Work`s Ergonomic Analysis of the Production Sector of a Plastic Bag Factory in Cataguases/ Minas Gerais

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Abstract

This study aimed to evaluate the ergonomic conditions of the company, proposing ergonomic changes of the work, for the integrity and well-being of the employee, contributing to the performance of the same in the work environment. For the ergonomic analysis of the work, the questionnaire of the employee profile adapted from Bezerra (2011) and Kuorinka's Checklist (1987) was applied to 11 employees, representing 73.33% of the total employees in the sector of production of plastic bags in the company. For a better visualization of the information obtained, the software R was used. It was verified that the majority of the workers feels greater musculoskeletal discomfort in the upper limbs, being most cited: shoulders, lumbar spine and, significantly, the neck. It was concluded that the target company has ergonomic deficiencies which are detrimental to employees' health and productivity. Ergonomic measures such as job rotation, gymnastics and changes in furniture and machinery were proposed.

Keywords — *Ergonomics, musculoskeletal discomfort, production sector.*

I. INTRODUCTION

The study proposed in this article focuses on the importance of ergonomics in the environment of production of plastic bags in a medium-sized factory located in the state of Minas Gerais, Brazil. The competitive market and the economy are constantly being altered and renewed, placing increasingly innovative organizations in the face of challenging scenarios, making globalization and free competition a daily adversity in business. Faced with the increase of information and the easy transition of the same within the companies, the attention and concern with the employees in health, satisfaction with the work environment and performance of their functions was developed. However, at the same time, many activities within companies rely on the relationship between man and computer, or man and machines, as it's the case in this article. These relationships, being performed inadequately, can lead to musculoskeletal discomforts that in a medium or long term can result in health problems for the employee and, consequently, an aggravation for the company.

According to [1], the word "Ergonomics" comes from the Greek, where "Ergon" means work and "nomos" means laws, norms, rules. It refers to a discipline focused on a systemic approach to all the particularities of human activities.

According to [2], Ergonomics is a science based on the understanding of the correlation between systems / elements and human beings, through the application of data, methods and foundations in order to improve the wellness of the human being and the performance of the organization as a whole.

The general objective of the study is to evaluate the ergonomic situation in which the research company is located, ascertaining if it has ergonomic deficiencies in the plastic bag production sector, and if it proposes ergonomic changes in the work, for the purpose of the integrity and wellness of the employee, contributing to the performance of the duties of the same in the work environment. The specific objectives of the study are: To identify the main discomforts and musculoskeletal symptoms experienced by the employees, to indicate which part of their body is most affected by their performed functions, and to check if any musculoskeletal discomfort has been the reason for their absence in the company.

II. LITERATURE REVIEW

A. Ergonomics

Ergonomics, according to [3], covers, analyzes that pervade the working conditions of companies, taking into account the architectural equipment, floors, walls and physical arrangements, for example, and the physical environment itself, encompassing observations on lighting, acoustics and ventilation, as well as materials used as work tools.

Ergonomics can also be defined as:

> The application of human biological sciences in conjunction with engineering resources and techniques to achieve the ideal, mutual adjustment between man and his work, whose results are measured in terms of human efficiency and well-being at work. [4]

"The objective of ergonomics is to provide man with working conditions that are favorable, in order to

make him more productive through a healthy and safe work environment" [5], which, for others, promotes less wear and tear and increased productivity.

Reference[2] considers ergonomics in three divisions, Physics, which "deals with the interaction of the human body with the physical and psychological burden," Cognitive, which "deals with the mental processes that affect the interactions between human beings and other elements of a system, "and Organizational, which" deals with the optimization of socio-technical systems, which include organizational structure, policies and processes. "

Another definition can be highlighted:

According to the Brazilian Association of Ergonomics (ABERGO), ergonomics is understood as the study of people's interactions with technology, organization and environment, aiming at interventions and projects aimed at improving, in an integrated and non-dissociated way, the safety, comfort, well-being and effectiveness of human activities. [6].

According to [4], it is necessary to follow the activities of employees and identify the ergonomic risks offered by work environments, and to dispose of these threats to health at physical and psychological levels. According to these authors, these factors interfere with the physical and mental conditions of the employees, since the requirement of handling heavy materials, long journeys and higher control of work activities, which can lead to conditions of stress. According to [7], discomfort, real decrease in strength, muscle stiffness and repetition of tasks developed in the work, besides the physical environment that the worker is inserted can cause repetitive stress injuries / work-related osteomuscular disorders). According to [8], which approves the Technical Standard on RSI / RSD, these are characterized by the conjunction of several symptoms related to pain and neurology entities, which can be identified or not and are caused by permanent disability or temporary employment.

In view of the above, [5] emphasize that ergonomics confers gains in the organizational process, behaving as a discipline that guides human activities in the industrial production scenario.

According to the authors [6], the increase of the complexity of the industries modified the interaction between the employees and the machines, increasing ergonomic risks, inherent in the physical conditions of the machinery and the arrangement of the working environment, due to the presence of physical agents such as noise, vibration and lighting. In this context, the aforementioned authors still comment that through knowledge of ergonomics it is possible to seek out solutions to solve such conditions and provide a safer environment for workers.

B. *Ergonomics and work environment*

According to [3], in the face of the structural transformations of the industries, the ergonomic risks are related to the repetition of movements, in front of the work routine, where the worker always has to interact with the machines. The author also mentions as conditions of ergonomic risks the inadequate posture of workers, bad lighting and excessive working hours, with monotonous activities and involving the handling of materials within the production system. Thus, ergonomics is "a branch of science that studies the development and application of techniques and methods that aim at the knowledge of both physical and psychological human limitations and their relationship between man and his job." [6].

Reference [6] argue that the volume of information and level of knowledge has increased significantly in business organizations, increased production income and raised the level of concern for the health of workers and their income in the realization of their daily routines in industries.

According to [3] the ergonomic analysis of work in the industrial production sector is now an important tool for improving working conditions, requiring companies to plan in this direction, aiming to guarantee safety and quality of life for employees. The Ergonomic Work Analysis (EWA) has generated considerable improvements in production environments, contributing to safer environments and improving the efficiency of production processes.

Define the LEA (Labor Ergonomics Analysis) as "a method of job analysis based on the observation of the activity as it is happening at the time of analysis and whose main objective is to improve the work situation." [9].

According to [4], ergonomics can be called 'human engineering', being a very recent science in the industrial sphere, which relates man and his work environment.

C. *Regulatory Standard 17 and Ergonomics*

According to information in [10], in the legal scope, ergonomics is governed by the Regulatory Standart 17 (RS-17), which predisposes parameters for working conditions, according to the psychic and physical characteristics of workers, aiming to guarantee safety and good performance in the activities. In its specifications, the RS-17 establishes conditions for the handling of loads, as well as indicating the conditions of the work environment, equipment and to the way the work itself is organized. Also according to RS-17 it is the duty of the employer to carry out the ergonomic analysis of the work, according to the conditions prescribed in said standard.

Reference [6] assert that the main objectives are focused on the reduction and prevention of work-related diseases, which are responsible for health problems in workers.

According to [10], ergonomics is applied in the scope of work basically in all the daily tasks of the employees, establishing guidelines for the accomplishment of the tasks at work, starting from the notion that each worker presents different needs

regarding the adequacy to the environment and to the machinery it operates. In view of this, it is inferred that RS-17 has set parameters to regulate and monitor inappropriate behaviors and postures of workers, as well as to monitor and correct unsafe conditions of the environment and machines, which when neglected can lead to serious damages to the worker's health.

According to [4], the absence or lack of ergonomic patterns in the workplace usually causes repetitive strain injuries (RSI), usually due to incorrect use of equipment, ranging from computers to heavy machinery. Activities such as excessive physical exertion, long periods of standing, or long standing static conditions are also related by the authors as responsible for occupational injuries, which characterize the focus of RS-17.

Regulatory Standard 17 confers benefits to workers, since it guarantees a safer and more comfortable environment, with low levels of ergonomic risks, resulting in the prevention of the above mentioned problems.

The reference [11] mentions the importance of recognizing ergonomic hazards in the workplace as a prime first step in correcting risks and offering better protection to workers. So, [11] reports the importance of the employer to predict what can go wrong and change tools and the work environment in order to make the activities safer for the employees.

III. METHODOLOGY

The present article was characterized as a descriptive research, with qualitative approaches. According to [12], descriptive research has the main purpose of reporting characteristics of a certain group of people, place of relations or phenomenon, and all of its points, the most important is the use of standardized tools for collecting information and data.

For the elaboration of the same, a bibliographical research was made, through already elaborated literatures, among them scientific journals, books and articles published in congresses, available in the database of Google Scholar, Scielo, Yahoo.

Regulatory Standard 17 was used for the purpose of ascertaining the situation in which the company is in terms of the employee's ergonomics and well-being. It "aims to establish parameters that allow the adaptation of working conditions to the psycho-physiological characteristics of workers, so as to provide maximum comfort, safety and efficient performance." [10].

The production sector was chosen for the present study because it requires repetitive efforts, or at times inadequate postures, so ergonomics is directly linked to it.

A. Company characterization

This study was carried out in a medium-sized factory that has been present in the labor market for more than 27 years in the production of Oxy-biodegradable plastic bags and paper bags, located in the state of Minas Gerais, Brazil. It is composed of 30 employees, 20 women and 10 men. For each sector of manufacturing of bags (plastic and paper), employees were distributed according to the norms and the management of the company. The employees work from morning to the afternoon, more precisely from 7:00 a.m. to 5:00 p.m.

B. First Visit

The visit to the company happened on 03/05/2018, where, in the first moment, a meeting took place between the researcher of this study and the chief owner of the company. He was presented with the research plan, in which his production sector would submit and the purpose of it. Being present in the production sector, the main approach to be taken was to observe the workplace of the employees, as well as the ergonomic question, besides the postures that the service requires of its body and its movements in front of its function. Annotations were made in front of everything that was observed and then a filming of the entire place during working hours, for later observation purposes, in an Apple 5S cell phone was also made.

C. Second Visit

The second visit to the company was held on 06/20/2018, with the purpose of discussing the reason for the research through the study research plan and for academic purposes. The questionnaire for analyzing the profile of the employees, adapted from [13], and the checklist of [14] - Nordic questionnaires' standardized for the analysis of musculoskeletal symptoms - can be taken at home and returned within 48 hours.

D. Employee profile analysis questionnaire

The questionnaire delivered to employees is an adapted version of [13], composed of nine closed-ended multiple choice questions, in a clear and objective way for data collection, as diverse aspects related to the context of the work and presented according to the Likert scale, containing responses with five alternatives.

The validation of this questionnaire was carried out on 06/18/2018, through the SPSS Program. The same "provides test options that correct the violation of the variance homogeneity hypotheses."[15]

At first, the analysis of responses in the program was presented with the alpha level of cronbach below that allowed. Questions that presented problems due to their increasing alternatives were number 4 and 5. In order to solve the problem, question number 1 was inverted with number 5 and question number 2 with number 4. After this exchange, the alpha level of cronbach presented with the result of 79.4 , that is, above the allowed level of reliability of the questionnaire, being this one above 70.

The questionnaire was applied in order to know the profile of the company's employees, thus enabling a more coherent analysis of the results obtained. It is intended to find out the personal opinion of each employee on certain issues, their labor and ergonomic condition within the company, and how this in fact contributes to their well-being.

The analysis of the questionnaire took into account the percentage of the employees' answers in each closed question, demonstrated through graphs arranged in the results presented in this article.

E. Checklist to musculoskeletal systems analysis

The Checklist of [14], also known as Ovako Working Posture Analysis System (OWAS), is a tool that aims to evaluate the postures assumed by the collaborators through the observation of the researcher.

[16] states that according to the authors of this questionnaire, it is not indicated as a basis for medical analysis, but to recognize musculoskeletal disorders and, in this way, it becomes an important diagnostic tool for the environment or the workplace. The checklist evaluates all anatomical areas, and two specific ones for the lumbar and neck and shoulder regions. According to officials, the Tool consists of multiple or binary choices according to the occurrence of symptoms in the various anatomical regions in which they are most frequent.

The questionnaire was applied in order to measure the musculoskeletal symptoms felt by each employee of the company, focusing on the analysis and comparison of the obtained data and the results found, for example, which symptoms are more frequent among the collaborators and if their functions contribute to it.

F. Production sector

The target sector of research for the construction of this article was delimited in the unit of production of plastic bags located in "Zona da Mata Mineira", where it is composed by 15 collaborators.

The division of production per step, as shown in Figure 1, occurs as follows: 4 are in the initial stage of the process, where the oil in grains is subjected to 200º, and after a certain process, the ready-made plastic material is transferred to its second stage. In the second stage, the material is sent to two areas of activity: personalization, where the plastic is submitted to the print process of logos of the client companies that opted for this type of service, where 4 employees are in the handling of this service; in the other, the plastic is sent only to the cutting, where 4 employees are responsible for the removal of the already finished plastic packaging of the machine, both the customized packaging and the packaging without personalization, and take them to the packaging. The loading of the bags is done by 3 employees, where they carry bags of 15 kg each to the stock or to the delivery, in case of order.
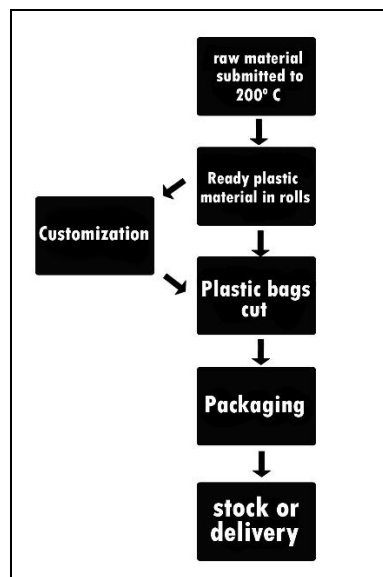

Figure 1 - Flowchart of the plastic bag production process

G. Program R

The R program (R DEVELOPMENTCORETEAM) is a free software for statistical computing and graphics. R provides a wide variety of statistics (linear and nonlinear modeling, classical statistical tests, time series analysis, classification, grouping, ...) and graphic techniques and is highly extensible. The S language is often the vehicle of choice for research in statistical methodology, and R provides an Open Source route for participation in this activity. [17]

According to [18], the program has an integrated environment that grants control and manipulation of information, execution of calculations and the creation of graphs. These authors further cite that although R is not a statistical program, it allows easy manipulation, evaluation, and interpretation through procedures that involve statistics when applied to data.

The purpose of the R program in the present study is to manipulate the data collected through statistical analysis, in addition to construction of graphs.

IV. RESULTS AND DISCUSSION

In the present study, an ergonomic analysis of the work was carried out, aiming to identify the main discomforts and musculoskeletal symptoms experienced by employees, as well as their level of well-being in their workplace, through observations, questionnaire and checklist described in the methodology. It is considered that the ergonomic guidelines presented here will contribute to the health of the employees, resulting in a decrease in the wear and tear generated by the work performed, thus increasing their productivity.

A. Analysis of the questionnaire adapted from Bezerra (2011)

The first tool used was the [13] Adapted Questionnaire, with the objective of analyzing the

characteristics of the sample and the level of satisfaction of the workers in performing their functions.

The initial sample universe consisted of 15 workers who performed their duties from 7:00 a.m. to 5:00 p.m. However, 11 employees answered the questionnaire, that is, 73.33% from the total in the participated sample.

The analysis of the profile of the employees through questionnaire is presented in Figure 2, in terms of gender, age, schooling, time of the exercise of the function in the company and monthly income.

It is noticed that the majority of the employees are up to 25 years old, this youthful age, in which it is understood that they do not have health problems resulting from a more mature age. In the same way, the vast majority of employees, more precisely 54.55% of the total have up to 5 years of service to the company.

It is concluded that 45.45% of the employees have a low level of education, and this percentage refers to the sum of incomplete, complete fundamental and incomplete secondary schooling levels. Thus, almost half of the total number of employees does not have

an ideal and desirable level of education, that is, they do not have a complete secondary education.

In order to evaluate the satisfaction level of the work environment, there were questions in the questionnaire about satisfaction with the environment where it works, whether the physical working environment is pleasant, whether it has adequate and adequate work equipment to perform the function and, finally, has adequate and sufficient work safety equipment to perform the function. The questions contained answers ranging from totally agreeing to totally disagree, and the employee should make an alternative. For better visualization of the result, bar graphs were performed to the level of employee satisfaction through Software R, where the code shown in figure 3 was executed.

```
employees<- matrix(c(1,3,4,2,1,2,1,4,2,2,2,1,4,1,3,3,3,3,2,0), nrow=5,
ncol=4, dimnames=list(c("DT", "DP","NCND","CP","CT"), c(("Job satisfac
tion", "Nice workplace", "Work equipment", "Safety equipment")))
barplot(employees)
barplot(employees, beside=TRUE)
barplot(employees, beside=TRUE, ylim=c(0,5),main="Employee satisfactio
n with the workplace and equipment", ylab="number of employees",xlab="
level of satisfaction")
```

Figura 3 - Code executed in program R

ANÁLISE DO PERFIL DOS FUNCIONÁRIOS		
GENDER	Female	45,45%
	Male	54,55%
AGE	Up to 25 years	45,45%
	From 25 to 35 years	36,36%
	From 45 to 55 years	18,18%
SCHOOLING	Incomplete Elementary School	18,18%
	Complete Elementary School	18,18%
	Incomplete High School	9,09%
	Complete High School	45,45%
	Incomplete College Education	9,09%
TIME AT COMPANY	Up 5 years	54,55%
	From 5 to 10 years	36,36%
	Over 20 years	9,09%
MONTHLY INCOME	Until 2 minimum wages	90,91%
	From 2 to 5 minimum wages	9,09%

Figure 2 - Employee profile analysis

As a result of the executed code, we found the bar graph shown in Figure 4, where DT, DP, NCND, CP, CT respectively mean: Strongly Disagree, Partially Disagree, Neither Agree nor Disagree, Partially Agree, and Totally Agree.

According to the graph generated from data collected, most of the employees opted for the 'Neither agree nor disagree' alternative in the questions presented to them. Because of this, it was shown that the employees may not understand the work environment in which they are inserted. One reason for this would be the low level of schooling

they have. Reaffirming that 45.45% from the total of the sample has a lower level of education than the full secondary school.

B. *Analysis of Kuorinka's checklist (1987)*

The second tool used to be the checklist of [14], in which its use aims to evaluate the postures assumed by the collaborators through the observation of the researcher. For a better visualization of the data collected, the code was executed in the software R presented in Figure 5. This code generated the graph of Figure 6.

```
employees<- matrix(c(1,3,0,2,0,3,0,0,2,0,3,2,0,0,0,2,0,0,0,0,5,0,0,0,0
,0,0,0,1,0),nrow=10, ncol=3, dimnames=list(c("neck", "shoulders", "elb
ows", "wrists and hands", "backbone", "lumbar spine", "hips or thighs"
, "knees", "ankles or feet", "no symptoms", c("pain in the last seven d
ays", "pain in the last twelve months", "Missed in the last 12 months
")))

barplot(employees)

barplot(employees, beside=TRUE)

barplot(employees, legend.text=rownames(employees), main="Nordic Quest
ionnaire on skeletal muscle symptoms ", ylab="number of employees", xl
ab="time", sub="Source: Own, 2018"))
```
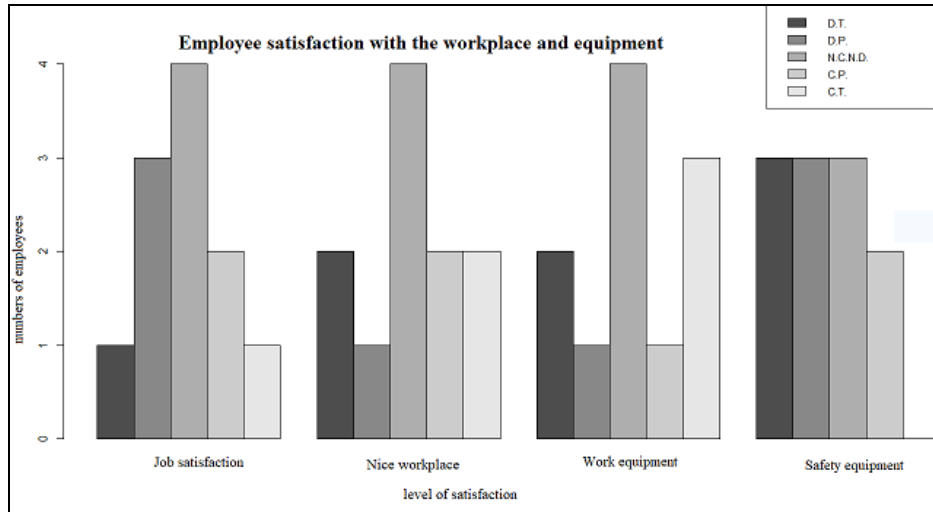
Figura 5 – Code executed in program R

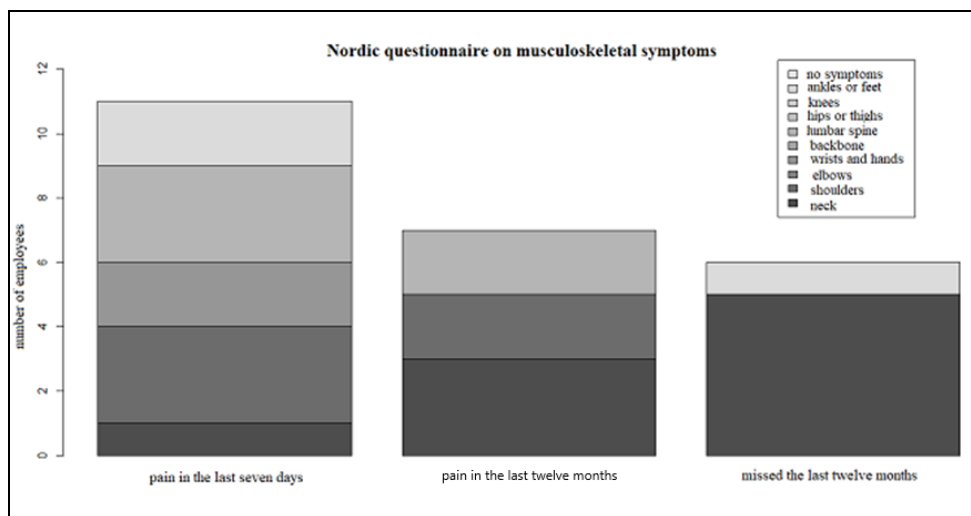**Figura 4 – Level of employee satisfaction**

Figura 6 - Level of musculoskeletal symptoms

In view of the data indicated in Figure 6, it is highlighted that in the last 7 days the parts of the body with more complaints of pain are the shoulders and lumbar spine. In the last 12 months, the pains in the neck stand out, however, shoulders and lumbar spine also point out their relevance in that space of time. However, neck pain is the cause, for the most part, of employee misconduct. Therefore, with such analysis, it is concluded that the muscle discomfort of the same is predominant in the upper limbs, these being: shoulders, lumbar spine, and, significantly, the neck. The effort required of the body parts cited is a result of the way in which the employees are imposed to work through the conditions that the environment and the machinery meet. Figure 7 shows in a faithful manner the curved position that the worker needs to be in order to handle the machine that cuts the loops of the plastic bags, which is a crucial step in the production of the final product. It is noticed that the neck is being impacted of negative force in this positioning, as well as the shoulders and lumbar spine.

Figure 7 - Collaborator in curved position

In Figure 8, the employees' workplace is presented. It is noted that the machine, with the function of cutting the bags, is slightly below the waist, and causes an inappropriate angle of the arms, and for the neck, because the handling of the machine requires that the worker looks down with his head.

Figura 8 - Company production sector.

C. Ergonomic Recommendations

It is recommended to readjust the layout of the work station studied, as well as the replacement of furniture and machinery respecting Regulatory Norm 17, adjusting the height of the machines and equipment according to the anthropometric particulars of the employees for the determined work performed by them, so that they don't have to bend their body for the accomplishment of the work, allowing the adoption of consistent postures with good occupational health practices.

It is advisable to maintain the organization and cleanliness of the workplace, allowing the best performance of the employee's activities and also contributing to their wellness.

It is suggested, with some importance, to introduce a program of work-related gymnastics and of regulated and sufficient breaks for a satisfactory recovery. "The main objective of occupational gymnastics is the prevention of occupational diseases, it is carried out in the workplace three times a week or daily for periods ranging from 8 to 12 minutes during the working day."[19]. The author also points out that the workout programs aim at balancing the muscular activity performed at the work itself, also resulting in the prevention of occupational diseases operating in the musculoskeletal system.

V. CONCLUSION

The study is important since Ergonomics is related in a significant way to Production Engineering, because it concerns the planning of companies so that they can guarantee productivity, safety and quality of life of their employees. For the construction of the same, data were collected and analyzed from 11 employees of a plastic bag production sector through the Employee Profile Questionnaire adapted from [13] and checklist [14] to analyze musculoskeletal symptoms.

It was evaluated the ergonomic situation in which the research company is located, verifying its ergonomic needs in the plastic bag production sector, in order to propose ergonomic changes of the work.

In view of the study, it was concluded that the company targeted by the research has ergonomic deficiencies, which are detrimental to the employees' health, thus compromising their productivity. It was also concluded that the ergonomic requirements of the activities of the plastic bag production sector constitute considerable factors for the occurrence of employees' lack of work, resulting from an overload in the upper limbs caused by the inadequacies in the working devices, showing a greater discomfort in the neck, missing motive in the last 12 months, and shoulders and lumbar spine, cause of complaints in the last 7 days from the date of application of the questionnaire. Moreover, the organizational model of production may also be contributing to the development of musculoskeletal damage by exposure to repetitive and monotonous work. Propose changes in the furniture and machinery and the introduction of a workout program, which should be implemented in the short and medium term.

The present study presents relevance and contribution to the scientific community and to the company that is the target of the research, since it is an important issue from the point of view of accident prevention and reduction of health problems arising from activities in the work environment. since ergonomics in the work environment is not only related to the well-being and integrity of the employee, but also to the productivity of the employees and the quality of the product or service provided by the company.

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