineer who has been at the company for 23 years and has specialized in EHS (Environment, Health, Safety).

Industry 2 (I2) is a metallurgic multinational, which has been operating for over 57 years in Brazil. It produces car parts and electric tools. It has over 5000 workers in its RMC plant. Simultaneously to the implementation of a labor gymnastics program, ergonomics arose in 1997, in the occupational safety engineering department, along with the medical department. Work breaks were implemented in production tasks in 1998. In 2005 there were changes as the management of ergonomy was shifted from the safety engineering to industrial engineering department. Ergonomy training was given to supervisors in 2006 and to operators in 2008. The company's ergonomy group was created in 2009 and in 2012 the jobs outside the production area were mapped according to the tool from the head office. During this development there were several training sessions on ergonomy provided by the head office, with the training of professionals involved with courses in Brazil. There were many inspections from the labor prosecution office, which had a positive influence in the continuity of ergonomic initiatives in this industry. The professional in charge of ergonomy is a mechanic technologist and a times and methods analyst who has worked in industrial engineering for 15 years and in the company for 40 years.

Chart 2. Ergonomic characteristics and aspects of the selected industries.

	Industry 1	**Industry 2**	**Industry 3**	**Industry 4**
Characterization				
Field of activity	Chemistry	Metallurgy	Chemistry/ Agriculture	Metallurgy
Origin	Multinational	Multinational	Multinational	Multinational
Length of existence	112 years	57 years	36 years	36 years
No. of Workers	2400	5200	568	1600
Work shifts	3	3	3	3
Risk level	3	4	3	4
Ergonomic practices and analyses				
Responsible department	Health, safety, and environment	Industrial engineering	Health, safety, and environment	Medical Service / HR
Ergonomist Professional	Engineer	Analyst of times and methods	Occupational Hygienist	Physical Therapist
Responsibility	Internal worker	Internal worker	External company	Outsourced professional
Periodicity	Periodically	On demand	Periodically	Periodically
Scope	All sectors	Sectors with complaints	All sectors	All sectors
Strategy	Company program	Company program	Company program	Company program
Motivation	Head office/ Legislation	Local/Legislation	Head office/ Legislation	Local/Legislation

Industry 3 (I3) is a chemical/agricultural multinational, which has been operating for over 36 years in Brazil. It produces products for the agricultural sector. It has 568 workers. Ergonomics was first implemented in 2009, when the safety, health, and environment manager questioned the compliance with labor regulations, because a checklist was routinely applied in the company's headquarters to address the ergonomic issues. So, they decided to perform ergonomic workplace analyses every three years, for complying with the legislation. The person in charge of ergonomics is the occupational hygienist, who works in the HSE department (Health, Safety, Environment) and has been working in the company for 10 years.

Industry 4 (I4) is a metallurgic multinational, which has been operating for over 36 years in Brazil. It produces car parts and has 1600 workers. Ergonomics was implemented in September 2004, to improve the working conditions in one of its operational units, due to the high number of complaints related to musculoskeletal disorders. An ergonomics consultancy firm was hired for providing services for 3 hours a week. The activities included training the technical staff on ergonomics theory, and helping workers dealing with complaints. In 2008, after an inspection in the company by the labor prosecution office, and due to the development of a new methodology, the company's ergonomist's work hours increased to 30 a week, and this person's work scope moved to include all operation units in RMC. The professional in charge of ergonomics is a physical therapist (outsourced) who works in the company's occupational medicine department. She has been working for this company for 10 years.

Inspection was observed to have a decisive influence in the implementation of ergonomics in the three companies studied. Only one of them implemented ergonomic practices for prevention purposes, in order to comply with the related legislation.

The persons in charge of ergonomics in the industries worked at different departments. In two of the companies, they worked in the occupational safety engineering department. Another company had ergonomic professionals in its industrial engineering department, and the ergonomic professionals in the last company worked at the occupational medicine department, below the human resources department.

In three industries, the departments that were more directly involved were similar, such as occupational safety engineering, industrial engineering, production, maintenance, occupational medicine, and legal department. The actors involved were process engineers, new product development engineers, safety technicians, leaders, production supervisors, operators, maintenance workers, and health care professionals.

In regards to the duties of ergonomists, some differentiations were shown to be connected to the very educational background of the professionals and to the sector they are inserted in.

3.2 Schools and methods adopted

We observed a relevant influence from the industry headquarters in industry 1, which was driven by the human factors-based ergonomic approaches, whose main concern was related to the physical aspects of the man-machine interface (anatomical, anthropometric, physiological, sensory).

In industries 2 and 4, influences were observed both from human factors ergonomics and human activity ergonomics. We noticed a concern with the study of the work activity of the operators from real work situations. In industry 4, we noticed higher commitment to human variability, interferences, awkward situations during work and the operator's participation in the process to solve problems and validate improvements.

In industry 3, the analysis was conducted by an outsourced professional and the report was made with the use of some quantitative tools for analyzing physical risks, with a poor characterization of the operator's activities. Therefore, a more detailed evaluation was not possible in this case.

3.3 Ergonomic practices and adopted strategies

The ergonomic demands from the three companies came from common sectors: production, administrative, occupational medicine, legal, and engineering departments. In industry 3, they came from production, safety engineering, and occupational medicine departments.

We observed, in industry 1, a structure that was well defined by the main office and then at the branch. The strategies were defined in a top-down manner, with policies at the organizational level, which enabled a cross-sectional ergonomic program in the whole organization and the incorporation of this topic as a value and as a belief in the company, as found and reported by Bolis (2011).

In industry 2, even with the influence from the headquarter, the strategies were developed locally, and several changes in the program took place due to the exchange of managers. This fact demonstrated that, despite having a good structure, part of the model was still connected to the managers rather than to the organization itself.

Industry 3 didn't have a proper ergonomic program, but rather some initiatives related to ergonomics, coordinated by the occupational safety engineering department. The fact that an external professional

conducted the ergonomic analysis kept the initiative far from the organization level and even from the workers. Thus, the transference of knowledge from the specialist to the actors involved was limited.

In industry 4, the strategies were developed as the ergonomist conducted his analysis and as the needs for change appeared. It was conducted in a bottom-up manner. At the beginning, only the occupational medicine department supported the initiatives. As the initiatives were evolving, other actors started getting involved, and a model started to being built. The upper management members were noticed to recognize this process, which is already incorporated in the organization, albeit with little support. Most initiatives were found, at the beginning of the process, to be of a reactive nature. As the program matured, it became gradually involved with more proactive measures, becoming part of the company policy, the same way it was observed in studies by Hägg (2003).

Regarding the design teams, the presence of ergonomists was highlighted in three of the industries. The participation of the specialist was found to be necessary and recognized by the technical team and managers.

Another characteristic that was present in all industries was the interconnection between ergonomists and occupational medicine staff. Each of the organizations had a different way to act. However, common elements were found, such as the monitoring of musculoskeletal disorders and physical discomfort at the workplace; task adaption for workers with physical restrictions; and technical instructions for identifying work stressors to prevent diseases, as well as an effective treatment.

Regarding the implemented improvements, the physical, organizational, and cognitive aspects are understood to be inter-related in work duties, and modifying one of these also interferes in the others. However, to identify which aspects the improvements were related, we considered the ergonomic improvements per specialty field. Thus, we found that in all industries most changes were related to physical ergonomics. As an examples, we found the corrections of work postures, repetitive movements, load lifting, and excessive forces; changes in machines and devices; creation of instruction booklets, instructions for configuring new equipment and products.

In regards to the organizational ergonomics, the improvements focused on establishing task rotation, pauses, and the discussing of work rhythm and cycles. Only one of the industries was observed to deal with these aspects in more depth.

Concerning the aspects related to cognitive ergonomics, we noticed that, although present in all work activities, it was not recognized or understood by most actors.

3.4 Perception of the actors involved about the ergonomic practices/ergonomic programs

About the positive aspects, we observed similar perceptions in all industries regarding worker's health and safety, such as the reduction of diseases, accidents, sick leaves, increased wellness and comfort and aspects connected to productivity improvement of influence in the organizational culture.

In relation to the difficulties found, much of the improvements were not implemented due to the cost of the initiatives. Other difficulties were the need to prove financial value, the high demand for ergonomic initiatives for a small number of ergonomists, the delay in effecting improvements, and the need for higher upper management support in the ergonomics program.

Both the positive aspects and the difficulties mentioned above were in agreement with the issues revealed by the questionnaires that were applied in the first stage of this study.

4 Discussion

Inspections and the need to comply with regulations are still relevant drivers for industries to conduct ergonomic analyses and improvement implementations. According to Montmollin & Darses (2011), the ergonomic regulatory norms attempts to officially fix (often legally) ideal values and limits beyond which the existence of danger and the excessive fatigue of workers is considered. Many ergonomists fear that this practice may encourage the people responsible for adapting work stations to only implement changes as the regulations require, leaving behind more complete and specific work analysis. Although ergonomists consider regulations useful, they equally consider, like Wisner (2003), that a normative view may be inappropriate. The attitudes of the company managers are often limited to complying with the legislation, although they are sometimes legitimated by prevention. On the other hand, in the Brazilian job market, this set of legal and normative devices still support and suggest the construction of ergonomics in industries.

As pointed out by Hägg (2003) in his study on ergonomics programs in large-sized corporations, we observed that the operational responsibility for these programs was more commonly found in health and occupational safety departments.

Concerning schools and methods, we found an array of methodologies employed by the industries, which are available to ergonomists (Wisner, 2003), who have to choose among all of them and adapt the chosen methodology to the identified problem.

In regards to the ergonomic practices, as reported by Hägg (2003), common elements are identified in the

corporate initiatives in different ergonomic programs, such as health prevention and promotion, projects for changes in work stations, projects related to quality, participatory aspects and training sessions. Each of the industries had different strategies, analysis tools and forms of actuation.

The role of an ergonomist in the design of new work situations, as shown in these industries and corroborating Daniellou (2007), goes beyond predicting in detail the activity that will be conducted in the future, but also evaluating to which extent his/her choices will allow implementing operational methods that are compatible with the chosen criteria, in terms of health, productive effectiveness, personal development, and collective work.

The ergonomic improvements that were implemented were shown to be closely related to the physical aspects of work, often because these are the easiest to identify by the actors involved. The organizational aspects were also mentioned, albeit in a lower frequency. In agreement with authors such as Garrigou et al. (2007), the cognitive dimensions that underlie the activity are still very underestimated.

The positive aspects that were noticed by most actors involved with ergonomics in the industries refer to improvements in workers' health and safety, such as the reduction of diseases, accidents, sick leaves, and increased wellness and comfort.

Among the difficulties found, the highlights are the need to have more professionals engaged in ergonomic initiatives, higher support from upper management representatives, and the increasing need for convincing managers to conduct ergonomic improvements, having to prove the financial value of the suggested recommendations. In order to overcome these difficulties, participatory approaches, which involve the workers in the identification and solution of problems, made it easier for all actors to support the recommendations from ergonomists. Besides that, they connect the safety/health objectives to the productivity goals of engineers, making it easier to justify projects and give higher significance to the organization.

Corroborating Silva (2012), the companies do not approve programs that require high investments without expecting significant results, and the key for the successful justification of an ergonomic project and the successful approval from management is in the incorporation of all costs and benefits that influence a specific project. Some pieces of information are important to calculate the financial cost and to justify ergonomic projects such as: productivity; work days lost; defective or returned products; task cycles; performance below the standard; rework cost; employee turnover; overtime; costs with sick leaves; costs with administrative process for new hires; costs of legal actions due to interdictions, fines, and compensation regarding diseases or lesions; costs with training new workers; absenteeism due to lesions or diseases; wasted time caused by lesions or diseases; prevalence and severity of lesions and diseases; prevalence of physical pains; costs with occupational lesions or diseases treatment (medical, examinations, medications, physical therapy, transportation). However, none of the industries studied was found to keep these kinds of records in order to support the justification of ergonomics projects.

The clear recognition of ergonomic practices in industries is observed in regards to issues related to health, safety, productivity, and quality at work. However, the organizations still have difficulties that prevent these practices from being quickly executed, easily accepted, and incorporated to upper management goals. In agreement with the studies by Hägg (2003), the ergonomics programs are still often seen as a health and safety issue. Only a few companies have reached the state in which ergonomics is part of their global strategy.

5 Conclusion

The ergonomic schools mentioned by the literature, such as Human Factors Ergonomics, Human Activity Ergonomics, and more recently, Macroergonomics, were found in industries practices through their elements, which are mixed, one complementing the other.

The essential challenge of an ergonomist while intervening in industries consists of mobilizing the existing knowledge and methods, and, at the same time, remaining available for new dimensions that these preliminary knowledge and methods did not allow predicting (Daniellou & Béguin, 2007).

Ergonomics experts use different strategies, methods, and tools to understand work, with the responsibility of carrying out ergonomic initiatives according to the specific characteristics of an organization, its activities, and the actors involved. The participation of ergonomists is highlighted in work design. The ergonomic action in new projects implies more than a technical construction based on the analysis of an activity. It is also a social construction, that is, a participatory project structure that is based on the engagement of operators and the remaining workers responsible for production, in order to make future facilities operate more efficiently and in a more reliable way, recognizing the capital of experience and knowledge a company builds during its existence (Duarte, 2002).

When the ergonomic practices in industries are studied, it is found that ergonomics may contribute to renovate business strategies, foster worker creativity for innovation, support the industry to create processes and operations by providing new efficient and effective production methods.

It is fundamental to increase the awareness of people who control resources and make decisions, in regards to the value of ergonomic initiatives; to promote better education to ergonomic specialists, thus ensuring an excellent standard in their practices.

Ergonomic practices allow understanding the work activity, giving significance to it; allows the establishment of a dialog between the actors involved in the various hierarchical levels, and contribute to changes and improvements that aim to preserve the health and safety of workers. These practices also allow organizations to have better performance.

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