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A WEIGHT ON THE BACK: THE WORK BACKPACK OF COMMERCIAL RELATIONSHIP AGENTS OF AN ENERGY GROUP FROM THE PERSPECTIVE OF ERGONOMICS

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ABSTRACT: The research describes the Ergonomic Analysis of Work (AET) carried out in a Brazilian energy distribution company. The construction of the work is a participatory process, with representation of the working class, the security and medicine sector and managers in the area. The help data for physicians were indicators to help develop the study. From the analysis of the activity, it was possible to verify that the backpack used by the commercial relationship agents needs transformation. This analysis is the basis of the designed backpacks, for a new model presented through prototyping.

Keywords: Ergonomic Work Analysis; Ergonomics; Backpack; Relationship Agents

1. INTRODUCTION

According to the International Energy Agency (IEA, 2021), Brazil is the largest individual energy consumer in South America, accounting for around 36% of total final energy consumption in the region. Work in the Electrical Sector consists of the generation, transmission and distribution of electrical energy, and requires physical and mental efforts, associated with risks to the health and safety of workers (MARTINEZ & LATORRE, 2009). This study describes the Ergonomic Work Analysis (AET) carried out in a Brazilian energy distribution company, focusing on the work activity of commercial relationship agents (readers).

The initial demand arose from information from a former employee of the company, who signaled the existence of possible demands to be studied in the sector. After contact with the occupational health and safety coordination, the readers' backpack was identified as an area that needed improvement. Regulatory Standard No. 17 establishes that all equipment that makes up a workstation must be suitable for the psychophysiological characteristics of the workers

and the nature of the work to be performed. To this end, a participatory process, with representation from the working class, the Occupational Safety and Medicine sector and managers in the area was fundamental for the development of this research.

According to Soares et al. (2012), ergonomics seeks, within its possibilities, to efficiently reduce problems arising from the incompatibility between man, machine and the work context. According to the Regulatory Standard Application Manual nº 17 (2002), equipment, environmental conditions and work organization must be adapted to the psychophysiological characteristics of workers and the nature of the work, in addition, workers must be consulted and approved equipment, environmental conditions and work organization, as only they can attest to your comfort or not.

The ergonomist's responsibility is not only to prevent the risk of pathologies by transforming work, but to act on the causes, reducing the ergonomic risk arising from a method of developing working conditions (GONÇALVES, 2010). In all contexts that require an analysis of human work, it is important to use appropriate mechanisms to arrive at the proposed project, taking into account all the factors that influence and affect work activity.

1.1. Objective

The main objective of this study is to improve the working conditions of commercial relationship agents at a Brazilian company in the energy segment, with a focus on developing a backpack model that is more suitable for the worker's activity.

2. METHODS AND TECHNIQUES

This study was developed in accordance with the Ergonomic Work Analysis (AET).

In the exploratory phase, after knowing the demand, the first visit to the company was carried out, where the equipment that the commercial relationship agent carries during his journey was weighed and measured and the uniform and types of footwear used were checked. Unstructured interviews were carried out with relationship agents and data regarding workers' health were requested from the Occupational Safety and Medicine sector.

In parallel with the analysis of workers' health data, open observations began, which totaled approximately 48 hours in the field. During the observations, semi-structured interviews were carried out in parallel with the activity, as well as recording the workers' spontaneous verbalizations and constraints. Furthermore, the length of time that the

relationship agents spent with their backpacks on their backs during the work period was verified.

2.1. The company and characteristics of the working population

The company studied is part of a group of companies in the energy distribution, generation and commercialization segments and is the fourth largest energy distributor in Brazil. Operating in 31 municipalities in the State of Rio de Janeiro and headquartered in the capital, where it has been operating for over a hundred years, its services cover a region with over 10 million people. There are 603 agents including contractors and outsourced workers. The team is made up of 88% pedestrian relationship agents and 12% motorcyclist relationship agents. Relationship agents are mostly male, and represent 92.6% of total readers. The team of pedestrian readers is made up of 487 men and 44 women. The team of motorcycle readers is made up of 71 men and 01 woman.

In the team of pedestrian agents, the predominant age range is between 30 and 40 years old, followed by the ranges of 19 to 29 years old and 41 to 51 years old. In the team of motorcycle agents, the age group between 30 and 40 years old stands out above the others. Between the two teams, workers in the prevalent age group represent 40.8% of the company's total number of agents.

Regarding length of service, both in the team of pedestrian readers and in the team of motorcycle readers, the period of time that stands out is up to 02 years of service, 61.7% of workers leave the company during this period. This data portrays a high rate of worker turnover, and negatively affects the company's performance. The turnover rate may increase due to factors external to the company, however factors such as the company's structure, processes and management directly interfere.

2.2. Absenteeism among the working population

Data were collected from the Occupational Safety and Medicine sector, referring to absences over the last year. These data were separated according to the International Code of Diseases (ICD), which assigns a category to each individual's health status, according to the pathologies cataloged by the World Health Organization.

The categories of codes that stand out are classified with the initial letter 'M', related to illnesses that affect connective, bone and muscular tissue, with emphasis on category M545,

which refers to the description of acute or chronic pain in the lumbar or sacrum and may be associated with sprains and strains of muscle ligaments, disc displacement and other conditions. This pathology generated a total of 58 sick leave in 2020.

Another data analyzed is the average number of days of leave generated from each ICD code category. The M545 category, in addition to presenting the highest number of absences, also caused the highest average number of days of sick leave. Workers affected by this pathology spent an average of 155 days away from work.

Based on information collected in the health area, the focus was on the back problems of relationship agents. Therefore, the objective of the analysis would be to generate specifications for the work backpack of these agents.

2.3. Equipment

During monitoring of the activity, it was observed that the relationship agent does not start his route with all the work instruments made available by the company, represented in figure 1. Considering that according to the route of the day, he uses between 03 and 05 reels of invoices, it was found that he would carry a minimum weight of 1,310kg during an 8-hour journey if he took all the equipment with him. To this weight must be added the weight of personal objects and food that each agent carries with them.

Figure 1 - Commercial Relationship Agent Equipment

IMAGEM	item	QUANT.	Dimensions	PESO
	Invoice reel (90 invoices)	03 - 05	10 x 5.5 cm	78g
	Label reel	01	11 x 4 cm	38g
	Data collector	01	14.7 x 7.5 x 2cm	64g
	Battery for collector	01	13 x 7 x 2cm	82g
	Printer	01	19 x 16.5 x 7 cm	471g
	Protector against animal attack	01	11 x 5.2 x 3.5 cm	43g
	Sunscreen and insect repellent	01	-	51g
	Bottle for liquids	01	33 x 8 cm	327g
	Food bag	01	20 x 15 x 12 cm	-
	Minimum weight			1,310 kg

Source: Own authorship (2021)

2.4. Task

Commercial Relationship Agents work in an external environment and have the following duties:

a. The. Reading energy meters;
b. Delivery of energy bills;
c. Field indications such as: broken wire, fallen pole, bumped and damaged pole, leaky transformer;
d. Updating customer records;
e. It is. Reading supervision;
f. Support in the company's commercial actions.

Regarding the organization of the activity, there is division into work routes, carried out by the supervisor of the relationship agents, who uses prior knowledge of the route to be worked by the agent as a criterion. It is the supervisor who also defines the production target, which is between 200 and 700 readings per day, using as a criterion the difficulty of accessing the meters with readings predicted for the day.

Shifts at the company are 8 working hours per day, distributed as follows: Monday to Friday from 7am to 4pm with a 1am break for pedestrian agents; Monday to Friday from 8 am to 5 pm with a 1 hour break for motorcycle agents; Saturday from 7am to 11am without food breaks for pedestrians; Saturday from 8am to 12pm without food breaks for motorcyclist agents.

According to the company's HR policy, the minimum education required to be hired as a commercial relationship agent is a high school diploma.

The hierarchical communication structure to which the agent has access is vertical: Manager – Supervisor – Inspector – Commercial Relationship Agent, respectively from top to bottom.

2.5. Main problems

In the initial contact, the workers were presented with the way in which the ergonomic action would be conducted: what ergonomics is, their importance for the study, anonymity and the analysis methods that would be used.

The workers spoke about their day-to-day activities and highlighted some complaints:

a) The backpack does not close properly

> "It is not a zippered backpack, so its mouth is wide and it stays open, depending on the stance I take, if I go down to put a bill, an invoice under the door for example, it is at risk of the products that It's inside, like safety equipment, sunscreen, alcohol gel, falling out of the backpack and even the bill itself. The water bottle has already fallen." (Agent 02)

Figure 2 - Opening on the sides of the backpack

Source: Own authorship (2021)

The backpack has a closure with pass-through straps, which does not completely seal the upper opening. When carrying out some body movements during the activity, the backpack is in positions that cause the objects inside it to fall.

b) The backpack causes physical discomfort

"The backpack itself, if it doesn't have anything there, if you lift it, it's light, but having it on your back all day is heavy, understand?" (Agent 03)

Figure 3 - Backpack with few objects inside

Source: Own authorship (2021)

Readers report that although the weight carried in the backpack is not high, the time they spend with the backpack on their back causes a greater perception of weight, in addition to causing physical discomfort at the end of the work day.

CP-Rede meters, whose equipment is installed on poles or other structures owned by the distributor, located on roads, public places or underground compartments, require greater attention from the meter reader, as visibility is reduced due to the weather, light and/or cleaning of equipment. Readers use a closed-focus LED flashlight to assist with measurement, but this equipment is not provided by the company, so only some workers have it.

2.6. Activity analysis

The supervisor informs the route and the number of readings/goal that the agents will work on 01 (one) day in advance, so that they can organize the materials that will be used according to the route, such as the number of invoice rolls per example.

To carry out the activity, the relationship agent uses the data collector, a device where he records the reading numbers of the energy consumption meters and sends the invoices for printing, enters the reading impediment codes and registers new customers.

Figure 4 - Data collector

Source: Own authorship (2021)

The collector works with a data chip, which allows the collected information to be sent to the company's system in real time. This device also indicates the direction in which the worker should follow the route, according to the geographical position of the energy meters, and allows the inspector to know the progress of the work.

The printer used to print invoices is interconnected with the data collector and can print one invoice at a time (a function generally used after reading house meters) or a batch of invoices (a function generally used after reading building meters), in addition to of the invoice reprint function. Invoice reels are attached to the printer, resulting in the printing of 90 invoices each.

Figure 5 - Printer

Source: Own authorship (2021)

After printing, the worker folds the invoice and seals it with the company label, thus guaranteeing the confidentiality of customer information. The invoice is then delivered directly to the customer/concierge or placed in the mailbox.

Throughout the work, it was observed that the agents were uncomfortable with their backpacks. They commonly support the backpack with one hand when bending down to read the meter.

Some regulations were also recorded, such as the use of the backpack on the shoulders, the backpack left at the building entrance and the printer placed on the floor. These adjustments are demonstrated in the following figure.

Figure 6 - Regulations

Source: Own authorship (2021)

During the semi-structured interview, carried out in parallel with the observations, the relationship agent spoke about the most frequent regulation.

> "I leave it at the reception because it avoids, you know, holding the backpack too much so as not to harm my spine anymore, you know, because it's already a little heavy [...] so anything you take off the backpack is very good." (Agent 02)

The meter reader explains why he leaves his backpack at the entrance of the buildings he enters to read the meters.

Agents also carry out the separation and delivery of already printed invoices. These invoices refer to electronic meters with chips, which send consumption data directly to the concessionaire.

Figure 7 - Invoice screening

Source: Own authorship (2021)

Invoices are separated by street and ordered by property number. This separation is done at Base Centro and delivery is carried out daily by one of the agents.

According to the consumer units, the routes can be classified as follows:

- House route – work route with a predominance of meters in houses, on flat terrain, slopes or slopes;
- Building route - work route with a predominance of meters in buildings, on flat terrain, slopes or slopes;
- Diversified route - work route with meters in houses, buildings and businesses, on flat terrain, slopes or slopes;

Monitoring the activity began with simple observations, concomitantly with unstructured interviews. In the following follow-ups, the observations were more detailed, measuring the time the worker spent with the backpack, the number of times he accessed it and the adjustments made. The systematic observations, carried out in a cursive and participatory manner, contributed to the collection of information on the actual performance of the work that was useful for understanding the activity. At the end of each monitoring of the execution of activities, the records obtained were validated by the participants in the process.

2.7. The backpack

The way in which the worker transports the equipment can be determined by factors such as the weight carried, the size and shape of the equipment, the transport time, the terrain, the climate and the individual characteristics of each one.

The backpack used by relationship agents, represented in the following figure, has dimensions of 40 x 31 x 20 cm, and a 7 cm wide strap. It is made from 100% cotton fabric, with a waterproof rain cover and padding on the back and shoulder straps, which are also adjustable.

Figure 8 - Commercial Relationship Agents Backpack

Source: Own authorship (2021)

A spontaneous verbalization, in the form of a suggestion, was made by one of the agents accompanied during the observations. He verbalizes what could be improved in the backpack for the comfort and safety of his work.

> "It should be a more closed backpack so that the products we carry are better retained, with a zipper. The pockets are not closed so everything inside the pocket, depending on the movement, could fall out, someone with bad intentions could also put their hand inside the backpack because it doesn't close completely."

The motorcyclist relationship agent also spoke, in a non-structured interview, about the functionality of the backpack during the activity.

> "The fact that it's not waterproof is a bit of a hindrance, because when it rains the raincoat doesn't hold up much."

He explains that the rain cover does not perfectly protect the entire backpack, and because the backpack's fabric is not waterproof, objects and/or printed invoices end up getting wet on rainy days.

Reference situations allow, based on current experiences, to develop equipment with greater possibility of suitability for use in the future. The bag used by postmen and the backpack used by photographers were references for this research.

3. DIAGNOSIS

From the analysis of workers' activity, focusing on the backpack used by commercial relationship agents, possibilities of harm to workers' health and the need for frequent adjustments were highlighted.

The size of the backpack is larger than necessary to accommodate the equipment that the reader needs to carry out their work, this can lead to an increase in the load generated by objects unrelated to the activity. The backpack also does not have a structure that prevents it from moving during some body positions adopted by agents when taking meter readings, generating physical discomfort and constraints that increase the time needed to carry out the readings.

Furthermore, the backpack does not have compartments that ensure the distribution of the weight carried, concentrating all the weight at the bottom of the backpack and overloading the lumbar spine. Due to this overload, frequent regulations were observed, such as the use of

the backpack on the shoulders or in the hand and the backpack being left at the building entrance.

Another no less important point is the precarious closure of the backpack, which does not completely seal its openings, causing the loss of objects. This situation requires the agent to pay greater attention throughout the entire route and ends up taking the focus away from the activity carried out.

Furthermore, the backpack is made of permeable fabric and has a rain cover, which for motorcycle agents does not work properly. The rider's movements, combined with weather factors, mean that the cover does not remain attached to the backpack for the necessary time.

4. RECOMMENDATIONS

As a result of the analysis of the activity, the documentary analysis and the verbalizations of the actors involved in the course of this study, based on the theoretical framework, I present in the following table recommendations for a new backpack model.

Table 1 - Study recommendations

ITEM	SUGGESTION
01	**What?** Reduction in backpack size. **For what?** Encourage the worker to take only what is necessary to carry out the activity. **Why?** The size of the current backpack is larger than necessary to accommodate the equipment the agent needs to carry out his work. **Ergonomic principles?** NR-17.4.1 - All equipment that makes up a workstation must be suitable for the psychophysiological characteristics of the workers and the nature of the work to be performed. **Recommendation?** Dimensions 46x30x15 with empty side pockets and 46x44x15 with filled side pockets.
02	**What?** Structuring the backpack. **For what?** Ensure the stability of the backpack. **Why?** The backpack does not have a structure that prevents it from moving during the numerous body positions adopted by agents when taking meter readings. **Ergonomic principles?** NR-17.4.1 1 - All equipment that makes up a workstation must be suitable for the psychophysiological characteristics of the workers and the nature of the work to be performed. **Recommendation?** Ventilation panel and dorsal padding, 5 cm wide, padded, curved and adjustable straps, Adjustable chest belt.

Continua...

03	**What?** Backpack compartmentation. **For what?** Ensure distribution of the loaded weight and avoid adjustments. **Why?** The backpack has no compartments, concentrating all the weight at the bottom of the backpack and generating adjustments. **Ergonomic principles?** NR-17.4.1 1 - All equipment that makes up a workstation must be suitable for the psychophysiological characteristics of the workers and the nature of the work to be performed. **Recommendation?** Compartments on the left/right outer sides for water bottle and coils; top external pocket for raincoat; top internal pocket for personal documents; partitioned internal pocket for printer, collector, collector battery and sunscreen/insect repellent; pocket on the strap.
4	**What?** Backpack closure. **For what?** Ensure the compartments are completely closed. **Why?** Closing the backpack does not completely seal its openings, causing objects to be lost. **Ergonomic principles?** NR-17.4.1 1 - All equipment that makes up a workstation must be suitable for the psychophysiological characteristics of the workers and the nature of the work to be performed. **Recommendation?** Zipper closure.
05	**What?** Waterproofing the backpack fabric. **For what?** Prevent equipment and invoices from getting wet. **Why?** The backpack is made of permeable fabric and has a rain cover at the bottom. The rider's movements, combined with weather factors, mean that the cover does not remain attached to the backpack for the necessary time. **Ergonomic principles?** NR-17.4.1 1 - All equipment that makes up a workstation must be suitable for the psychophysiological characteristics of the workers and the nature of the work to be performed. **Recommendation?** Nylon fabric, waterproof stitching and rain cover on the top.

Source: Own authorship (2022)

4.1. Materials and specifications

Based on the recommendations presented, the search began for materials that best suit the project.

External Body: 350g waterproof nylon 600 pvc coating; Reinforced bottom in 1200 polyester reinforced fabric, weight 370g/M².

Internal Body: Nylon 70 coating.

Rain cover: Resin 70 nylon coating; 12mm welt elastic.

Shoulder strap: Outer covering in sanded perforated mesh fabric; Internal lining in 8mm pack foam; Polyamide shoelace strap, width 3cm and thickness 0.9mm; Castle regulator injected in nylon 6.6 with locking teeth, internal base 3cm and external height 5cm.

Strap pocket: Nylon 70 coating; Opening with slider zipper nº 5, polyester laces and nickel-plated Cursor nº5.

Internal pocket: Nylon 70 lining; Opening with slider zipper nº 5, polyester laces and nickel-plated Cursor nº5.

Partitioned internal pocket: 300D PU Oxford fabric lining.

Chest belt: Polyamide shoelace strap, width 2.5cm and thickness 0.9mm; Quick-connect closure in nylon 6.6, width 3.5cm, internal base 2.5cm and length 6cm; Rectangular regulator in polypropylene plastic, internal base 2.5cm and external width 3.5cm.

Opening and Closing: Main opening with slider zipper nº 10, nylon shoelace and toothpick cursor nº 10; Opening of the side pockets with a #8 slider zipper, nylon laces and #8 metallic slider.

Back padding: External covering in Air sanded perforated mesh fabric; Internal lining in 8mm pack foam.

Hand strap: Pressure reduction cushion with external covering in sanded perforated mesh fabric and internal covering in 6mm pack foam; Polyamide shoelace strap, width 3cm and thickness 0.9mm.

Finishing: Boneon bias/25mm piping.

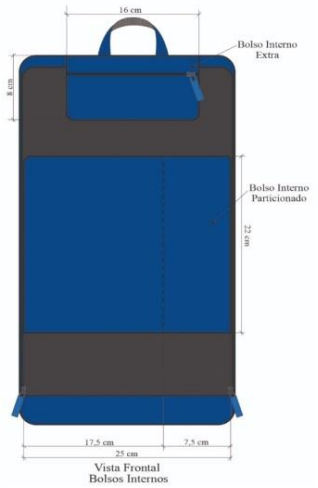
Sewing: Thread 40 in 80g polyamide.

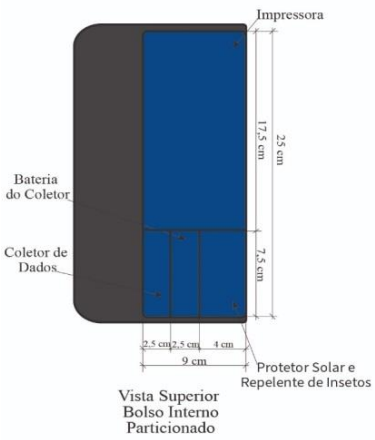
Logo: Silkscreen engraving on the upper front.

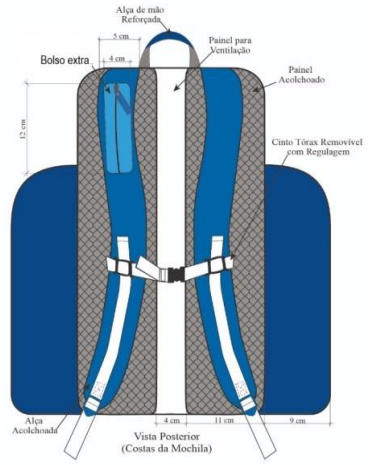
4.2. Prototyping

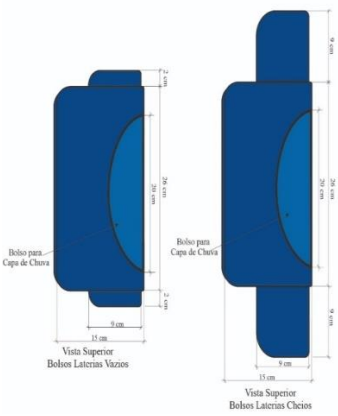
The first version of the backpack is a low-fidelity commercial prototype with a focus on functionality, designed to be an initial draft of recommendations and provide a visualization: product ➡ idea.

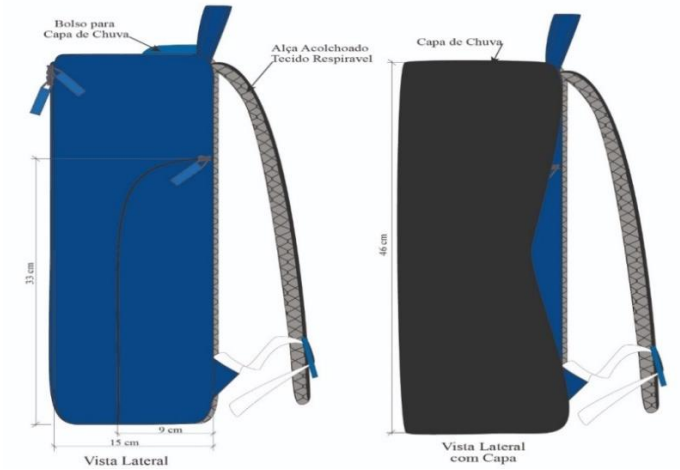
Figure 9 - Commercial Relationship Agents Backpack











Source: Own authorship (2022)

Internal part: pocket in the upper central part for documents, partitioned pocket in the center to accommodate a printer or printed invoices, data collector, data collector battery and sunscreen/insect repellent, ensuring weight distribution. The lower internal part is reserved for storing personal objects.

Back part: padded and with ducts that reduce the surface in contact with the back and facilitate ventilation, preventing excessive sweating.

Shoulder straps: padded and made from sweat-wicking fabric, with pocket for easy access. The 'S' shape ensures uniform distribution of the weight of the backpack across the chest, reducing discomfort in the shoulders.

Opening and Closing: on the front, in a 'U' shape, providing a full view of the inside of the backpack. Zippered, ensuring complete opening and closing.

Hand strap: reinforced and padded stitching.

Side pockets: to accommodate bottles and printer reels. Zippered, ensuring complete opening and closing.

Chest belt: with size adjustment, height adjustment and front closure, it presses the backpack closer to the body and distributes part of the weight with the chest. Reduces unwanted movements that can cause fatigue due to weight variation on the sides of the body.

Rain cover: located in the upper central part.

5. CONCLUSION

It was verified through this study that the characteristics of the activity that agents perform can contribute to the development of musculoskeletal diseases. Therefore, it is vital to act on working conditions to adequately prevent their negative effects on the worker's body, as from the beginning of their working life the process that will determine their health status in the future begins.

All work equipment must be analyzed at the project design stage, so that ergonomics can be applied preventively, thus avoiding corrective or post-traumatic application. In general, it can be said that the size and structure of the backpack are inadequate for the work of commercial relationship agents. All work equipment and personal objects are concentrated at the bottom of the backpack, causing physical discomfort and embarrassment during the journey. Furthermore, concerns about the backpack being closed precariously require greater attention from the worker, taking the focus away from the activity being carried out.

Furthermore, ergonomic analysis cannot be understood as a mechanism with a ready-made recipe, transformations require a long time of study and monitoring of the activity, in addition, involving the worker in decisions regarding their own work provides the professional with greater autonomy, power of control and creativity in your working life.

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