https://doi.org/10.4322/rae.v13e201826.en

Revista Ação Ergonômica - v. 13 n. 1 (2018)

ASSOCIAÇÃO BRASILEIRA DE ERGONOMIA
Revista Ação Ergonômica
www.abergo.org.br

Proposal for adequate thermal comfort conditions for workers at the Parcel Delivery Center of a Postal Company in Paraíba

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SUMMARY

Several researches indicate that when the work environment offers adequate thermal conditions, motivation tends to increase and consequently there will be an increase in productivity. Thus, this research had as its main objective to analyze the thermal comfort conditions to which workers at the Parcel Delivery Center (CEE) of a Postal company in João Pessoa, Paraíba are subjected, in order to provide improvements in the quality and conditions of the work performed by them, resulting in increased productivity. To carry out this analysis, the guidelines determined by ISO 7730/2005: Ergonomics of the thermal environment were adopted. Given the results found, two improvement proposals were developed: a) adoption of a new uniform whose thermal insulation value was reduced and b) increase in air speed in the study environment. However, a significant reduction in PMV and PPD was found, thus implying an increase in thermal comfort and consequently a decrease in the percentage of dissatisfied people.

Keywords: Motivation, Productivity, Thermal Comfort, ISO 7730/2005.

1. Introduction

Different studies have shown that the productivity and quality with which a given activity is performed are directly related to the working conditions of the place where this activity is being carried out. Often, the environment in which workers carry out their activities does not have favorable thermal conditions, which directly influences their performance.

Ergonomics corresponds to a scientific discipline that analyzes the relationship between the worker and their work environment.

This research is within the scope of environmental ergonomics, since the worker's relationship with the environment in which he is carrying out his activities will be studied.

In this sense, a worrying scenario was observed in the Parcel Delivery Center (CEE) of a Postal Company in João Pessoa/PB, high absenteeism and a decline in productivity, impacting

a drop in profitability and an increase in costs to try to minimize the damage in the services offered, but without great results.
In this context, this research aims to analyze the thermal comfort conditions to which CEE workers are subjected, in order to provide improvements in the quality and conditions of the work performed by them, resulting in increased productivity.

2. Theoretical Reference

rgonomics has a very comprehensive conception, but in a succinct way it aims to study the relationship between work and man, offering adequate conditions to workers when carrying out their activities.
According to the International Ergonomics Association (IEA), Ergonomics is a scientific discipline related to understanding interactions between human beings and other elements or systems.
Within the scope of environmental ergonomics, also known as ergonomics of the built environment, the environment in which the worker is inserted is analyzed, so that it is possible to understand whether this environment offers conditions for him to carry out his activities, in order to maximize efficiency and effectiveness in their development. It is important to mention that an adequate and pleasant environment increases motivation and consequently productivity.
For Camargo and Furlan (2011), unfavorable environmental thermal conditions can cause thermal stress situations. Thus, Lamberts et al. (2014) believe that thermal stress can be estimated as the psychological and physiological state of a person subjected to environmental situations of extreme heat or cold.
Workers subjected to such situations while carrying out their activities may experience changes in their psychological and sensory reactions, a decline in their health status, as well as a drop in their productivity. Therefore, it is necessary to know the environmental conditions that can lead workers to thermal stress, as well as the type of activity being carried out by them and the time in which they will be subjected to such a situation.
It is necessary to meet the human comfort conditions of the environments in which man carries out his activities. Therefore, a thermal assessment is necessary. The thermal conditions of the work environment must meet certain conditions, to provide people with a feeling of comfort (DUL; WEERDMEESTER, 2004).
Ashrae (2005) defines thermal comfort as the condition expressed by the mind that exhibits satisfaction with the thermal environment. Thermal comfort, in turn, is related to a person's condition of satisfaction in relation to the thermal environment in which they are inserted.
According to Fanger (1970), thermal comfort is related to the physiological characteristics of individuals such as age, sex, body shape, ethnic differences, among others, in addition to physical or environmental variables (air temperature, average radiant temperature, air humidity and relative air speed) and subjective (activity performed and the clothing used to perform a certain activity).
The evaluation of thermal comfort has often been based on studies carried out by Fanger (1970), who established a method that comprises two indices, the PMV (Predicted Mean Vote) and the PPD (Predicted Percentage Dissatisfied).), adopted by ISO 7730/2005, which determines the use of this method for evaluating moderated environments.
Thermal comfort is relative, since each person reacts differently to certain conditions. Therefore, it is important to develop a thermally comfortable environment for the vast majority of people who work in that location.

Vergara (2001) believes that the condition of thermal comfort can be achieved when an individual is neither feeling cold nor hot in a given environment, thus achieving thermal neutrality. This condition will depend on the correlation of environmental variables, namely: air temperature, average radiant temperature, air speed and relative humidity with personal variables: physical activity performed by the individual and their clothing at the time of the activity performed.

3. Methodological Aspects

This research was initially carried out using the inductive method, later the deductive method was used. These methods were developed through applied and exploratory research. It is worth emphasizing the relevance of this research, as it develops an approach to the problem in question. Thus, this work began through on-site observation. Then, deduction was adopted using data collected in the field.

Therefore, the methodological stages of the study in question are:

- ✓ Brief characterization of the CEE production process;
- ✓ Brief characterization of the activities carried out by workers directly linked to distribution in the CEE production process;
- ✓ Data collection;
- ✓ Determination of PMV and PPD indices.

3.1. Brief characterization of the CEE production process

The CEE production process begins with the arrival of orders. They are then forwarded to the state tax authorities, after checking, they are stored in CDLs (Lightweight Demountable Containers). Subsequently, we have the first sorting that occurs through the process of the list of objects delivered to the worker directly linked to distribution, which consists of reading the order's bar code, which will provide a label containing the cell, district and delivery order. Once this is done, the order is forwarded to the cell to which it belongs. Then, the second sorting will take place, so that workers belonging to each cell will now sort the process that concerns the separation of orders by district and order. Thus, soon after being separated, the orders are taken by workers to company vehicles to be delivered to recipients.

3.2. Characterization of the activities carried out by workers directly linked to distribution in the CEE production process

After the first sorting, which corresponds to the separation of all cargo by cell, the second sorting will take place, where workers belonging to each cell will now separate the orders by district and order. The orders are then taken to company vehicles to be delivered to the recipients. When deliveries are completed, workers return to the CEE to report on the orders delivered, and those that for some reason were not delivered, thus concluding their activities for the day.

3.3. Data collect

Questionnaires were administered, measurements of thermal and physical variables, observation of the work environment, the activity carried out by workers and the clothing they wore.

3.3.1. Instruments and methods

The questionnaires were administered on the 16th and 18th of June, in the morning, with the aim of obtaining the necessary data to calculate the PMV. The questionnaires applied were based on Lamberts et al. (2014).

Measurements of environmental variables: air temperature (Tar), relative humidity (RH), mean radiant temperature (Tmr), were carried out on the 16th and 18th of June (Table 1). To obtain such values, the TGD – 300 thermal stress meter was used.

The variable air speed, in turn, was measured on the 25th and 27th of August, using the TAFR -180 anemometer, finding a value of 0.1 m/s for both days. This fact will not imply any change or harm to the results obtained, since the climatic conditions remain the same in the region.

It is possible to observe that for June 16th the ambient temperature range was from 26.9 ºC to 28.4 ºC. On the same day, relative humidity was above 69%, reaching a maximum value of 79%. For June 18th, the ambient temperature range was from 24.5 ºC to 27.4 ºC, with relative humidity on that day being above 79%, reaching a maximum value of 92.50%.

Table 1: Environmental Variables for the two measurement days

06/16/2015				06/18/2015		
Hour	**Tar (º)**	**Trm (º)**	**UR (%)**	**Tar (º)**	**Trm (º)**	**UR (%)**
09:00	27,0	26,9	79,00	25,8	25,7	87,30
10:00	28,2	28,0	69,30	26,6	26,4	79,40
11:00	28,4	28,1	71,10	27,4	27,1	80,10
12:00	28,4	28,2	70,60	26,4	26,2	87,90
15:00	28,2	28,2	74,50	27,2	27,0	81,00
16:00	27,8	27,8	75,20	27,0	26,8	81,50
17:00	27,4	27,4	75,90	24,5	24,7	92,50
18:00	26,9	26,9	78,20	24,6	24,8	88,00

Source: Own elaboration, 2015

3.3.2. Population and sample

The CEE has a total staff of 35 workers directly linked to distribution. However, due to absenteeism and exchanges between units, 29 workers were working on the 16th and 18th of June. On each day, 24 questionnaires were answered. In this sense, a daily percentage of 82.7% of questionnaires were answered.

3.4. Determination of PMV and PPD indices

With the environmental and personal variables known, the environment can be analyzed from the point of view of thermal comfort. To this end, the guidelines established by ISO 7730/2005 were adopted. ISO 7730 uses the PMV index, proposed by Fanger (1970), with the aim of calculating the probability that thermal sensations will occur in the environment under study, using a scale that varies from +3 to -3, namely: + 3 Unbearably hot; + 2 Hot; + 1 Slightly hot; 0 Thermal neutrality; - 1 Slightly cold; - 2 Cold; - 3 Unbearably cold.

At the same time, ISO 7730/2005 presents the PPD index that allows calculating the percentage of people who would be dissatisfied with the thermal conditions of the environment under study. The PMV can be calculated using tables provided by ISO 7730/2005 itself or using specific software for this purpose (RUAS, 2001).

For this work, the CBE Thermal Comfort Tool software was adopted, a program developed by Tyler Hoyt, Stefano Schiavon, Alberto Piccioli, Dustin Moon and Kyle Steinfeld (2013) from the University of Berkeley. For the purpose of calculating the PMV, the values of the environmental variables measured on the days chosen for study were inserted, according to topic 3.3.1 of this article.

The metabolic rate, obtained through the analysis of the activity developed, will be the same for all individuals in the sample, as they all carry out the same activity. The activity they carry out requires intense movement of the arms, legs and trunk, causing a lot of physical effort, as they need to separate and carry heavy boxes, therefore, this activity is considered heavy, with a high metabolic rate.

However, the value of 235 W/m² or 4.0 met was adopted, as established by ISO 7730/2005. The clothing is a standard uniform, that is, it is the same uniform used by workers throughout Brazil. It consists of a short-sleeved shirt or long-sleeved shirt, pants or shorts, belt, long thick socks, boots, gloves and a cap or hat.

There are also clothing items for cold days. For this study, the uniform items that were being used on the days of measurement and application of the questionnaires were considered, namely: short-sleeved/long-sleeved shirt, pants, belt, long thick socks and boots. The clothing insulation value was obtained using the calculation guidelines established by ISO 7730/2005. A value of 0.63 clo was found for a uniform with a short-sleeved shirt and 0.69 clo for a uniform with a long-sleeved shirt.

4. Results

4.1. Análise dos questionários

Through the results obtained through the questionnaires applied, it was observed that on June 16th, the thermal sensation “hot” was chosen by 12 workers (representing 50%), with very hot by 10 workers (representing 41.67%) and only 2 workers considered the neutral option (representing 8.33%). There was no record for the other options.

For thermal preference, “much more refreshed” was chosen by 13 workers (representing 54.16%), more refreshed by 9 workers (representing 37.50%), slightly refreshed by 1 worker (representing 4.17%), neutral for 1 worker (representing 4.17%), there was no record for the other options.

It is important to mention that the result obtained for June 18th was similar.

4.2. Analysis of the environment under study using PMV and PDD indices

During measurement times, the environment under study has high values of air temperature, average radiant temperature and relative humidity. Furthermore, a high load can be seen in the activity carried out by workers, as well as high thermal resistance in the clothing they use. In this way, it is possible to observe an increase in body temperature, which makes it difficult for the body to maintain thermal balance according to Dul and Weerdeester (2004). It is important to mention that in these conditions, organisms can undergo physiological changes, which can cause harm to workers' health.

As previously reported, to evaluate the thermal comfort of the CEE, the method based on studies carried out by Fanger (1970) was used, which comprises two indices, the PMV (Predicted Mean Vote) and the PPD (Predicted Percentage Dissatisfied - Predictable Percentage of Dissatisfied), adopted by ISO 7730/2005. Therefore, the PMV calculation for June 16 and 18, 2015 was carried out using the Comfort Tool program.

Thus, on June 16th, workers who wore a uniform with a short-sleeved shirt had a range of PMV values from 3.64 to 3.84. Workers who wore a uniform with a long-sleeved shirt had a range of PMV values from 3.66 to 3.85.

Similarly, we have June 18th, where workers who wore a uniform with a short-sleeved shirt had a range of PMV values from 3.32 to 3.72. For workers who wore a uniform with a long-sleeved shirt, the PMV range of values is 3.36 to 3.74.

In this way, it is possible to verify that for the two measurement days the PMV values are high, both for workers who wore uniforms with short-sleeved shirts and for workers who wore uniforms with long-sleeved shirts. According to the model proposed by Fanger (1970), the PMV values found mean that during the two days the environment is unbearably hot. Therefore, the percentage of dissatisfied people (PPD) for the 16th and 18th of June was 100%.

Thus, the result obtained revealed the dissatisfaction and discomfort of all workers regarding the thermal conditions of the work environment, since, to obtain an environment considered thermally acceptable, the PPD must be < 10%, that is, -0.5 < PMV < +0.5 (ISO 7730, 2005).
Therefore, in relation to environmental ergonomics, it is observed that the environment in which workers are carrying out their activities is thermally inadequate, causing a lack of motivation and high absenteeism, resulting in a significant drop in productivity.
Therefore, the development of activities in the environment under study is compromised, since the working conditions of users of that environment are not in accordance with the guidelines stipulated by ISO 7730, which may even make it impossible for them to continue carrying out these activities and even life-threatening.

5. Proposals to help achieve better working conditions in terms of thermal comfort in the CEE.

To obtain improvements in working conditions regarding the thermal comfort of workers in the CEE, it was concluded that two measures could be implemented. The first proposal concerns the change in the use of new uniforms by workers. The suggested uniform was designed with the aim of reducing the insulation value of the clothing, thus increasing the feeling of comfort. The proposed uniform will consist of: t-shirt, shorts, normal socks and sneakers. The insulation value for the proposed uniform is 0.22 clo.
According to Givoni (1992), in summer, with high humidity, the temperature range throughout the day must occur between 25 °C and 26 °C, reaching a maximum of 32 °C, with an air speed of 2.0 m /s.
According to Cândido et al. (2008) with temperatures above 24°C, room users prefer air speed values above 1.00 m/s, on average.
The second proposal concerns increasing the air speed inside the CEE to 1.5 m/s, through the acquisition of fans, since the speed found on the measurement days was 0.1 m/s.
Considering the two proposals suggested in this work, the PMV was calculated for the 16th and 18th of June 2015. So, on the 16th of June, the PMV values began to comprise the range of 0.63 to 0. .97 and on June 18, the values ranged from 0.09 to 0.83. Thus, with the results obtained, a significant decrease in PMV was observed. According to the scale of Fanger's model (1970), it was reduced from unbearably hot to slightly hot. Therefore, thermal discomfort was significantly reduced.
The percentage of dissatisfied people (PPD) within the study environment on the 16th and 18th of June suffered an equally significant reduction, as previously the percentage was 100% during both days. We now have a percentage for June 16th of 13% to 25%. As of June 18th, a percentage of 5% to 19% was reached.
Thus, it is concluded that for the 16th and 18th of June, with the change in the insulation value of the clothing and the air speed, an increase in thermal comfort was achieved and consequently a decrease in the percentage of dissatisfied people.

Conclusion

With the reduction of the thermal insulation of the clothing, as well as the increase in air speed to 1.5 m/s, a significant decrease in PMV and PPD values became evident.
It is important to mention that through this study an increase in thermal comfort was obtained in the CEE, enabling workers to improve working conditions, thus providing an increase in motivation and, consequently, an increase in productivity, taking into account the values achieved with relation to PMV when making improvement proposals. Simple and easy-to-implement proposals.
Finally, the project developed meets the proposed research needs, with the objectives achieved. Thus, this research contributes to the area of Environmental Ergonomics, also called Ergonomics of the Built Environment, presenting an example that addresses this topic, in order to assist future work in this segment.

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