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Research article

Effect of psychophysiological breaks on the hand temperature of meat processing plant workers

Efeito das pausas psicofisiológicas na temperatura das mãos de trabalhadores de frigoríficos

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Abstract

Objective: To evaluate the temperature of the hands and its relation to psychophysiological breaks of different durations in workers at a pig slaughterhouse. **Methods:** This study included 40 male workers divided into two groups based on the external ambient temperature (Group 1: ≥ 15 °C and Group 2: < 15 °C). Psychophysiological breaks were scheduled throughout the work shift with durations of 20/15/15/10 minutes. In order to measure the temperature of the hands, thermal images were captured using a portable infrared camera. **Results:** It was observed that in Group 1 (n = 34), regardless of the duration of the breaks, the temperature of the middle finger's palm of the hand that handled the products was significantly higher after the breaks compared to before the breaks ($p < 0.001$). Group 2 (n = 6) exhibited significantly lower finger temperatures after the breaks, as the external ambient temperature was lower than the indoor working environment, and the break areas did not provide thermal comfort. **Conclusion:** Breaks of at least 10 minutes resulted in thermal recovery of the workers' fingers, and the external ambient temperature directly influenced the thermal recovery of the hands, suggesting that the regulation (NR-36) should be reviewed concerning the characteristics of psychophysiological break areas.

Keywords: Slaughterhouse; Meat-Packing Industry; Thermography; Personal Protective Equipment; Ergonomics; Occupational Health.

Resumo

Objetivo: Avaliar a temperatura das mãos e sua relação com as pausas psicofisiológicas de diferentes durações em trabalhadores de um frigorífico de suínos. **Métodos:** Participaram deste estudo 40 trabalhadores do sexo masculino divididos em dois grupos, conforme a temperatura ambiente exterior (Grupo 1: ≥ 15 °C e Grupo 2: < 15 °C). Os períodos de pausas psicofisiológicas estavam distribuídos durante a jornada de trabalho em 20/15/15/10 minutos. Para aferir a temperatura das mãos, foram registradas imagens termográficas utilizando uma câmera infravermelha portátil. **Resultados:** No Grupo 1 (n = 34), independentemente da duração das pausas, a temperatura da palma do dedo médio da mão que manipulava os produtos, após a realização das pausas, foi significativamente maior que a registrada anteriormente às pausas ($p<0{,}001$). No Grupo 2 (n = 6), observaram-se temperaturas do dedo significativamente menores após as pausas, pois no ambiente externo a temperatura foi menor que no interno de trabalho e os locais das pausas não forneciam conforto térmico. **Conclusão:** Pausas de no mínimo 10 minutos causaram recuperação térmica dos dedos sob temperatura ambiente exterior ≥ 15 °C. A temperatura do ambiente externo influenciou diretamente na recuperação térmica, indicando que a norma (NR-36) deve ser revista quanto às características dos locais das pausas psicofisiológicas.

Palavras-chave: Abatedouro; Indústria de Embalagem de Carne; Termografia; Equipamento de Proteção Individual; Ergonomia; Saúde do Trabalhador.

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Introduction

Brazilian pork production has been growing, driven by the expansion of the domestic market and the increase in exports. According to the Brazilian Association of Animal Protein (ABPA)[1], pork production in Brazil in 2010 was 3.237 million tons, reaching a volume of 4.983 million tons in 2022. Brazil is the fourth largest exporter of pork in the world (1,230 thousand/ton), ahead of the European Union (4,150 thousand/ton), the United States (2,873 thousand/ton), and Canada (1,430 thousand/ton)[1].

Although this economic activity results in benefits such as job creation and economic development in Brazil, it also causes its workers to fall ill[2]. The appearance of work-related musculoskeletal disorders (WMSDs) is often associated with the characteristics of the activities performed. Based on Regulatory Standard No.·36 (NR-36) - Health and Safety in Meat Processing Companies - workers who carry out activities directly in the production process must be guaranteed psychophysiological breaks distributed according to the working day, due to the requirement for repetitive activities and/or static or dynamic muscle overload[3].

In addition, according to Ordinance No.·1,304, of August 7, 2018, of the Ministry of Agriculture and Livestock (MAPA)[4], the maximum product temperature in the deboning rooms of pig slaughterhouses must not exceed 7 °C and, according to MAPA[5], the ambient temperature for exporting slaughterhouses must not exceed 12 °C. Although environmental factors are incorporated into complementary factors when assessing the risk of WMSD, cold temperatures in combination with the aforementioned risk factors can potentially increase the risk of developing WMSD[6].

Cooling of the extremities (hands and feet) can increase when handling cold products or in contact with cold surfaces[7,8]. ISO 13732-3[9] classifies the type of effect on the skin during contact with surfaces of different temperatures. When subjected to temperatures of 0 °C, the skin shows signs of gelation, a freezing effect; at 7 °C, at which the contact sensory receptors are blocked, the skin will become numb; and at 15 °C the effect of a subjective sensation of pain will occur. According to the encyclopedia of the International Labor Organization (ILO)[10], hand and finger temperature of 15-20 °C results in a reduction in the performance of simple work carried out with these body regions and an occasional sensation of pain.

ISO 11079 - Ergonomics of the thermal environment[11] states that finger temperatures ≤ 24 °C cause "low physiological stress" and ≤ 15 °C is considered "high stress", the former being contraindicated for prolonged exposure and the latter only acceptable in sporadic situations[7].

No studies were found that analyzed the effect of psychophysiological breaks on the temperature of the hands of pork slaughterhouse workers. Only one study looked at the behavior of index finger temperatures in poultry slaughterhouse workers[12]. The present study is relevant and unprecedented, as it analyzes the thermal recovery of hand temperature from breaks, the efficiency of gloves and the interference of external environmental variables and the environment where breaks are taken. It provides a framework of information to guide occupational health and safety (OHS) professionals in developing actions to improve the working environment, generating thermal comfort and health for workers. Therefore, this study aimed to evaluate hand temperature and its relationship with psychophysiological breaks of different durations in workers at a pig slaughterhouse.

Methods

This is an observational study carried out in a pig slaughterhouse in southern Brazil, with approximately 2,200 workers working two shifts.

In this study, the tools used by the workers were knives and chisels. The working days were Monday to Friday. The daily working time was 8 hours 48 minutes, with 60 minutes for the main meal (lunch), with a 20-minute change of uniform, totaling 448 minutes of work in an artificially cold environment.

Participants

The research participants were selected on a non-probabilistic basis. As inclusion criteria, only male workers were selected (as this is the gender of most workers in the slaughterhouse analyzed and in the deboning activity), allocated to the pork cutting sector (temperature of 10 to 12 °C), from the first production shift (sector with the largest number of workers) and who used a knife during the activity. To eliminate the possibility of altered skin temperature, the following exclusion criteria were adopted: workers who smoked[13], those who had not slept before the assessment[14], and those who had drunk alcohol 12 hours before the data was collected[15].

In the cutting sector of the first shift, there were 49 knife activities, in which 69 men and 59 women worked. Due to the complexity of the data collection (12 times during the working day), it was decided to collect data only from men, as they were the majority in the company (55.0%) and in the sector (62.6%). Based on the inclusion and exclusion criteria, 40 workers were individually invited to take part in the study, resulting in all 40 workers joining (mean age: 29.3 ± 8.8 years; range: 18 to 54 years; mean time working at the company: 2.3 ± 4.4 years, range from one month to a maximum of 21.2 years). The workers carried out the following activities: opening the belly, opening the patella, Korea belly, Japan belly, boning the belly, boning the steak, boning the shoulder, trimming the shoulder, removing the hip, removing the neck, separating the ribs from the belly, and trimming the neck.

Instruments

To measure the temperature of the workers' hands, thermographic images (palm and back of hands) were recorded using a Flir Model E8xt portable infrared camera (Flir Systems Inc., Portland, USA). The resolution of the thermal imager is 320 x 240 (76,800) pixels in the infrared image and with fixed focus, IFOV spatial resolution of 2.6 mrad and with a 45° x 34° lens. Flir Tools software version 6.4.18039.1003 was used to analyze the images.

A structured interview was carried out with all the participants, asking questions about the workers' identification data (age, smoking, physical activity, sleep duration), work organization (time working for the company, activity, and tools) and thermal sensation in the hands. A numerical and visual scale was used to assess the thermal sensation in the hands, where zero indicated neutral thermal sensation, -1, -2, and -3 indicated cold to very cold sensation, and from 1 to 3, hot temperature sensation[16].

Personal protective equipment (PPE) - Gloves

The workers wore three models of gloves, in the following order: on the dominant hand (knife), the worker wore a cut prevention glove (against mechanical agents - CA 32718), positioned in contact with the skin, and a nitrile glove in direct contact with food (against mechanical agents - CA 16102). The non-dominant hand (of the product) wore a nitrile glove positioned in contact with the skin (against mechanical agents - CA 16102); and a steel mesh glove (against mechanical agents, cuts by hand knives, and similar sharp objects - CA 42158) in contact with the product. Both gloves were supplied in sizes compatible with each worker's hand.

The process of supplying gloves at the meatpacking plant was as follows: before the start of each working day, workers received the gloves in the pork deboning department; when they left for their breaks, they left them at their workstation, below their bench, and returned them at the end of the working day to the same place where they were picked up. As for cleaning, the nitrile gloves, which last an average of 15 days, and the anti-cut gloves, which last an average of one month, were cleaned daily in the company laundry at the end of each shift. The steel mesh gloves, which do not have a defined average lifespan and require regular maintenance, were sanitized daily in the knife sharpening department. Workers were instructed to contact their supervisor to ask for their gloves to be changed if they were damaged during the working day.

Break locations

As the breaks analyzed in the present study are psychophysiological, NR-36 does not require them to be taken outside the work environment, only outside the workstation[3]. In the investigated refrigeration plant, workers had two areas outside the production sector to take their breaks, both with benches and chairs for 100% of the workers taking breaks at the same time, as well as drinking water. The buildings of the break areas were covered, but not closed on all sides, making it impossible to fully protect workers from adverse weather conditions, such as wind, for example.

Pauses

According to the climate map of the Brazilian Institute of Geography and Statistics (IBGE)[17], the study site is in the seventh climate zone. The temperature in the cutting room remained between 10 °C and 12 °C. For this reason, the workers were entitled to psychophysiological breaks, which should total 60 minutes in a working day of up to 8h 48min, according to NR-36[3].

At the meatpacking plant, the four psychophysiological break periods were distributed over the working day in 20/15/15/10 minutes (**Figure 1**). This break schedule was determined because NR-36 allows the unit duration of breaks to be between 10 and 20 minutes[3]. The 20-minute duration of the first psychophysiological break is justified by the need for more time to eat the "breakfast" meal, during which workers use the break area to eat. The duration of the other breaks was distributed to comply with NR-36.

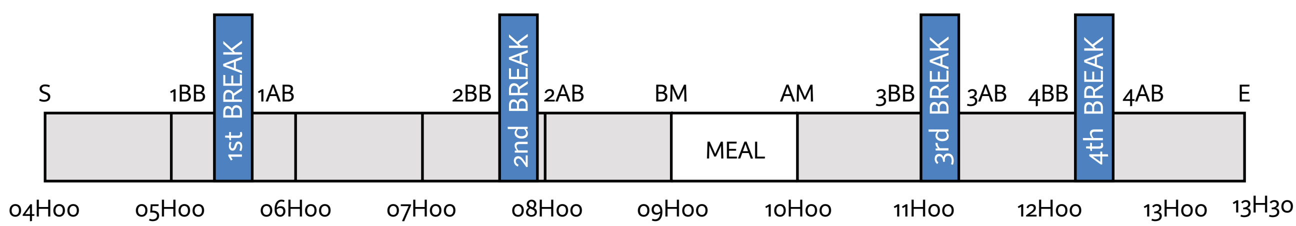

Figure 1 Distribution of psychophysiological breaks in the pork cutting sector 1st Shift and the times when thermographic images were taken

S: Start of day; BB: Before break; AB: After break; BM: Before meal; AM: After meal; E: End.

Procedures

Data was collected over nine working days between April and May 2022, when the external temperature varied between 15 °C and 33 °C on the first eight working days and between 11 °C and 22 °C on the last working day. The measurements were classified into two groups according to the temperature of the outside environment on the day of data collection. In Group 1, the measurements were carried out with the workers taking part in the collections on days when the external temperature was 15 °C or higher (temperature range 15 °C to 33 °C) (n = 34). In Group 2, the external temperatures were below 15 °C (temperature range 11 °C to 22 °C) (n = 6).

Each day, thermographic images were taken of three to six workers at 12 times during the working day. The first images were taken before the start of the working day (4 a.m.), during which time the workers were instructed to go to the work safety department when they arrived at the company (room temperature 18 °C). All the other images were taken internally in the production sector, always before leaving and returning from breaks, as well as at the end of the working day (**Figure 1**).

During the 12 moments when thermographic images were taken, the workers answered the following question: "How is the thermal sensation in your hands?". The printed and colored numerical and visual scale was made

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available for the workers to indicate how they felt, either verbally or just by indicating the number on the scale, to eliminate difficulties in understanding. Only one numerical value was recorded for both hands at any one time.

During data collection, workers were instructed to position their hands in two positions (palm and back) to capture the images. To avoid interference from the environment during collection, a technil plate was used for the workers to rest their hands on.

For the thermographic images taken before breaks, on return from breaks and at the end of the working day, the data was collected in the work area itself. Workers were instructed to stop work, go to the start of the production line, remove their gloves, and place their hands on the technil plate to capture the images. When they returned from their breaks, for hygienic and sanitary reasons, the workers washed their hands with warm water (± 37 °C) and a bactericide before putting on the overlapping gloves, maintaining the actual working conditions.

The camera was positioned approximately 1.0 m away from the participant, 0.7 m above the ground, and perpendicular to the worker's hands. The temperature and humidity of the environment were recorded for image analysis, and an emissivity of 0.98 (human body) was adopted. Two thermographic images of the palmar and dorsal surfaces of the hands were taken of each worker. The software's ellipse tool was used to select the coldest area of each finger, avoiding covering the edges of the fingers and with a size of approximately 20 pixels. The average finger temperatures were extracted from the software for subsequent data analysis.

To compare the temperatures of the fingers at different collection times and between the groups, we used the temperatures of the middle fingers of the palmar region of the hand that was handling the product (left). Given that, in the study by Tirloni et al.[18], this was the finger with the lowest temperatures for those using a hand tool.

Statistical analysis

Groups 1 and 2 were compared according to the temperature of the external environment on the day of data collection: Group 1 - temperature of the middle fingers of the palms measured when the external temperature was ≥ 15 °C (n = 34) and Group 2 - external temperature < 15 °C (n = 6). This analysis used the t-test or Mann-Whitney test for independent samples, according to the normality of the data.

To analyze the effect of the breaks and compare the mean and median temperatures of the palm of the middle fingers of the left and right hands, the Student's t-test or Wilcoxon test for dependent samples was used, depending on the normality of the data. Temperature comparisons were made between the beginning and end of the working day before and after the four breaks and the main meal. A significance level of 5% was adopted for all tests.

Finally, they checked whether there was at least one finger with a temperature ≤ 15 °C and ≤ 24 °C in the palmar and dorsal regions of the fingers. We used as a reference the classification cited in ISO 11079:2007 - "Ergonomics of the thermal environment", which recommends that when the temperatures of the fingers are above 24 °C, there is preservation and proper functioning of the hands, but up to 15 °C are considered conditions of high physiological stress, characterized by peripheral vasoconstriction, irregular sweating, and thermal sensation of cold[11].

Ethical aspects

The study project was approved by the Ethics Committee of the Federal University of Santa Catarina, Brazil, under opinion 5.318.318, on March 29, 2022. All participants signed an informed consent form.

Results

The **Table 1** shows the comparisons between the temperatures of the middle fingers of the hand handling the product before and after each break and at the beginning and end of Group 1's working day.

Table 1 Comparison between the temperatures of the middle fingers of the palmar region of the hand handling the product before and after the breaks (Group 1: external temperature ≥ 15 °C, n = 34)

Product palm - Middle finger temperature						p-value
Moment	**Minimum**	**Maximum**	**Amplitude**	**Mean (SD)**	**Median**	
Start of the day	19.2	32.4	13.2	26.4 (3.5)	26.7	< 0.001#
End of the day	12.5	26.2	13.7	17.2 (2.7)	17.2	
Before the 1st break	12.4	23.8	11.4	16.9 (2.8)	16.3	< 0.001
After the 1st break	17.2	30.2	13.0	24.4 (3.1)	24.7	
Before the 2nd break	12.9	26.0	13.1	18.1 (3.2)	17.2	< 0.001
After the 2nd break	17.4	30.3	12.9	24.3 (3.1)	24.4	
Before the meal	13.2	24.2	11.0	17.0 (2.6)	16.0	< 0.001#
After the meal	20.3	30.2	9.9	24.7 (2.7)	24.1	
Before the 3rd break	13.8	27.1	13.3	18.4 (3.5)	17.4	< 0.001#
After the 3rd break	16.7	29.5	12.8	25.2 (3.4)	26.2	
Before the 4th break	14.0	27.0	13.0	19.3 (3.7)	18.5	< 0.001
After the 4th break	17.5	30.5	13.0	25.2 (3.3)	25.6	

1st break: 20 minutes; 2nd break: 15 minutes; 3rd break: 15 minutes; 4th break: 10 minutes; Meal: 60 minutes, Student's t-test;
Wilcoxon test

SD: standard deviation.

It was found that, regardless of the duration of the breaks, the average or median temperature of the middle finger of the product's hand after the breaks was significantly higher than before the break ($p< 0.001$). There was also a difference in temperature at the start and end of the day ($p< 0.001$), but the average temperature at the end of the day was significantly lower than at the start (**Table 1**).

Figure 2 shows the average temperature of the middle finger of the palm of the hand handling the product before and after the breaks, showing an increase in the temperature of the finger after the break in most workers in Group 1.

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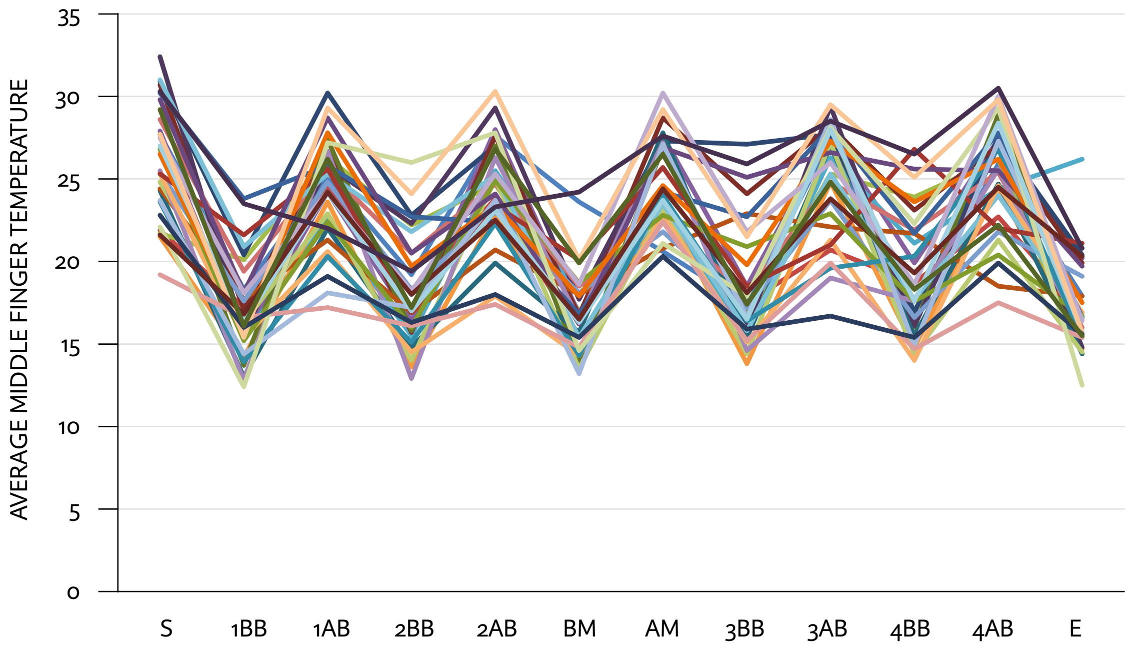

Figure 2 Average temperature behavior of the middle finger of the left palm among workers in Group 1 (external temperature ≥ 15 °C, n = 34).
Number of breaks: four; S: Start of day; BB: Before break; AB: After break; BM: Before meal; AM: After meal; E: End.

Figure 3 shows the behavior of the average temperature of the middle finger in the dorsal and palmar regions of Groups 1 (n = 34) and 2 (n = 6), with workers exposed to a covered break environment, but not closed on the sides. In Group 2, there was no thermal recovery after the breaks; on the contrary, there was a decrease in the temperature of the fingers, especially on the dominant side of the body (right hand). Furthermore, in Group 2, the average temperature of the middle finger at the start of the day was only higher than 24 °C on the back of the left hand (24.7 °C) (**Figure 3**).

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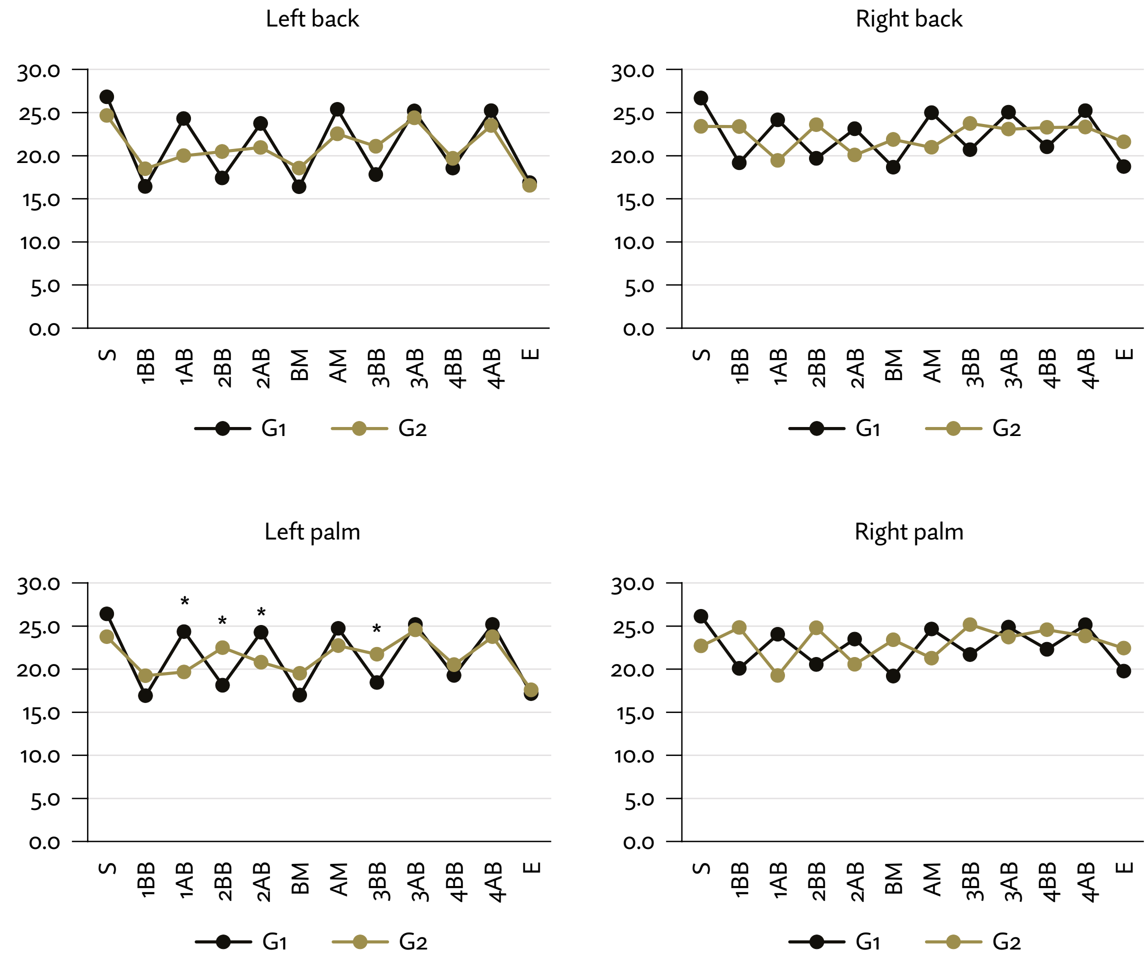

Figure 3 Average temperature behavior of the middle finger in the dorsal and palmar regions of both groups of workers at different times during the working day, measured in Group 1 (G1: external temperature ≥ 15 °C, n = 34) and Group 2 (G2: external temperature < 15 °C, n = 6).
* Significant difference in the temperatures of the palmar region of the left hand between the groups - t-test and Mann-Whitney for independent samples ($p \leq 0.05$).
Number of breaks: four S: Start of day; BB: Before break; AB: After break; BM: Before meal; AM: After meal; E: End.

When comparing the temperatures of the fingers in the left palmar region of the two groups of workers, it was found that there were significant differences in four of the situations analyzed: after the 1st break (1AB), before and after the 2nd break (2BB, 2AB), and before the 3rd break (3BB). It was found that Group 2 had significantly lower temperatures after the breaks, because the outside environment had a lower temperature than the inside work environment, and this is also why the temperatures were higher before the breaks. In fact, the average temperature of the dominant hand (back and right palm) was different between the groups in various data collection situations (**Figure 3**)

Figure 4 shows the thermal sensations in the hands perceived by the workers at the start of the working day, before and after the four breaks and the meal, and at the end of the working day in Group 1.

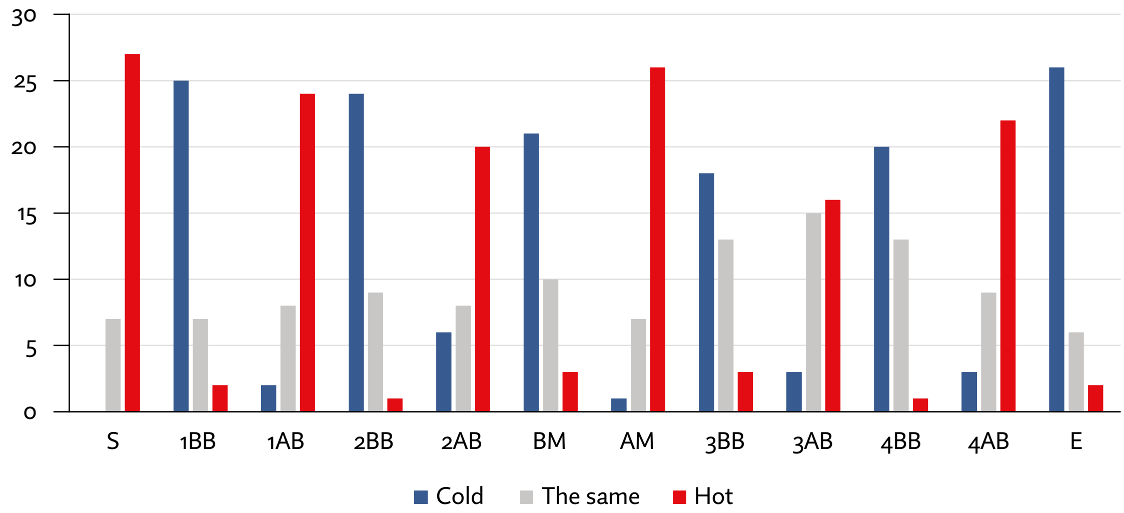

Figure 4 Thermal sensation in the hands perceived during the working day by slaughterhouse workers in Group 1 (external temperature ≥ 15°C, n = 34)
Number of breaks: four; S: Start of day; BB: Before break; AB: After break; BM: Before meal; AM: After meal; E: End.; The same (gray): Neutral or identical thermal sensation to the previous break.

It was found that at the start of the working day, seven of the 34 workers in Group 1 perceived their hands to be slightly cold (-1), while at the end of the day more than two thirds of the workers felt cold in their hands (26). It was found that the thermal perceptions of the workers' hands were consistent with the measured finger temperatures, because at the start of the day and after breaks and lunch, the perceptions of cold hands were positive (hot) for most of the workers. However, except for after the third break (3AB), several workers had the same thermal sensation before and after this break (**Figure 4**). In addition, it was found that at the start of the working day and after the breaks, the temperatures of the middle fingers were higher than 15 °C, unlike before the breaks and at the end of the working day.

Evaluating the temperatures of all the fingers of the 34 workers during the working day, it was found that all of them had at least one finger with a temperature ≤ 24 °C and 24 workers (+ 2/3) had at least one finger with a temperature ≤ 15 °C in the palm and/or back of their hands. In both the palmar and dorsal regions, before breaks and meals and at the end of the working day, at least one finger of all the workers analyzed had a temperature ≤ 24 °C. At the end of the working day, more than 1/3 of the workers had a finger with an average temperature ≤ 15 °C (12). Eight workers had fingers with temperatures ≤ 24 °C before starting work, a variable that cannot be controlled due to the workers' means of transportation to the company (bicycle, motorcycle, bus, car, walking).

When comparing the temperatures of the middle fingers of the right and left hands of Group 1, it was found that at all times before the four breaks, the meal, and at the end of the day, the temperatures of the middle finger of the left hand were significantly lower than those of the right hand (mean and median; $p \leq 0.05$). At the start of the day and after the breaks there was no significant difference between the temperatures of the middle fingers, except after the 2nd break, when the right hand had a lower average temperature than the left hand ($p = 0.039$).

Discussion

This study showed that, regardless of the length of the breaks, all the intervals provided thermal recovery for the hands of Group 1 workers when the external temperature was ≥ 15 °C, but did not provide efficient thermal recovery for Group 2 workers at all the times analyzed, when the external temperature was < 15 °C.

Takeda et al.[12] used a system to assess the thermal discomfort of workers exposed to low temperatures in a chicken slaughterhouse, using a network of wireless sensors throughout the working day. The results showed that the

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index finger and hallux were cold and painful for almost the entire working day, even after three 20-minute psychophysiological breaks. In that study, the minimum temperature found on the index finger of the hand was 14.4 °C before leaving for a meal[12]. However, in the present study, the minimum temperature found was 16.9 °C when leaving for the first break, which was higher than that found in the aforementioned study.

Still according to NR-36[3], in order for breaks to provide workers with psychophysiological recovery, they must be taken away from the workstation, in a place where benches or chairs and drinking water are available. However, there is no requirement for the psychophysiological break to take place outside the work environment, in conditions that provide thermal comfort, even if the internal ambient temperature remains between 10 and 12 °C and is below the outside ambient temperature. Studies show that meatpacking workers feel cold while working in artificially refrigerated environments[19,20] regardless of whether they take a psychophysiological or thermal break.

Although NR-36[3] does not require that the place where psychophysiological breaks are taken provide thermal comfort for workers, it was found that the outside ambient temperature directly influenced the thermal recovery of the hands of workers exposed to temperatures between 10 and 12 °C in the work environment, indicating that the standard should be revised with regard to the characteristics of the places where breaks are taken.

The recommendations of NR-36[3] are general and do not address what the physical structure of the break room should look like, especially in the "cold" regions of Brazil or in winter, leaving it up to company managers to define this. Furthermore, there is an association between the perception of musculoskeletal discomfort among meatpacking workers and the perception of cold (OR = 2.05; 95%CI 1.44-2.91)[19], highlighting the need to adapt working conditions and break areas to provide thermal protection for these workers

In general, slaughterhouse workers feel cold, and their fingers have temperatures below 24 °C and 15 °C, as this study also showed. Tirloni et al.[19] analyzed the finger temperatures of 143 poultry slaughterhouse workers and their association with personal and organizational variables, perception of bodily discomfort and feeling cold. Most of the workers had at least one finger with an average temperature ≤ 15 °C (66.4%) and ≤ 24° C (99.3%).

In another study, Tirloni et al.[20] found that most workers had at least one finger with an average temperature ≤ 15 °C (76%), ≤ 24 °C (98%) and felt cold in their hands (75%). Both studies, although carried out in poultry slaughterhouses, presented similar data to the current study, when all the workers in Group 1 had at least one finger with an average temperature ≤ 24 °C (100%) and more than two thirds had a temperature ≤ 15 °C (70.6%). This condition causes "physiological stress"[11], reducing the work performance of these body regions and occasionally causing pain[10].

One study evaluated the temperature of the hands of workers in pig slaughterhouses and their relationship with the thermal sensation of the hands and the use of a knife. The results showed that the majority of workers felt cold in their hands (66%), and the (left) hand that handled the products had lower temperatures than the right hand (knife)[21]. These findings corroborate with the results of the current study, in which 2/3 of the workers felt cold in their hands at the end of the working day and the temperature of the hand holding the product was significantly lower than that of the hand using a knife

According to NR-36[3], the employer must rotate activities within the daily workday to meet at least one of the eight specific criteria listed, none of which addresses the need to alternate activities that do not use hand tools. This item could be included in the standard, since one of the factors that reduces the temperature of the hand opposite the knife is direct contact with the cooled product, as well as the use of a steel glove. The results of this study indicate that the use of a nitrile glove under the steel glove on the product hand does not guarantee adequate protection of the fingers from the cold risk arising from the low temperatures of the working environment and the products handled, as the gloves used are only intended for mechanical protection.

Gloves with a certificate of approval (CA) against thermal agents must comply with Standard EN 511[22], which establishes requirements and test procedures for protective gloves against cold caused by convection or contact, at temperatures down to -50 °C. The specific values for the different levels of effectiveness are determined according to the particular requirements of each risk category or for specific applications[22]. It is important for OSH professionals to be familiar with the manual and the instructions for the protective gloves that their workers will be using, because, according to the manual for a thermal glove, the glove's thermal resistance is up to -10 °C, for example, and contact must be intermittent for 15 seconds[23].

Regardless of the animal being slaughtered, it is known that work in slaughterhouses is repetitive[24,25]. When analyzing 22 work activities in a pig slaughterhouse, it was found that workers performed 64.1 ± 14.3 technical actions per minute[26], around one technical action per second. Similar data was presented in another study by Reis et al.[25], 57.3 ± 12.3 technical actions per minute. However, in these studies and in other studies on hand temperature and PPE[19-21], the active working time in a cycle was not verified, nor was the duration of contact between workers' hands and cold products. This is a risk factor that must be considered in order to protect the hands from muscle fatigue (recovery time - passive work in a cycle) and the provision of PPE appropriate to the time spent in contact with cold products.

Finally, it was found that regardless of the length of the breaks, there was thermal recovery when the ambient temperature outside the workplace was ≥ 15 °C, as the places where the breaks were taken were unsuitable for promoting thermal recovery of the hands on days with lower temperatures, as they were open.

As for the limitations of this study, we would highlight the fact that the research participants did not have a specific place to take their breaks. The workers could take their breaks in any of the available break areas and even in the corridors outside the company. As well as the presence of sample selection bias, as it was a non-probabilistic sample and had a small number of workers participating in Group 2. This was due to the difficulties of collecting data in meat processing plants, the willingness of workers to take part in the research and the complexity of collecting data at different times of the working day. However, despite the limitations presented, this is an exploratory study, the first to investigate the effects of psychophysiological breaks on the thermal recovery of the fingers of the hands of workers in pig slaughterhouses.

Conclusion

Regarding hand temperature, it can be concluded that all the workers in Group 1 had at least one finger with a temperature ≤ 24 °C during the working day and more than two thirds of the workers had temperatures ≤ 15 °C.

The breaks proved to be efficient for the thermal recovery of the hands on days when the external temperatures were higher (Group 1), regardless of the duration of the breaks and after the meal, as there was a significant increase in the temperature of the middle fingers, as well as equality between the temperatures of the hands.

Consequently, the temperatures of the middle fingers before the breaks and at the end of the working day were significantly lower than the temperature values after the corresponding break and at the start of the working day. At the times before the breaks and at the end of the working day, the average temperature of the middle finger of the hand handling the product was significantly lower than that of the hand holding a knife. This shows that the hand handling the product should be better protected from the cold risk agent, and studies using thermal gloves (with CA) should be carried out to verify the efficiency of this PPE for the activity carried out in the artificially cold environment of slaughterhouses.

The workers perceived that the break improved the temperature of their fingers, but this perception was not unanimous among the workers, perhaps due to the inadequacy of the place where the breaks were taken. For this reason, meat processing plants should provide appropriate clothing and places for breaks that offer thermal comfort to workers, regardless of the type of break given, thermal or psychophysiological, because only in this way can breaks help to increase the temperature of the hands, as well as mitigating the effects of the cold physical agent.

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Efeito das pausas psicofisiológicas na temperatura das mãos de trabalhadores de frigoríficos
Effect of psychophysiological breaks on the hand temperature of meat processing plant workers

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