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Assessment of postures and manual handling of loads at Southern Brazilian Foundries

Evaluación de las posturas y la manipulación de cargas manuales en fundiciones del sur de Brasil

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ABSTRACT: Foundry workers are exposed to health risks arising from several factors, especially weight handling, adopted postures, and taken routes. This paper aims to evaluate the postures and cargo handling in foundry areas of industries at the south region of Brazil. Data was collected from a population of 35 workers that volunteered to take part in the research. The techniques used include an organizational questionnaire, interviewing, the Nordic musculoskeletal questionnaire, and the REBA and NIOSH methods. It was found that 74.3% of the sample reported symptoms of discomfort and pain in different parts of the body. The lumbar region appeared as the most affected part, as well as wrists, hands and fingers. The REBA method results indicated that 78.9% of analyzed postures are between medium and very high risk levels. Likewise, 100% of shipments surveyed carried risks of injury in the spine and musculoskeletal ligament system.

RESUMEN: Los trabajadores de las áreas de fundición son expuestos a cargas de trabajo que pueden afectar su salud debido a varios factores, entre los que se destacan el peso que es manipulado, las posturas adoptadas y los recorridos realizados. Este artículo tiene como objetivo evaluar las posturas y la manipulación de cargas en áreas de fundición en empresas del sur del Brasil. La población estudiada fue de 35 trabajadores que voluntariamente decidieron participar de la investigación. Fue aplicado un cuestionario organizativo, entrevistas, cuestionario nórdico de síntomas osteomusculares, método REBA y método NIOSH. Se destaca que el 74,3% de la muestra estudiada presentó síntomas de molestias y dolores en diferentes partes del cuerpo, siendo la región lumbar la más afectada, así como las muñecas, manos y dedos. Los resultados del método REBA identificaron que el 78,9% de las posturas analizadas poseen niveles de riesgo entre medio y muy alto. De la misma forma, el 100% de los levantamientos de pesos investigados presentaron riesgos de lesiones en la columna y el sistema de músculos y ligamentos.

1. Introduction

Four main causes of health problems attracted the attention of specialists in ergonomics and health and safety at work in the last few decades: postures at work, manual handling of loads, repetitive movements and occupational stress [1]. This is due to the frequency of health problems arising from these causes in that period. A worker will be more productive if he is more satisfied and motivated at work [2]. Satisfaction and motivation are highly dependent on conditions of work in which activities are developed. Equally important is the employee participation in finding and solving problems of his working environment. A direct and close relationship of productivity, satisfaction and motivation arises from the correct management of working conditions.

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The inappropriate postures that workers are forced to adopt due to the working conditions may be causing musculoskeletal disorders. It is emphasized that whenever circumstances permit the change of postures, this change will be welcome once the adoption of the same posture for a long period may cause health problems. Therefore, a proper posture is the one that the employee chooses and that changes throughout the development of activities.

The manual handling of loads, in particular weight lifting, should be considered a heavy work, even if the power consumption and the pulse rate are not increased significantly. The load on the back is so great that further pathological complications can arise. The main problem of cargo handling is not so much the demand on muscles, but rather the wear and tear of the intervertebral discs [3].

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The working population is frequently exposed to physical load, a major risk factor for postures adopted in the workplace. A large majority of workers have shown increasing musculoskeletal discomfort in the last few years, attributing them to efforts and postures related to working characteristics or conditions [4].

Manual handling charge may present a lumbar back risk, particularly in the following cases [5]:

-When the load is too heavy or too large;
-When the load is voluminous or difficult to grasp;
-When the load is in unstable equilibrium and its content may move;
-When the load is placed in such a way that must be maintained and manipulated at a distance from the trunk or with a twist or inclination thereof;
-When load can cause injury to the worker because of its appearance or consistency.

Workers frequently complain about pain, discomfort and loss of function in the back, neck and limbs. According to the Statistical Yearbook of Social Welfare of Brazil, during the year 2011, 26,495 pensions were awarded for disability related to musculoskeletal system and connective tissue diseases, which represented 14.5% of the total (183,301) [6].

In Spain, a study carried out in 2011 showed that 77.5% of workers suffer from some kind of disease as the result of bad posture or derived efforts of the activity they perform [7].

This situation is not different in Brazil. The foundry activities are not adverse to these problems because many of the tasks are performed manually. A research about physical load of workers at a foundry in the state of Rio Grande do Sul showed that the activities of breaking and deburring impose a high physiological demand, once the difference of heart rate between resting and performing those activities exceeded the acceptable physiological limits of working load [8].

At the same foundry, it was found that back, legs, neck and hands were the body parts in which workers had higher discomfort or pain [8]. At another foundry industry in the same region, 75.2% of workers reported some musculoskeletal symptom in the last twelve months, 53.3% in the last seven days and 38.5% already took a time off of their activities due to this problem [9].

In the state of São Paulo, the research carried out at a foundry identified that 56% of workers directly involved in productive process complained about discomfort due to pain in the body, and 43.75% of them reported that the pain increases during the working hours. It is noteworthy that 37.5% of these workers take some medicine to ease the pain, and 37.5% have already undergone some kind of medical treatment involving knees and spine [10].

So far in another foundry in the state of Paraná, through ergonomic analysis and heart rate monitoring, it was found that the body region with higher musculoskeletal load is the lumbar region and the upper limbs due to static postures and repetitive movements. At this company, also load transportation exceeds human capabilities and limitations, demanding productive process changes, mainly those related to molding and demolding [11].

In research conducted in a foundry in the State of Paraná in Brazil [12], it was found that 42.86% of the employees surveyed feel severe pain in the spine region, and 38.10% feel some soreness during working hours.

The casting process shows high rates of injuries, with the highest percentage of them being attributed to strains and sprains. The ergonomic training together with administrative controls and engineering, is a recommended way to reduce these types of injuries [13].

A study about working conditions on China foundries [14] showed that the most affected areas after 12 months' work are the back, shoulders and hands and wrists with 29.2%, 10.5% and 6.2% occurrence frequencies, respectively. In a foundry study, it was found that 57.89% of workers surveyed had pain in the lumbar region with 26.32% having declared significant reductions on their working capacity due to pain [12]. The same author points out that 15.79% of the foundry workers said they experienced pain in the last seven days and 26.32% experience pain every day. According to data provided by the survey of working conditions [7], 44.9% of Spanish workers had musculoskeletal diseases in the lower back, 34.4% in the neck, 27.1% in the dorsal region, 13.8% in shoulders and 10.8% in the hands and wrists.

In this paper, we assess the working conditions of two foundries in southern Brazil. Postural and manual cargo loading analytical methods were employed in this study. Both methods allow for an adequate evaluation of risks of the activities into the working environments.

2. Methodology

Two foundry industries placed at the South Region of Brazil were studied. It was decided that the total number of employees (35 workers) would take part in the research. All of them were male, and the age distribution is as follows (Figure 1):

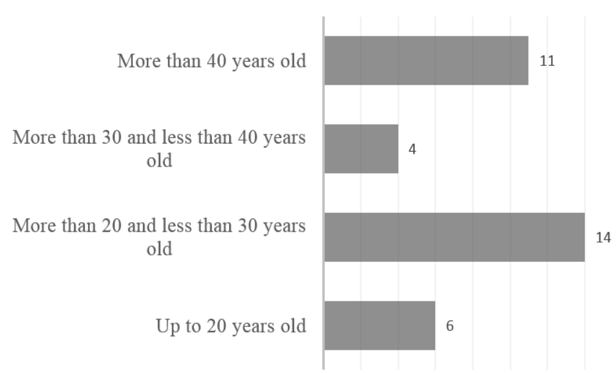

Figure 1 Sample distribution by age group

The staff has an average work time of 4.18 years at the company and at this sector. It can be observed that from all employees (35), 62.85% (22) are in this activity for up to 3 years, but from the total, 59.1% (13) are dedicated to this activity less than a year. Between 3 and 10 working years are 25.7% (9) of the total of workers, and only 11.4% (4) have performed this activity in the company for more than 10 years. Considering the work time at the company, this group is heterogeneous, as the standard deviation is 3.68 years (the coefficient of variation related to the average work time at the same company was 88%), showing a high variability.

The following methods were used in order to reach the objective of this research:

2.1. Organizational Questionnaire

It aims to the identification of interesting aspects to the research. It was divided into three parts: The first part sought demographic data, the second part dealt with work aspects. The third part was directed towards knowledge of the activities performed in the working sector. First, this questionnaire was answered by a test sample in order to correct any problems related to the wording of questions which could lead to misunderstanding for respondents.

2.2. Nordic Musculoskeletal Questionnaire (NMQ)

This questionnaire, validated in Brazil [15], was used aiming to identify, from information provided by employees, the body parts in which they felt pain, discomfort or numbness caused by performed activities [neck, shoulders (right, left and both), elbow (right, left and both), forearm (right, left and both), wrists/hands/fingers (right, left and both), dorsal region, lumbar region, hips and/or thighs, knees, ankles and/or feet] in three moments: in the last 12 months, in the last 7 days, and if in the last 12 months the workers had to avoid performing their regular activities (work, housework or hobbies) due to the problems reported in the searched regions.

2.3. Rapid Entire Body Assessment (REBA)

Beyond proving if workers' postures adopted when performing their work were adequate or not, the application of this method aimed to observe if there was a relation between what was reported by respondents when answering the Nordic Questionnaire, and the results obtained from REBA method. If the postures are inadequate, they may result in some kind of pain or discomfort.

This method is appropriated for analyzing the arms and the activities in which repetitive movements are performed. This is an analytical system which includes loading factors, dynamic and static posture, the load-person interaction and a new concept which incorporates what is known as "gravity-assisted" for maintaining the posture of the upper extremities [16].

The method is divided into two groups. Group A has 60 postural combinations to the trunk, neck and legs, and group B has a total of 36 combinations to arm, forearm and wrist. The results from A and B are combined in one table which shows 144 possible combinations [16].

The evaluated postures are scored in five action levels.

The result of the final score makes it possible to know the level of risk and future intervention according to five levels:

-Level 1: negligible risk. Ergonomic intervention is not necessary;
-Level 2: low risk. Ergonomic intervention may be required;
-Level 3: average risk. Ergonomic intervention is required;
-Level 4: high risk. Need readily ergonomic intervention;
-Level 5: very high risk. Need immediate ergonomic intervention.

2.4. NIOSH Method

As the workers searched in this study carry loads, it was necessary to use a method in order to determine if the conditions of handling and loading, as well as the cargo weight would be adequate or not.

The NIOSH method [17] was used to assess the loading of loads. The NIOSH equation determines the recommended weight limits (RWL). It also shows the risk index associated with the lifting obtained from the ratio between the weight of the load lifted and the recommended weight limits for these concrete conditions-lifting (1):

$$\text{Index of lifting} = \frac{\text{Actual weight of the load}}{\text{Recommende d load limit}} \quad (1)$$

Such that:
IL<1 The chance of injury is minimal.
1 <IL<2 increases the risk.
IL > 2 increases the risk of very spine injuries and muscle/ligament system.
The recommended load limit (RLL) is obtained by the following expression (2):

$$RLL(Kg) = 23 * fH * fV * fD * fF * fA * fL \quad (2)$$

where:

fH - correction factor for the horizontal position of the load, both the origin and the destination of the lift.
fV - correction factor for the vertical load on both the source and destination of the lift.
fd - correction factor for the vertical distance traveled, defined as the distance of the vertical displacement of the object.
fF - correction factor for the frequency of survey depending on the length of work in continuous time.
fa - correction factor for asymmetry of motion (lifting with trunk rotation).
fL - correction factor taking into account the interface hand-load.

In the fifth stage we generated a boxplot graph to compare the responses of the organizational questionnaire. We also computed a Pearson correlation coefficient to evaluate correlation between the diseases and pain as felt by workers in the long-run (one year) and in the short-run (one week).

2.5. Pareto Chart

Pareto Diagram is a graphic of bars which helps in decision making, allowing the selection of priorities between a wide range of items to be analyzed. In a Pareto diagram, the more significative items of a group are visualized through higher frequency bars, and normally represent a small proportion of the total items of the same group [18].

2.6. Boxplot

Boxplot is a graphic in which the summary of the statistics information is represented: minimum value, first quartile (Q1), median (second quartile Q2), third quartile (Q3) and maximum value observed in the sample.

The graphic consists of a box whose ends are the first quartile and the third quartile (that include 50% of the central values of the sample). The median and the mean are showed inside the box, and the sample extreme values are indicated by lines which go out of the box (whiskers). Distant points of distribution are indicated with an asterisk (outliers) [19].

2.7. Analysis of Variance (ANOVA)

Analysis of variance is a statistical technique which allows the evaluation of inferences made on populations' means. This kind of analysis aims at finding if there is a significative difference between the means, and if the factors exert some influence on any dependent variable. When performing the analysis of variance, basically two hypotheses are set:

H_0 (null hipothesis) – it shows that there are no significative differences between the observed means; H_1 (alternative hypothesis) – it shows that there are significative differences at least between two of the observed means.

In order to state the behavior of the means, the means values are set in confidence intervals of 95% (usual value), and are estimated considering the values of α (significance level) obtained from the Student t distribution [20].

This study was divided into 5 phases. First, researchers got in touch with the activities carried out in order to observe the way they are performed. A non-structured interview with the employees helped to define the questions which would be part of the organizational questionnaire. The second phase consisted of preparing the first version of the questionnaire which would be answered by a test sample, in order to evaluate if the questions could be understandable and include, eliminate or modify any of them. Then, the questionnaire was applied to the selected sample.

In the third phase, based on the results obtained from the organizational questionnaire, the Nordic questionnaire was applied, and when detecting pains and discomforts, the REBA method was used to identify if the postures adopted by workers were adequate or not.

The fourth phase consisted of using the NOISH method to know to what extent handling and loading could be a risk for health.

In the fifth phase, the results were analyzed through the Pareto diagram, boxplot and Analysis of Variance (ANOVA).

3. Results

The results obtained in the application of different techniques and methods in each stage of the research were the following:

3.1. Results of the organizational questionnaire

The workers were asked about foundry layout in the survey. It was observed that 68.6% rated it from poor to fair, while 22.9% rated it as good and 8.5% did not answer. During the interviews, workers reported that the layout disturb the development of activities. Besides, they stated it leads to the adoption of inadequate postures and unnecessary loading due to the distance.

The results showed in Table 1 are related to manual cargo of loads.

Table 1 Evaluation of workers on manual cargo of loads

Condition of manual cargo of loads		Percentage
Adequate		17.2
Inadequate	Regular	20.0
	Bad	37.1
	Very bad	25.7

It can be observed from Table 1 that 82.2% of the studied sample considers inadequate the activities related to manual cargo of loads. This is evident when observing the place and it meets the criteria of workers and researchers. This situation was analyzed in detail with the application of NIOSH method. When analyzing the results in relation to the force that held the upper limbs in different activities, 62.9% rated it as regular and high, 25.7% as appropriate and 11.4% did not answer the question.

When surveyed about how they classify the work, they answered as follows: 8.6% (3 employees) considered it monotonous, 25.7% as stressful, 40.0% as not very interesting, 22.9% as stimulant and one of the workers did not answer this question.

One factor that drew the attention of the authors of this research was related to how employees feel at work. These results can be observed in Table 2.

Table 2 Evaluation of workers on fatigue caused by work

Condition of fatigue		Percentage
Not tired		11.4
Tired	Little tired	28.6
	Moderately tired	22.9
	Fairly tired	37.1

It can be highlighted that 88.6% of workers feel tired, and two of them believe the fatigue is so intense, that it can change their mood. According to the results of the interviews with workers, tiredness is essentially due to work intensity, which is high, and it can be demonstrated by the fact that 94.3% of workers believe there is pressure for productivity in some extent (22.9% believe there is low pressure, 57.1% moderate pressure and 14.3% a lot of pressure). Other causes that generate fatigue are inadequate postures and the cargo loadings that are constant and inadequate. An interesting finding is the fact that there is no direct relationship between age and fatigue at work. It was found that that 57.1% are aged between 18 and 30 years and also have fatigue due to activity that they develop in the foundry area.

With respect to labor pains in the body it was observed that 74.3% responded positively in contrast to 5.7% negatively (20.0% did not answer this question).

Regarding the time of the working day in which the pain appears, the results show that 8.6% of the workers had pain at the start of the working day, 22.9% in the middle and at the end of the working day, 40.0% all over the working day, 14.3% at some moment of the day and 5.7% must go out of the work activity because of pain intensity. 6 workers did not answer the question.

Figure 2 shows the time of the working day in which pain is reported.

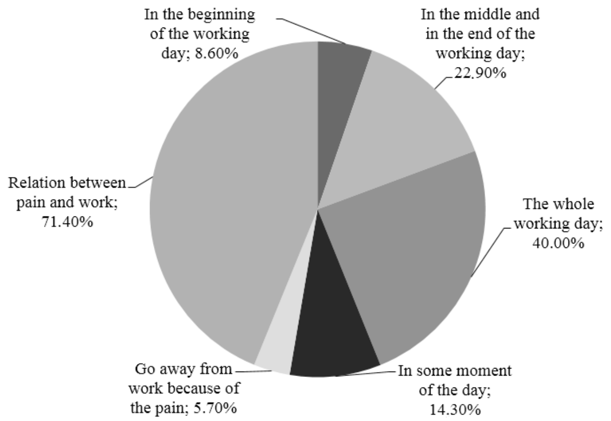

Figure 2 Distribution of sample by age group

As it can be observed from Figure 2, workers' pain is an extreme and worrying situation once 5.7% were off work due to this cause. It can be observed that 71.4% reported that there is some relation between the pain and the work they perform. This is strictly linked with working conditions that make the adoption of inadequate postures possible, loadings of inadequate cargo and even working rythyms that overcome psicophysiological capabilities of workers.

It was also asked to workers whether working conditions has worsened pain symptoms. The results were somewhat contradictory compared with the previous ones. For 45.7% responded positively, 40.0% responded negatively and 14.3% did not answer this question. Yet, most workers said that there is a relationship. This shows that there is a worrying situation at stack which is in line with the results of observations made by the authors at the working places of the foundries.

With respect to the factors which aggravate the symptoms of pain, it was observed that 31.4% declared that pain worsening was due to the fact that they are always working in the standing posture, 14.3% pointed to the dimensions of the workplace, 11.4% pointed at the organization of the workplace and 5.7% pointed to the reduced space to perform the work.

When asked if the work environment can cause stress, 54.3% answered positively, and 45.7% negatively. Table 3 summarizes the results about the kind of psicological alteration is produced due to the laboral stress and its influence.

The results presented above show that emotional stress influences the work activity and that this situation transcends the limits of the work and passes the influence of family workers.

When asked about the relationship with the leaders the results were positive: 42.8% to classify as good, 45.7% of reasonable 8.6% as bad and only 2.9% as bad. The relationship with coworkers, on the other hand, were considered: good/excellent for 85.7%, reasonable for 8.6% and only 5.7% as bad.

3.2. Results of application of the Nordic Questionnaire

The same source notes that the body parts that have a higher incidence of pain are the lumbar region, the dorsal region and neck. Metallurgy workers occupy the third place in the rank of activities where workers feel more diseases.

This information is consistent with the results of the application of the Nordic Questionnaire (see Table 4).

The results in Table 2 show that one of the parts of the body most affected is the lumbar region.

The on-site observation, as well as the examination of images recorded (movie/photograph), leads to the conclusion that there is a strong relationship between the observations and the reported problems from the Nordic questionnaire.

Table 3 Psycological disturb that causes emotional

Disturbs	Percentage of respondents (%)	
	Influence during the activity	Influence in family
Distraction	60	14.3
Irritability	37.1	23.1
Bad mood	28.6	60.0
Slow thinking	11.4	75.0
Learning capacity	17.1	33.3

Table 4 Results from the Nordic Questionnaire

Body parts		Had some disease over the past 12 months?		Had some trouble in the past 7 days?		Had to avoid normal activities in the last 12 months?	
		QTY	%	QTY	%	QTY	%
Neck		4	11.4	1	2.9	0	0.0
Shoulder	Right	3	8.6	3	8.6	2	5.7
	Left	3	8.6	3	8.6	0	0.0
	Both	7	20.0	3	8.6	0	0.0
Elbow	Right	2	5.7	1	2.9	0	0.0
	Left	2	5.7	2	5.7	1	2.9
	Both	2	5.7	1	2.9	0	0.0
Forearm	Right	0	0.0	0	0.0	0	0.0
	Left	0	0.0	0	0.0	0	0.0
	Both	4	11.4	3	8.6	1	2.9
Wrist/hands/ fingers	Right	2	5.7	1	2.9	0	0.0
	Left	1	2.9	2	5.7	0	0.0
	Both	14	40.0	6	17.1	1	2.9
Dorsal area		2	5.7	0	0.0	0	0.0
Lumbar area		24	68.6	13	37.1	2	5.7
Hips and thighs		6	17.1	1	2.9	1	2.9
Knee		3	8.6	1	2.9	0	0.0
Ankles and/ or feet		7	20.0	4	11.4	0	0.0

3.3. Results from the method REBA

The method REBA was applied to verify whether the diseases that workers said they felt were related to the positions they take on the job. Figure 3 shows two of the positions that were analyzed. Red lines highlight the slope of different body parts take to perform the activity.

The result of the analysis of 147 postures (activities related to mold finishing and manual green sand molding) are shown in Table 5.

Comparing these results with the method established by REBA it is then observed that 78.9% of the analyzed positions need ergonomic intervention and for the remaining 21.1% it could be necessary to propose measures to improve the situation. There were no significant differences when the right arm is comparing with the left and analyzed separately as required by the method.

The results of this analysis are in line with those obtained in the organizational and Nordic questionnaires. As shown in Table 2, the body parts most affected are the lower back and wrists, hands and fingers.

As shown in Figure 3, the dimensions are not adapted to the anthropometric characteristics of the population since the activities are carried out directly on the floor, leading to the adoption of awkward postures.

3.4. Results of application of the NIOSH method

We analyzed the loading of cargo in both the manual finishing operations of molding as well as in the activity of manual green sand molding with the NIOSH method, and the results are showed in Table 6.

We conclude that all shipments analyzed in mold finishing have ergonomic risks of injury in the spine and in muscle/ ligament system.

Figure 3 Example of postures analyzed by REBA in the finishing operation of molding

Table 5 Results from the method REBA

Level	QTY	%
1: negligible risk. Ergonomic intervention is not necessary	0	0,0
2: low risk. Ergonomic intervention may be required	31	21,1
3: average risk. Ergonomic intervention is required	35	23,8
4: high risk. Need readily ergonomic intervention	53	36,1
5: very high risk. Need immediate ergonomic intervention	28	19,0

An analysis comparing the results obtained when applying the Nordic Questionnaire (Table 2) with the application of the method REBA (Table 3) and NIOSH (Table 4). The Pearson correlation coefficient of r = 0.947 of the first two numerical columns of Table 1 shows that there is a strong correlation between the number of diseases presented in the body parts exposed to 7 days and 12 months of work. In other words, the effort expended in excessive activity (IL > 1 as method NIOSH) and the practice of postures (action levels 1, 2, 3 and 4, as REBA method) are causing problems to the same degree to the health of workers in both the long and in the short run.

Postures, cargo loading manual and inadequate working conditions can lead to the onset of pain, disease and discomfort in different body parts of workers exposed to these conditions.

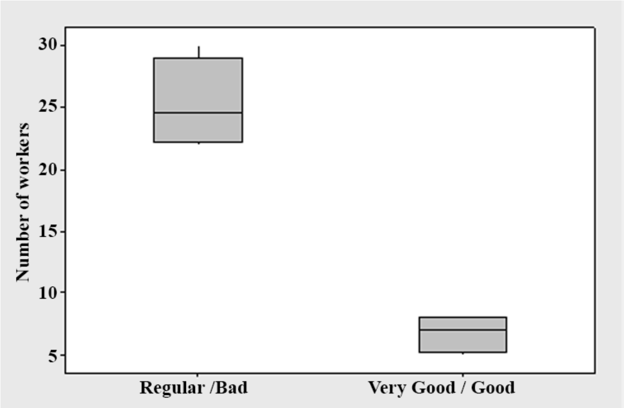

Figure 4 Boxplot on the perception of workers about the work

4. Discussion of results

The workers showed dissatisfaction with the labor activity they are involved (Figure 4) when asked about (through organizational questionnaire) the work they perform, their feeling about work, about the pressure for productivity, about the layout of the area, and at last, about the strength they perform with upper limbs.

In Figure 4, boxplots show a significative high quantity of workers (82.2%) that consider the activity they perform as regular/bad.

Figure 5 presents the analysis of variance report which indicates the most affected parts of the body, considering workers' age. The report shows that the p-value of 0.232 (upper of significance level of $\alpha = 0.05$) indicates that all confidence intervals are overlaid, i.e. it is not possible to state there are significative differences between the age means and the affected parts of the body. Also, the R^2

Table 6 Results from the method NIOSH

Operations/ activity	Total of loads	IL < 1		1 < IL < 2		IL > 2	
		QTY	%	QTY	%	QTY	%
Manual molding of green sand	43	0	0.00	18	41.9	25	58.1
Molding finishing	38	0	0.00	17	44.7	21	55.3
Total	81	0	0.00	35	43.2	46	56.8

```
Source          DF     SS    MS     F      P
Body parts       9   2009   223  1.34  0.232
Error           74  12346   167
Total           83  14355                       S = 12.92     R² = 14.00%

                                     95% confidence intervals for mean
Body parts             N   Mean  StDev  --------+---------+---------+---------+-
Forearms               4  26.75   6.65  (---------*----------)
Elbows                 6  40.33  10.82            (--------*-------)
Knees                  3  44.00  22.91           (------------*-----------)
Shoulders             13  32.08  12.53        (-----*-----)
Neck                   4  31.75  12.82    (---------*----------)
Wrist / hand / fingers 15 25.67  9.05     (----*-----)
Hips and/or thighs     6  37.50  17.58          (--------*--------)
Dorsal region          2  35.50  19.09  (---------------*--------------)
Lower back            24  30.21  12.69        (---*----)
Ankles and/or feet     7  36.86  15.49           (-------*-------)
                                        --------+---------+---------+---------+-
                                        Age    24        36        48        60
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Figure 5 – ANOVA report – Most affected body parts versus age

value of 14% shows that there is no direct relation between the affected parts of the body and the age of the workers involved in this research.

However, it is possible to observe from this report some tendencies related to the mean. The older workers present more problems in the knees, while the younger workers show more incidence of problems related to the forearm, wrist, hand and fingers. Furthermore, it can be observed that pains in the dorsal area have no distinction of age between workers.

In relation to the factors that worsen the pain symptoms, he Pareto diagram of Figure 6 shows that most of workers (about 68%) claim that the pain worsening is due to the fact that they are always working at the standing posture.

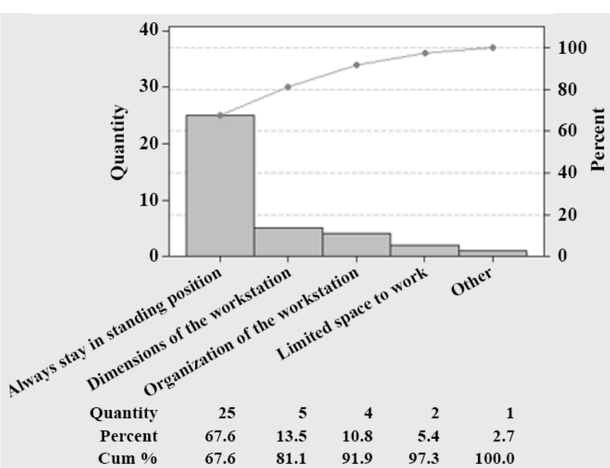

Figure 6 Pareto chart with factors that worsen the pain symptoms

The other causes, such as dimensions of work station, organization of the workstation and limited space to work showed less effect on pain symptoms.

5. Conclusion

The conclusion of this research is that the casting area has serious problems in workstations where no manual activities are performed as well as in those in which loads are performed.

This research showed that adopting the same posture, i.e. the standing posture, results in worsening the pain felt by 68% of the analyzed population. It stands out that 88.6% of workers feel tired, and 94.3% express that this fatigue is essentially due to high work intensity.

Also, it is highlighted that 78.9% of postures and cargo loadings analyzed are inadequate, and according to workers, there is a direct relation of this with the pain and discomfort they feel.

A new workstation for the activities of finishing and manual molding of green sand was proposed and it is in analysis to be built, as well as changes in layout which involve changes in working methods that would completely eliminate manual handling of cargo. In the same way, the station was designed to allow changes between the standing and sitting postures, considering the extreme percentiles of 5% and 95% which include 90% of the population.

The authors of this paper have as future challenge to replicate the results of this research for other foundry and/or thermal treatment sectors of the South region of Brazil in order to compare the results of the researches.

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