

Ergonomic risk and work-related musculoskeletal disorder in machine and equipment manufacturing workers

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Abstract: Introduction: Workers of the metallurgical industry are constantly exposed to occupational risk factors that can lead to the development of work-related musculoskeletal disorders (WMSDs). These disorders are highly debilitating, generating losses to workers, companies and the State. Objective: To identify and verify the connection between risk factors and WMSDs in metallurgical workers in the manufacture of machinery and equipment. Method: This is a cross-sectional epidemiological study that involves registered workers of the Occupational Health Reference Service (Cerest) in São Paulo state. The survey was conducted through review of electronic medical records. Results: 2116 electronic medical records were analyzed, from these, 36 were considered for the sample. We observed that 91.6% (n = 33) of the participants were men, age range from 29 to 62 years and the most prevalent occupational status was unemployment (47.3% (n = 17)). The WMSDs were found in the upper limbs and spine region, predominantly spine. Repetitiveness was the most prevailing risk factor (94.4% (n = 34)). A connection between repetitiveness ($p = 0.0046$) and physical exertion ($p = 0.001$) with symptoms in the spine was detected. Conclusion: The spine is the main body region affected in these workers. There was a link between repetitiveness and physical exertion with the symptoms of spine pain. The results strengthen the need for interventions in the workplace to minimize repetitive work and excessive physical exertion seeking prevention and workers' health promotion.

Keywords: *Ergonomic Risk, Occupational Health, Public Health.*

Risco ergonômico e distúrbio osteomuscular relacionado ao trabalho em trabalhadores de fabricação de máquinas e equipamentos

Resumo: Introdução: O trabalhador do setor de metalurgia está constantemente exposto a fatores de risco no ambiente de trabalho que podem levar ao surgimento de distúrbios relacionadas ao trabalho (Dort). Esses distúrbios são altamente incapacitantes, trazendo prejuízos para os trabalhadores, empresas e para o Estado. Objetivo: Identificar e verificar associação entre os fatores de risco e as DORT nos trabalhadores do setor de metalurgia, na atividade de fabricação de máquinas e equipamentos. Método: Trata-se de um estudo epidemiológico transversal, envolvendo trabalhadores cadastrados em um Centro de Referência em Saúde do Trabalhador (Cerest) do interior do Estado de SP. A pesquisa foi realizada por meio de avaliação de prontuários eletrônicos. Resultados: Foram analisados 2116 prontuários eletrônicos, desses, 36 foram considerados na amostra. Observou-se que 91,6% (n = 33) dos sujeitos eram homens, a faixa etária variou entre 29 - 62 anos. A situação ocupacional mais prevalente foi a de desemprego, 47,3% (n = 17). Os Dort foram encontrados em membros superiores e região de coluna. A repetitividade foi o fator de risco mais prevalente (94,4% (n = 34)). Foi encontrada associação entre repetitividade ($p = 0,0046$) e esforço físico ($p = 0,001$) com sintomas na coluna vertebral. Conclusão: Conclui-se que a coluna vertebral é a principal

região corporal acometida nesses trabalhadores. Houve uma associação entre repetitividade e esforço físico com os sintomas de dor na região da coluna. Isso reforça a necessidade de intervenções no ambiente de trabalho, visando minimizar o trabalho repetitivo e o esforço físico excessivo, buscando a prevenção e promoção na saúde do trabalhador.

Palavras-chave: *Risco Ergonômico, Saúde do Trabalhador, Saúde Coletiva.*

1 Introduction

The Reference Center for Occupational Health (Cerest) is a public institution that highlights the importance of workers' participation in health services, regardless if they are specialized units in Workers' Health (BRASIL, 2000). One of the most important functions of Cerest is to assist workers, promoting and ensuring health; to act on the prevention of occupational diseases and accidents at work and to provide care to the sick and injured workers for the physical and mental well-being of their clients (BRASIL, 2000). This service registers the workers who seek care and it has a database with several types of information about the worker and the reasons why they sought care. In this sense, studies have been developed to identify issues that need the care of worker health (NEGRI et al., 2014; SIQUEIRA, 2007).

Work-related musculoskeletal disorders (WMSD) are often identified in Cerest. WMSD affects diverse categories of workers (BRASIL, 2012). In Brazil, these disorders are considered a public health problem due to the high prevalence and involvement of different professionals (BRASIL, 2001). Moreover, they are highly disabling, bringing losses to workers, companies and also to the State, which currently has high costs for work, retirement, and treatment of the workers affected by these disorders (SALDANHA et al., 2013).

WMSD is the work-related disorder characterized by the occurrence of several symptoms, concomitant or not, such as muscular tiredness, chronic pain, the feeling of weight, paresthesia, among others. These symptoms come from the combination of overloading of the anatomical structures of the musculoskeletal system and lack of time for its correct recovery (BRASIL, 2000).

WMSD have a multifactorial origin (MORAES; BASTOS, 2013). Therefore, there are many risk factors that lead to the development of these disorders. The work environment exposes workers to different chemical, physical, and ergonomic risk factors (LUZ et al., 2013). Ergonomic risk involves repetitiveness, inadequate postures, furniture, work rhythm, physical effort, psychosocial and organizational factors, among others. These risk factors can lead to the development of work-related diseases, which

currently account for 80% of workers' removals in Brazil (BRASIL, 2001).

The Brazilian metallurgical industry is responsible for a large part of the country's economy (SANTOS et al., 2016) and includes a set of procedures and techniques for extraction, foundry, treatment, fabrication of metals, materials, equipment, and alloys. Thus, the worker in the metallurgical industry is constantly exposed to several risk factors in the work environment (GUILHOTO et al., 1995), a fact that can lead to the emergence of WMSD. A study has shown that in the metallurgical industry, over a period of two years, about 50% of workers attributed at least one episode of absenteeism to the work due to WMSD (BURDOF et al., 1998). The major impact of musculoskeletal disorders on the workforce was also demonstrated since these disorders accounted for 44% of all workdays lost in the metallurgy industry (BURDOF et al., 1998).

In the metallurgy industry, the area of machinery and equipment manufacturing is the third largest number of workers (CONFEDERAÇÃO..., 2012). Also, considering the total number of workers, the metallurgy industry shows a lower turnover rate. However, it is high (30.6%), when compared to the labor market as a whole (44.8%) (CONFEDERAÇÃO..., 2012). However, the area of machinery and equipment manufacturing has the highest rate of substitution of workers in the metallurgy industry (46.7%), even surpassing the turnover rate of the labor market as a whole (CONFEDERAÇÃO..., 2012).

There are many problems caused by the rotation in the work environment, highlighting the high costs with the selection and training of new employees; greater possibilities of errors or accidents at work due to the lack of experience of new employees; threat to the quality of the team by the loss of qualified professionals, among others (MAIER, 1973). The turnover rate is one of the problems in industrial policy since it is essential to guarantee job security to build a strong industry and, also, good working and qualification conditions for the employee (CONFEDERAÇÃO..., 2012).

Therefore, the activity of manufacturing machinery and equipment is an important industry of metallurgy. In this industry, the production lines, which require workers' high physical demands, inadequate postures, repetitive movements and intense work rhythm, stand out, which can predispose to

occupational diseases, as well as compromise the productivity and quality of manufactured products (SALDANHA et al., 2013).

Studies have shown that industrial workers have high rates of WMSD (MORIGUCHI et al., 2011; SILVA et al., 2011). However, the metallurgy area, specifically in the activity of manufacturing machinery and equipment is still little studied. Also, no epidemiological studies performed by Cerest with this population of workers were identified. Thus, studies that point out the main regions affected, the most prevalent musculoskeletal disorders, as well as presenting the main risk factors for workers, are of great importance for the planning and proposition of preventive measures.

1.1 Objective

To identify and verify the association between the risk factors and the most prevalent musculoskeletal disorders in workers in the metallurgy industry, in the activity of machine and equipment manufacturing, registered in a Cerest in the interior of the State of São Paulo (SP).

2 Method

2.1 Study design

This is a retrospective cross-sectional epidemiological study involving electronic records of workers enrolled in a Cerest in the State of São Paulo, from 2008 to

2015. This period was selected since it is related to the period in which the chosen Cerest adopted the use of electronic medical records. The study was approved by the Research Ethics Committee of the Methodist University of Piracicaba, under protocol number 118/2015.

2.2 Sample

The sample had electronic medical records of workers of both genders, living in a city in the interior of São Paulo, working in the metallurgy industry, developing the machine and equipment manufacturing activity, with a diagnostic hypothesis of WMSD. All the workers with non- musculoskeletal diagnostic hypotheses were excluded from the study. Figure 1 shows the inclusion and exclusion flowchart of the workers in the study.

2.3 Data collection

The research was carried out through electronic records evaluation, without direct contact with the workers. The variables included in the sample were: age, gender, marital status, function - according to the Brazilian Occupational Code (CBO) - time in function, clinical history (WMSD referenced body area), occupational situation, International Code of Diseases (ICD) and ergonomic risk factors.

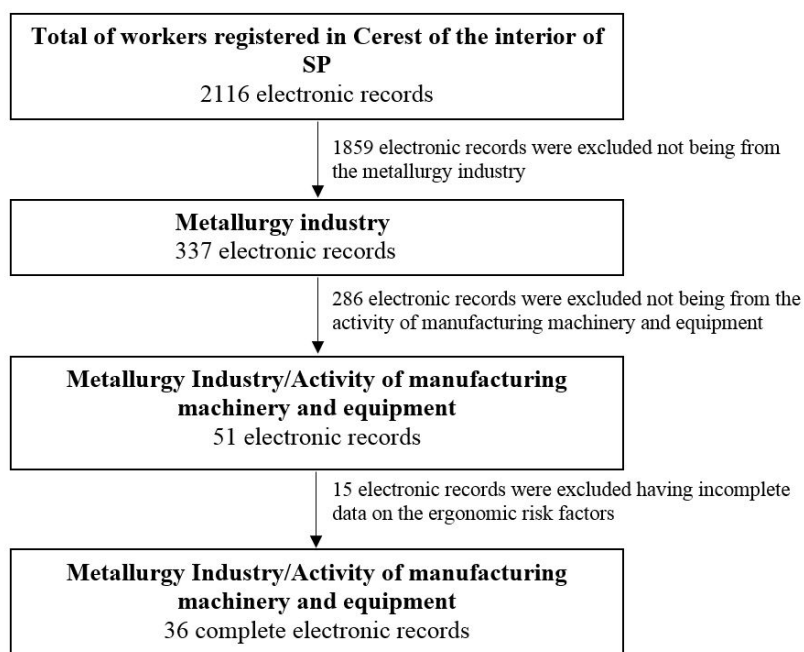


Figure 1. Flowchart of workers' inclusion and exclusion in the study.

2.4 Data analysis

Data were analyzed by descriptive statistics, expressed as mean, standard deviation, frequency, and percentage.

For data analysis purposes, the ergonomic risk factors found in electronic records were divided into repetitiveness, rhythm, physical effort, and furniture. Also, the pathologies, as reported by the ICD, were grouped in upper limbs (UL) when there were problems in the shoulder, elbow and/or wrist and in the vertebral column when there were problems in cervical and/or lumbar spine.

For the association of the variables “ergonomic risk factor” and “clinical history”, the Pearson Chi-square test was performed. The level of significance was considered $p < 0.05$. All analyses were performed in SPSS 17.0 software.

3 Results

There were a total of 2116 electronic records of workers enrolled in a Cerest in the interior of the State of São Paulo, from 2008 to 2015, and 36 electronic records were chosen for the sample containing complete data on ergonomic risk factors.

Table 1 shows the characterization of workers in the metallurgy industry in the activity of manufacturing machinery and equipment, registered in a Cerest in the interior of SP.

As observed in Table 1, there is a predominance of male workers (91.6%). The age range of workers

varied between 29 - 62 years old, with the most prevalent age being 44 years old. Most workers are married (41.7%) and the most prevalent occupational situation is unemployment, 47.3% ($n = 17$).

Table 2 shows the prevalence of WMSD in the body regions affected by workers.

The data in Table 2 show that workers in the metallurgy industry in the machine and equipment manufacturing activity presented WMSD only in UL and spine region, and the main medical diagnosis of the workers at initial consultation was low back pain, with 22.3% ($n = 8$) of the cases, and other intervertebral disc disorders, 11.1% ($n = 4$). For the UL region, the most prevalent musculoskeletal disorder was M77.1 lateral epicondylitis (8.34%) and, for the spinal region, the most prevalent WMSD was M54.5 Low lumbar pain.

It is worth noting that in 12.3% ($n = 12$) of the electronic medical records analyzed ($n = 36$), there was no established clinical diagnosis.

The most prevalent risk factors evaluated was the repetitiveness in 94.4% ($n = 34$) of the workers, followed by physical effort (86.1% ($n = 31$)) and rhythm (80.6% ($n = 29$)). The furniture was the least prevalent risk factor, verified in only 13.9% ($n = 5$) of the workers.

It was found an association between risk factors repetitiveness ($p = 0.0046$) and physical effort ($p = 0.001$) with spinal symptoms.

Table 1. Characterization of the workers in the metallurgy industry, in the activity of manufacturing machinery and equipment, registered in a Cerest in the interior of SP ($n = 36$).

	Variables	
Age (years)		46.08 ± 8.94
Gender	Female	3(8.34%)
	Male	33(91.66%)
Marital status	Single	4(11.11%)
	Married	15(41.72%)
	Stable union	3(8.34%)
	Divorced	2(5.5%)
	Not informed	12(33.33%)
Occupational situation	Activity with vehicle	12(33.3%)
	Removal B31	2(5.6%)
	Removal B91	4(11.1%)
	Unemployed	14(38.9%)
	Unemployment without insurance	3(8.3%)
	Unemployment with insurance	1(2.8%)
Time in the function (months)		98.39 ± 71.68

The values of the variables age and time in the function were expressed as a mean and standard deviation and of the variables gender and state frequency and percentage.

Table 2. Prevalence of WMSD in the body regions affected by workers in the metallurgy industry in the activity of manufacturing machinery and equipment registered in CEREST Piracicaba/SP (n = 36).

Region with pain/ailment	ICD	n(%)
UL	M77.1 – Lateral epicondylitis	3(8.34)
	G56 - Carpal tunnel syndrome	1(2.77)
	M65 - Synovitis and tenosynovitis	1(2.77)
	M75.3 - Calcifying Shoulder Tendonitis	1(2.77)
	M75.1 - Rotator cuff syndrome	2(5.55)
	Total	8(22.20)
Spine	M50.1 - Cervical disc disorder with radiculopathy	1(2.77)
	M50.2 - Another cervical disk displacement	1(2.77)
	M51- Other disorders of intervertebral discs	4(11.11)
	M54.4 - Lumbago with sciatica	1(2.77)
	M54.5 - Low back pain	8(22.28)
	M99.7 - Connective tissue stenosis and disk of intervertebral foramina	1(2.77)
	Total	16(44.47)
	Not informed	12(33.33)

The data were expressed in frequency and percentage. ICD = International Code of Diseases; UL = Upper Limbs.

4 Discussion

This study aimed to identify risk factors and to verify a possible association between them and the most prevalent musculoskeletal disorders in the workers of the metallurgy industry in the activity of manufacturing machinery and equipment, registered in a Cerest in the interior of SP. In this study, the predominance of male workers was observed, the main body region affected by the WMSD was the spine and repetitiveness was the most prevalent risk factor in the workers.

A study characterizing the profile of workers in an industry, located in the interior of the State of São Paulo/Brazil, also found that most (75.8%) of the workers were male (BATTAUS; MONTEIRO, 2013). Other studies also found a higher prevalence of males among workers in the industry (HÖFELMANN; BLANK, 2008; IGAMI et al., 2008). The predominance of men may be related to the type of activity involved, involving heavy work. Although the situation of women in the labor market is approaching that of men, most women work in the internal sectors (offices and human resources) (BATTAUS; MONTEIRO, 2013).

Concerning marital status, there was a predominance (41.72%) of married workers (41.72%) in the sample. Similar data were found in other studies with the same population (BATTAUS; MONTEIRO, 2013; PICOLOTO; SILVEIRA, 2008). Battaus and Monteiro (2013) found in their sample 64.3% of married workers and Picoloto and Silveira (2008), 64.6%.

Regarding the occupational situation, most workers (47.3%) are unemployed. Studies indicate that pain in the lumbar region is a highly disabling symptom for the performance of professional, social and family activities (ALENCAR; TERADA, 2012), generating high levels of absenteeism and high occupational health costs (ALMEIDA et al., 2008).

The results showed that the WMSD in metallurgists is located predominantly in UL and spine. The spine is one of the main regions affected by WMSD in workers in general, especially the lumbar region (ALEXOPOULOS et al., 2006; TOKARS et al., 2012). A study with the metallurgical population (PICOLOTO; SILVEIRA, 2008) also found a higher prevalence of symptoms in the regions of the spine and shoulders. These conditions may be related to the nature of the tasks performed, which involve great effort and physical exhaustion, besides the inadequate ergonomic conditions (PIGNATI; MACHADO, 2005). Also, metallurgy activity involves the constant adoption of a standing posture, weight loading and trunk rotation (AKTER et al., 2015). The muscles of the spine are the most affected during weightlifting, since, during this activity, the effort is transferred from the UL to the spine (PICOLOTO; SILVEIRA, 2008). The structure of the spine is composed of intervertebral discs that have a high capacity for absorption of loads when applied vertically to the axis of the discs. However, in different axes, these structures do not withstand heavy loads and they are more susceptible to injury (IIDA, 2005).

The most prevalent risk factors in this study were repetitiveness, followed by physical effort, and these

factors were associated with the development of disorders in the spine region. Metallurgy workers develop various activities that involve repetition (AKTER et al., 2015), such as assembly and dismantling of parts and gears, equipment mechanics, installations, among others. Also, these workers often perform activities involving trunk rotation and physical overload associated with repetitive work. This can cause lesions in the soft tissues of the lumbar, thoracic and cervical regions, which often suffer from fatigue and stress (AKTER et al., 2015). Symptoms may develop throughout the work day, due to the complex interaction between the individual, the work tasks and the environment (SANDERS, 2004). Similarly, several studies have found a significant relationship between musculoskeletal symptoms and ergonomic risk factors (LEI et al., 2005; GANGOPADHYAY et al., 2007; TOKARS et al., 2012). Bernard (1997) has shown in a review that the association between repetitive movements and physical exertion has strong evidence for spinal injuries. These results corroborate with the results of this study. Therefore, the need for preventive actions directed at the population of workers in the metallurgical industry, with a focus on minimizing repetitive work and excessive physical effort, is reinforced.

It is important to highlight that this study was developed in partnership with Cerest. This service has the performance in surveillance in WMSD as one of its main objectives (BRASIL, 2000). The work that Cerest accomplishes is directly related to the industrial poles of which each region is composed (PIRACICABA, 2010). In this study, we have a large industrial pole, especially metallurgical companies with a large number of workers attended and registered in the electronic records of this Cerest located in the interior of São Paulo.

The work of researching and working on the factory floor, the construction sites and the places where the workers work, has been fundamental so Cerest can combat all situations that may expose workers to risks in factories and metallurgists (PIRACICABA, 2010). In this way, Cerest acts as an important partner instrument of the worker. Therefore, it has been fundamental to combat situations that can cause accidents and/or occupational diseases. Also, it has an important partnership with the Metalworkers' Union, firmly working for the promotion and prevention of workers' health (PIRACICABA, 2010). Therefore, the results of this study may contribute to the adoption of more effective preventive measures by Cerest for workers in the metallurgical area to reduce the high WMSD rate in these workers and

the exposure to risk factors such as repetitiveness and physical effort.

5 Conclusion

It is concluded that the spine is the main body region affected by workers in the metallurgy industry, in the activity of manufacturing machinery and equipment. The most prevalent risk factor in this population was repetitiveness, followed by physical effort, with an association between the risk factors for repetitiveness and physical effort and pain symptoms in the spinal region. This reinforces the need for interventions in the occupational environment, aiming at minimizing repetitive activity and excessive physical effort, seeking prevention and promotion in the health of the worker.

One of the limitations of the study was the incomplete electronic medical records by the Cerest team. Therefore, the importance of correct filling and digitalization of medical records is emphasized, facilitating the flow of information among the different professionals, as well as facilitate various forms of analysis. This allows the identification of the main affected regions and the risk factors present in the work environments, enabling the proposition of preventive measures.

Also, it was observed a low number of workers involved in the manufacturing of machinery and equipment in the metallurgy industry. However, all available records were evaluated. Thus, future studies with multicentric analyses are suggested to make the sample more representative.

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Author's Contributions

Sabrina Alves Petrini Lopes: preparation of the initial project, data collection, text design, organization of sources and/or analysis and writing of the text. Elisa Bizetti Pelai and Fabiana Almeida Foltran: text design, the organization of letter fonts and/or analysis and writing of the text. Delaine Rodrigues Bigaton: organization of source and text review. Rosana Macher Teodori: preparation of the initial project, writing and text review. All authors approved the final version of the text.

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