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Physical load and heart rate behavior in workers in the slaughterhouse and meat packing industries

Carga física e comportamento da frequência cardíaca em trabalhadores de frigorífico

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Abstract – High physical overload during the workday and some conditions present in the workplace can generate several losses in the worker's health. The use of tools capable of identifying physical load (PL), such as heart rate (HR) analysis, is essential. The aim of the study was to evaluate the physical load and heart rate behavior of workers in the slaughterhouse. The cardiovascular load reached by two individuals was 12% and 24%. In relation to the PL rating, they fit as moderately heavy to heavy work. The HR, was higher at the end of the work when compared to the beginning. Furthermore, it was pointed out that the temperature, noise, and body mass index were above normality values. The physical workload was classified as moderately heavy to heavy. The limit HR was reached in some moments of the work by one of the workers and two of them reached higher HR values at the end of the work.

Key words: Animal culling; Ergonomics; Heart rate.

Resumo – *A elevada sobrecarga física durante a jornada de trabalho e algumas condições presentes no ambiente de trabalho podem gerar diversos prejuízos na saúde do trabalhador. A utilização de ferramentas capazes de identificar a carga física (CF), como a análise da frequência cardíaca (FC), é fundamental. O objetivo do estudo foi avaliar o comportamento da carga física e da frequência cardíaca dos trabalhadores de frigorífico. A carga cardiovascular alcançada por dois indivíduos foi de 12% e 24%. Em relação à classificação da CF, enquadram-se como trabalhos moderadamente pesados a pesados. A FC, foi maior no final do trabalho quando comparado ao início. Além disso, apontou-se que a temperatura, o ruído e o índice de massa corporal estavam acima dos valores da normalidade. A CF de trabalho foi classificada como moderadamente pesada a pesada. A FC limite foi atingida em alguns momentos do trabalho por um dos trabalhadores e dois deles atingiram valores maiores de FC ao final do trabalho.*

Palavras-chave: *Abate de animais; Ergonomia; Frequência cardíaca.*

INTRODUCTION

The meat industries in Brazil are responsible for a large part of the world market, having exported 1.8 million tons of meat and meat products in 2019[1]. Although important, this condition is a challenge for the worker's health and raises questions about workplace safety, considering in slaughterhouse the number of musculoskeletal diseases and accidents at work has increased[2].

This increase may be due to the accelerated, repetitive, and fragmented work pace, inadequate postures, exposure to inappropriate ambient temperatures, high levels of noise, humidity, and biological agents[3]. It is also noted that workers are exposed to handling machines and knives and carry large pieces of meat, which in addition to generating an overload on the spine, can lead to muscle fatigue[4-8]. Other environmental risk agents can also be considered as harmful to these workers, such as high noise levels that can generate cardiovascular overload, muscle tension, hearing loss and sleep disorders[9,10], and exposure to inadequate temperatures that reduce performance at work, as the cold combined with the use of fewer clothing items causes impaired motor performance and the heat significantly increases the heart rate (HR)[11].

Also, physical overload is capable of leading to fatigue and as this symptom increases, the pace of work, attention, and reasoning slows down and, consequently, the worker becomes less productive and more susceptible to errors and accidents. One way to assess physical loads in the workplace is by analyzing HR[12-16], which fluctuates according to the different intensities of labor activities[17]. Some studies have shown that HR is closely related to excessive physical effort and the appearance of diseases in different labor activities[12,15] and that technical and organizational factors that intensify activity, can promote an increase in HR[18,19].

Given this scenario, it is clear the importance of HR assessment in workers in slaughterhouses, since they are exposed to various conditions that can be harmful to their health and compromise their production, which is also important to be considered by the slaughterhouse and meat packing industries. It should also be emphasized that, although many studies use HR as an indicator of physical load in various work activities, there are no studies with this variable in slaughterhouse. Thus, the objective of this study was to evaluate the behavior of the HR and the physical load of workers in a slaughterhouse and meat packing industries, in the slaughtering sector.

METHODS

This study was characterized as a case study, developed from the analysis of three male individuals (41,66 ± 15,69 years), in the period from April to May 2019, of the dirty and clean areas of the slaughtering sector in the slaughterhouse and meat packing industries in Presidente Prudente - SP, Brazil. The dirty area involves stunning the animal until the complete removal of the leather, while the clean area corresponds to the activities developed after the removal of the leather until the direction of the carcasses to the cold room. In the slaughter sector evaluated there is no artificial refrigeration, which allows the outside temperature to influence the temperature of the working environment.

For the selection of individuals, lists of all industry workers were obtained and those who were over 18 years, male, workers in any slaughterhouse sector, and who did not use medications that could interfere in the analysis were selected. After evaluating the eligibility criteria and the initial invitation, three participants were randomly selected who were previously informed about the procedures and objectives of the study and, after the agreement, signed a written consent form. The procedures of the study were approved by the Committee for Ethics and Research of the Faculdade de Ciências e Tecnologia FCT/UNESP (CAAE: 65973317.9.0000.5402) and followed the Declaration of Helsinki.

Initial assessment and outcomes

Initially, an assessment was carried out to collect personal information from the participants (age, the position at work, previous diseases and medications in use) and anthropometric data (weight and height and, subsequently, calculation of the body mass index [BMI]) were measured. Then, a capture strap was attached to the volunteer's chest and in your wrist a Polar® V800 cardiofrequencymeter (Polar Electro OY, Finland) to capture the HR, which was initially collected with the patient at rest in the orthostatic position and subsequently, for one hour of the respective work activity carried out by the worker.

Measures of ambient conditions were performed in conjunction with the HR collection. The measurements of the thermo-environmental conditions were made to know the thermal comfort of the place, being measured the following parameters: ambient temperature (°C), relative humidity (%), and airspeed (m/s). For this purpose, two THAR-185 Thermo-Hygro-Anemometer equipment (Instrutherm, Brazil) were used, which were positioned on a tripod at 1.60 meters from the floor and at 1 meter from the worker who had the measured HR, and measurements were collected at 15-minute intervals. The noise measurement was made using a decibel meter DEC-5010 (Instrutherm, Brazil) and collections were performed in dB (A) every 5 minutes. For measurement, the following parameters were considered: the equivalent level of continuous noise (Leq), considering the weighting of the arithmetic mean of the task duration, and the duration of the work, of 8 hours or 480 minutes.

To assess the workers' physical load, the maximum heart rate (MHR) of each volunteer was calculated according to the formula (220-age)[20]. The physical workload or cardiovascular load (CVL) was expressed by the equation: CVL= [(WHR – RHR)/(MHR – RHR)]x100[21], in which WHR = working heart rate; RHR= resting heart rate; MHR = maximum heart rate.

Also, limit heart rate was calculated (LHR): LHR = 0,40x(MHR – RHR)+RHR[21] and working heart rate (WHR), which is the average HR during the work period, these methodologies were proposed by Apud et al.[21]. Besides, the minimum and maximum HR reached were calculated, selecting the lowest and highest HR value at each moment of the activity performed, at the beginning and end of the work period analyzed, which were divided into intervals of 15 minutes each and later performed the average of the values.

Based on the working HR, the physical workload was classified as follows[19]: below 75 beats per minute (bpm) the physical workload is classified as very light, between 76 and 100 bpm moderately heavy, between 101 to 125 bpm heavy, and between 126 and 150 bpm is considered extremely heavy.

For the analysis of data on the characterization of the population and the outcomes, we used the descriptive statistical method and the results were presented in absolute values, means, standard deviation, and percentage value. Also, line type graphs were plotted to expose the heart rate variation and behavior during an hour of work, these being performed using Microsoft Excel software (Microsoft Office Professional Plus 2019, United States).

RESULTS

Three individuals participated in the study, whose individual characterization is described in Table 1. They do not have any disease and do not use medication. The calculated data on resting and maximum heart rate, cardiovascular load, limit and working heart rate and the classification of the physical workload are exposed in Table 1.

Table 1. Characterization of the sample, environmental conditions, and heart rate variables (n = 3).

Worker	1	2	3
Workstation	Right groin (dirty area)	Carcass cleaning (clean area)	Polyvalent (dirty area)
Time experience (years)	20	4	29
Age (years)	47	24	54
Weight (kg)	82.00	62.00	86.00
Height (m)	1.70	1.70	1.75
BMI (kg/m2)	28.37	21.45	28.08
Environmental conditions			
Thermal comfort (°C)	29.00	29.00	27.40
Noises dB(A)	86.01	91.47	87.00
Heart rate variables			
RHR (bpm)	60	84	91
MHR (bpm)	173	196	166
CVL (%)	24	24	12
LHR (bpm)	105	129	121
WHR (bpm)	87.32±7.81	111.61±18.82	100.70±9.10
Physical workload rating	Moderately heavy	Heavy	Heavy

Note: Kg = kilogram; m = meters; kg/m² = kilogram/meter²; °C = degree Celsius; dB (A) = decibels; RHR = Resting Heart Rate; MHR = Maximum Heart Rate; bpm = beats per minute; CVL = Cardiovascular Load; % = Percentage value; LHR = Limit Heart Rate; WHR = Working Heart Rate.

The data referring to the average time spent in each activity performed and the average, minimum, and maximum HR of each worker during the phases of the work activity are described in Table 2. The average, minimum, and maximum HR in the initial and final periods of the day are shown in Table 3.

It is possible to observe the behavior of the HR throughout the different moments of the work, divided between the cut and the moment of sharpening and cleaning the knife (Figure 1 and Figure 2).

Table 2. Time and heart rate variables throughout the phases of work activity.

Worker	Activity	Time (sec)	Average HR	Minimum HR	Maximum HR
1	Cut	12.26±1.39	87.07±8.02	84.70±7.79	89.61±8.02
	Sharpen	23.70±28.00	87.56±7.65	83.71±7.71	91.04±7.88
2	Cut	52.93±46.04	110.67±18.46	101.86±16.46	118.53±20.39
	Sharpen	32.06±77.50	112.57±19.47	107.68±20.53	117.65±19.43
3	Cut	34.90±3.52	99.80±9.17	92.38±8.36	108.04±9.27
	Sharpen	52.05±93.74	101.64±9.17	94.20±8.78	108.20±9.80

Note. Sec = Seconds; HR = Heart Rate; Values shown as mean ± standard deviation.

Table 3. Heart rate variables during the initial and final 15 minutes of work.

Worker	Moment	Average HR	Minimum HR	Maximum HR
1	Initial	87.80±8.44	85.08±8.33	90.46±8.62
	Final	87.63±6.54	84.69±6.29	90.65±6.87
2	Initial	91.97±7.66	85.69±6.24	90.65±6.87
	Final	129.74±11.31	121.81±13.02	98.69±12.30
3	Initial	97.71±8.90	90.26±8.67	105.78±9.23
	Final	108.19±4.27	100.00±4.95	114.95±3.91

Note. HR = Heart rate

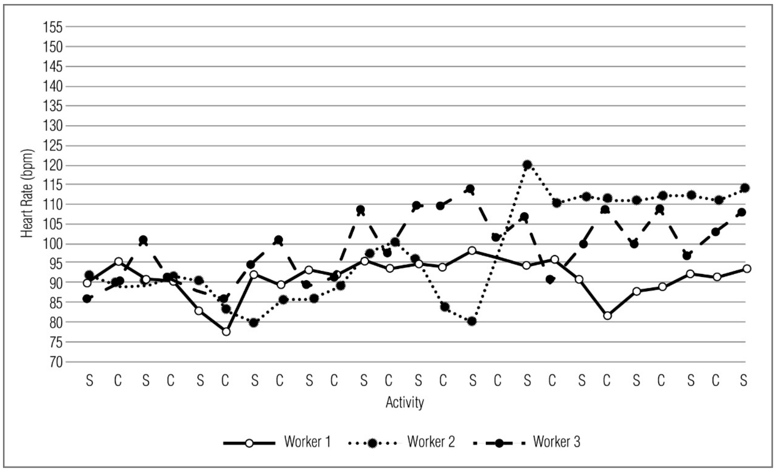

Figure 1. The behavior of heart rate from the beginning to the middle of the work period.
Note. bpm = beats per minute; S = Time to sharpen and clean the knife; C = Time to cut.

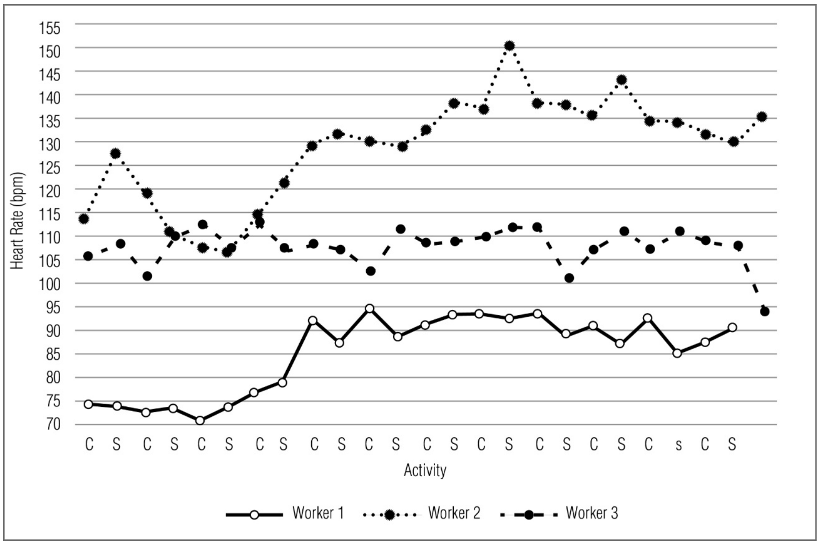

Figure 2. The behavior of the middle heart rate until the end of the work period.
Note. bpm = beats per minute; S = Time to sharpen and clean the knife; C = Time to cut.

Assessment of environmental working conditions

Regarding the analysis of environmental conditions, we observed that the temperature in the morning was, on average, 26.6 °C, and at noon, 29.1 °C. The temperature ranged from 26.6 ° C to 27.5 ° C from 9:30 am. In the afternoon, the temperature was, on average, 29.2 ° C, despite the presence of fans operating approximately two meters from the workstation. It is emphasized that the ambient is not acclimatized and the local temperature is affected by the external ambient temperature and the collection took place in autumn, where temperatures are milder. The relative humidity values varied between 73.3% and 80.2%, and the wind speed from 0.1 to 0.3 m/s. Still, the level of the average exposure to noise during an 8-hour day is 91.2 dB (A) with an expanded uncertainty of 3.3 dB (A).

DISCUSSION

The objective of this study was to evaluate the behavior of the HR and the physical load of workers of the slaughtering sector in the slaughterhouse and meatpacking industries. The main finding of this study shows that the individuals were in a job that ranged from moderately heavy to heavy and that, despite not exceeding the permitted cardiovascular load, one of them reached the limit HR and two had a higher HR at the end of the work when compared to the beginning. In addition, in relation to the moments of cutting and sharpening/ cleaning the knife, no large variations in HR values were observed.

Regarding the physical load, the heaviest loads were from workers 2 and 3, which were classified as heavy, while worker 1 was considered moderately heavy, suggesting that the work developed by individuals 2 and 3 is heavier physically, which is probably related to the varied functions that workers perform. It is important to highlight here that works considered light to moderate do not cause fatigue quickly, as the lactate and HR values reach a stable level, while in heavy work, these variables rise, causing fatigue and making breaks necessary during work[22].

Regarding the calculated cardiovascular load, the highest value reached was 24% by two workers, one who works in the dirty area and the other in the clean area. According to current legislation and using only this variable for analysis, these workers do not need additional breaks from work, as it is recommended to reorganize work activity, with the insertion of a rest period, only when the cardiovascular load is 40%[21].

Concerning HR, it is observed that the average HR of these individuals during the analyzed period was 87.32 ± 7.81 (Individual 1), 111.61 ± 18.82 (Individual 2), and 100,70 ± 9,10 (Individual 3), however, the analysis of graph 2 shows that at various times only worker 2 reaches high HR values, with a peak of 150 bpm, exceeding his limit HR which is 129 bpm.

The HR was higher at the end of the work period in two individuals who reached average values of 129.74 ± 11.31 (Individual 2) and 108.19 ± 4.27 (Individual 3). Values of this magnitude have also been found by other studies in harvesters and loggers and have been linked to fatigue[23]. Regarding the moments of cutting and sharpening and cleaning the knife, it is possible to verify that there are no large variations in the HR values.

In addition to the physical load, other aspects may be present in workers and influence the behavior of HR. Loads such as psychic ones, identified for influencing the mechanized work process due to the need for constant attention and concentration, pressure from supervision, awareness of the danger and lack of work control, intense work pace, absence of regular breaks, submission to the rhythm and movement of machines, constancy, and repeatability, among others, that favor the emergence of psychosomatic illnesses and increased severity of work accidents[24], may be involved in the behavior of HR. Also, in different areas of work, these psychosocial factors or stressors influence the increase in HR[19], and the tension and high demand present in the activity are related to an increased risk of coronary artery disease[25].

Another characteristic that stimulates the increase of HR, is the elevated temperature of the ambient[11], we identified that the temperature of the place varied from 27.4 ° C and 29 ° C, above the recommended in the work ambient, which is from 18 ° C to 24 ° C[26] and 20 ° C to 23 ° C by NR 17. It is important to emphasize that the increase in exposure to high temperatures is related to the increase in the rate of morbidity and mortality, especially in older individuals[27], also the performance of intense physical activities combined with the use of protective equipment, increase the chance of thermal overload, which can be harmful to health[28].

Still ambient aspects, we identified a sound level above 85 decibels, which is above the tolerance limits described in Brazilian regulations. This is a factor that influences the appearance of fatigue and makes concentration difficult[19]. The relative humidity of the air and the speed of the wind presented values within the recommended by the Brazilian legislation that is above 40% and below 0.75 m/s, respectively.

Another factor that influences HR responses is the pace of work[23]. During the work period of individual 2, there were delays to start the cuts and, consequently, the pace was accelerated, which may have led to an increase in HR.

Regarding the characteristics of individuals, two of them are over 40 years old, being more indicated for tasks with less physical demands, due to the progressive deficit in muscle strength that occurs in this age group[29]. The same individuals have a BMI above the ideal value, which, in addition to being associated with increased mortality from cardiovascular diseases and diabetes[30], interferes in the performance, cardiorespiratory condition, and physical status of the individuals[15].

As limitations of the study, we can point out the low number of volunteers evaluated, which prevents the extrapolation of the results observed to the general population. Despite this, the results point to the need for studies of this nature with these workers, which may protect the health of the worker, guaranteeing their productivity without damage during their work. Another aspect to be highlighted is the short period of the workday evaluated. However, even in this short period, it was possible to find aspects related to worker health that deserve attention, highlighting the importance of checking HR during work activity, for the prevention of pathologies and the appearance of symptoms.

We observed that there are several gaps in the literature about workers in these industries that deserve to be studied, the slaughterhouse industry has in its organizational structure several work sectors with requirements completely different from those observed in the evaluated individuals, which opens the possibility of new studies covering this population.

CONCLUSIONS

The results allow us to conclude that the individuals' physical workload fits in moderately heavy to heavy physical work. Regarding the analyzes aimed at the cardiovascular system, one of the individuals reached the limit HR and two of them had a higher HR at the end of the work when compared to the beginning and there were no large variations in the HR values when comparing the cutoff times and sharpen and clean the knife.

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COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee – Faculdade de Ciências e Tecnologia FCT/UNESP and the protocol (no. 65973317.9.0000.5402 was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: LAS, LCMV, IAM; Performed the experiments: IAM, LAS; Analyzed the data: LAS, LCMV; Contributed reagents/materials/analysis tools: AG, PP, LCMV; Wrote the paper: LAS, LCMV, AG, PP, IAM.

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