Musculoskeletal disorders among workers in plastic manufacturing plants

Distúrbios músculo-esqueléticos em trabalhadores da indústria de plásticos

Rita de Cássia Pereira Fernandes[I]
Ada Ávila Assunção[II]
Annibal Muniz Silvany Neto[I]
Fernando Martins Carvalho[I]

[I] Departamento de Medicina Preventiva e Social da Faculdade de Medicina da Universidade Federal da Bahia

[II] Departamento de Medicina Preventiva e Social da Faculdade de Medicina da Universidade Federal de Minas Gerais

Correspondência: Rita de Cássia Pereira Fernandes. Departamento de Medicina Preventiva e Social. Faculdade de Medicina da Universidade Federal da Bahia. Rua Machado Neto, 223 apto. 1403 – Pituba - Salvador, BA - CEP: 41.830-410. E-mail: ritafernandes@ufba.br

Abstract

Background: Epidemiological studies have indicated an association between musculoskeletal disorders (MSDs) and physical work demands. Psychosocial work demands have also been identified as possible risk factors, but findings have been inconsistent. **Objectives:** To evaluate factors associated with upper back, neck and upper limb MSD among workers from 14 plastic manufacturing companies located in the city of Salvador, Brazil. **Methods:** A cross-sectional study design was used to survey a stratified proportional random sample of 577 workers. Data were collected by questionnaire interviews. Factor analysis was carried out on 11 physical demands variables. Psychosocial work demands were measured by demand, control and social support questions. The role of socio-demographic factors, lifestyle and household tasks was also examined. Multiple logistic regression was used to identify factors related to upper back, neck and upper limb MSDs. **Results:** Results from multiple logistic regression showed that distal upper limb MSDs were related to manual handling, work repetitiveness, psychosocial demands, job dissatisfaction, and gender. Neck, shoulder or upper back MSDs were related to manual handling, work repetitiveness, psychosocial demands, job dissatisfaction, and physical unfitness. **Conclusions:** Reducing the prevalence of musculoskeletal disorders requires: improving the work environment, reducing biomechanical risk factors, and replanning work organization. Programs must also be aware of gender specificities related to MSDs.

Keywords: Ergonomics. Musculoskeletal disorders. Repetitive strain injury. Upper limb disorders. Psychosocial.

Resumo

Introdução: Estudos epidemiológicos têm indicado uma associação entre distúrbios músculo-esqueléticos (DME) e demandas físicas no trabalho. Demandas psicossociais no trabalho também têm sido identificadas como possíveis fatores de risco, mas os achados são inconsistentes. **Objetivos:** Avaliar fatores associados aos DME em região alta do dorso, pescoço e extremidades superiores entre trabalhadores de 14 fábricas de plástico na Região Metropolitana de Salvador, Brasil. **Métodos:** Estudo de corte transversal foi realizado para avaliar uma amostra aleatória estratificada proporcional de 577 trabalhadores, utilizando questionário administrado por entrevistador. Análises fatoriais foram realizadas com as 11 variáveis relacionadas a demandas físicas, resultando em dois fatores. Demandas psicossociais no trabalho foram medidas através de questões para demanda psicológica, controle e suporte social. A importância das variáveis sociodemográficas, de estilo de vida e trabalho doméstico também foi examinada. Regressão logística múltipla (RL) foi utilizada para identificar fatores relacionados com DME em região alta do dorso, pescoço e extremidades superiores. **Resultados:** Resultados da RL mostraram que DME em extremidades superiores distais estão relacionadas com manuseio de carga, repetitividade, demandas psicossociais, insatisfação no trabalho e ser do sexo feminino. DME na região alta do dorso e pescoço estão associados ao manuseio de carga, repetitividade, demandas psicossociais, insatisfação no trabalho e condicionamento físico precário. **Conclusões:** Reduzir a prevalência de DME requer medidas que reduzam as demandas físicas no trabalho e ao mesmo tempo promovam mudanças na organização do trabalho, visando a reduzir as demandas psicossociais. Os programas devem ser sensíveis a uma provável diferença de gênero na ocorrência de DME.

Palavras-chave: Ergonomia. Distúrbios músculo-esqueléticos. LER. DORT. Distúrbios ocupacionais de membros superiores. Fatores psicossociais no trabalho.

Introduction

Musculoskeletal disorders (MSDs) are an important public health problem in both developed and developing countries, with substantial impact on quality of life and a substantial economic burden in compensation costs, lost wages and productivity[1-3].

In Brazil, the most common occupational health problem is MSDs, according to data from The National Institute of Social Security[4]. Descriptive studies on MSDs among industrial populations have focused on workers that experience chronic pain and are on long-term paid sick leave due to temporary or permanent disability. Increasing the knowledge about active workers who exhibit MSDs symptoms provides the opportunity to assess potential risk factors and to implement control measures. This could prevent the development of incapacitating clinical conditions.

Epidemiological studies indicate an association between MSDs and physical demands at work[5-10]. Psychosocial demands have also been identified as possible risk factors for MSDs[11-16].

Non-occupational factors such as obesity, sports activities and gender have also been associated with MSDs, but the findings of previous studies have been inconsistent[17-20].

The aim of this study was to identify the factors associated with MSDs among workers who were employed in plastic manufacturing plants.

Methods

A cross-sectional study was conducted on a target population of all workers performing maintenance and operation activities in 14 plastic plants in the city of Salvador, Brazil. The plants were representative of factories in the Salvador Metropolitan Area. The decision to select companies from the plastics industry was based on the presence of epidemiological, technological and social considerations. Work processes in the plastics industry are associated with

repetitiveness, use of force, and a highly demanding work pace. Details on the type of work performed in those plants, types of work shifts and gender characteristics of the worker population were published elsewhere[21,22].

There were 1,177 eligible workers in 14 factories, the number of workers varying from factory to factory. A proportional and stratified random sample, comprising 577 subjects, was selected. In this sample, the number of workers was such that the proportional participation of workers from each plant did not change. The sample was calculated considering a degree of precision of 4.0%, a level of significance of 95.0%, an expected MSDs prevalence of 50.0%, and a design effect of 1.4.

Data were collected in the year 2002, by a pre-tested questionnaire administered by trained interviewers. The interviews took place within each participating company, during a work day, in a place set aside for this purpose.

Collected data included sociodemographic information, occupational history (including periods of formal and informal employment), daily and weekly working hours, physical demands of work, physical environment of the workplace, psychosocial demands of the work (Karasek, 1985[23,24]), tobacco use, medication use, alcohol consumption, housework, physical fitness, MSDs, and other health information (e.g. previous bone fractures, history of diabetes, rheumatoid arthritis or hypothyroidism). Physical fitness was assessed based on the workers' answers regarding the perception of their own (physical) fitness. The response scale had six ordinal descriptors (0 to 5), including two anchors at extreme levels (poor; excellent).

The questionnaire used in this study is a translation to Portuguese of the Nordic Musculoskeletal Questionnaire (NMQ)[7,25], with questions to evaluate the severity, duration and frequency of symptoms in all body areas. The Nordic Musculoskeletal Questionnaire is the most widely used survey tool to measure the prevalence of musculoskeletal disorders. Results showed a percentage of agreement higher than 80% in the test-retest method to evaluate reliability and in validity tests against clinical history [25,26]. In Brazil, results of a study by Pinheiro et al. (2002)[27] revealed an 86% agreement rate between symptoms reported in the NMQ and the respondent's clinical history.

The case definition of MSDs in distal upper limbs included reporting pain or discomfort (symptoms of pain, numbness, tingling, burning and swelling) in fingers, wrists, hands, forearms or elbows, with or without pain in other body areas, over the past twelve months of work that lasted at least one week or occurred at least once a month, and had not been caused by an acute injury, and in which one of following conditions applied: current symptom severity rating was 3 or greater (0 - 5 scale) or sought medical attention or lost time (official or unofficial) or changed to light or restricted work (official or unofficial) or changed jobs because of these problems. All workers who presented pain or discomfort in the neck and/or shoulder and/or upper back, with or without pain in other body segments, with the criteria mentioned above, were considered to be cases of MSDs of the neck, shoulder and upper back.

Physical demands of work were evaluated by means of workers' answers, on a scale ranging from 0 to 5 (regarding duration, frequency or intensity of physical work). Questions about repetitive movements with hands, force exerted with arms or hands, seated, standing or walking posture while working, arms raised above shoulder height, trunk inclined forwards and rotated, lifting loads, and contact pressure were selected for analysis.

Psychosocial aspects of work were measured by means of the Job Content Questionnaire (JCQ). The questions in the JCQ allowed scores for psychological demands, control or decision latitude and social support to be obtained. A psychosocial exposure variable was defined from these scores. Criteria for high exposure were high psychological demands, low control and

low support. Fulfillment of at least two of these criteria characterized high exposure to psychosocial demands. Low psychosocial exposure criteria were low psychological demands, high job control and high social support. At least two of these criteria for low psychosocial exposure had to be met in order to assign a subject in this group[14]. Questions from the JCQ[23] were also used to evaluate job dissatisfaction.

As the variables measuring physical demands of work could be related to each other, a matrix of Spearman correlations was analyzed. Following, a decision was made to reduce the 11 variables, using factor analysis[28].

Multivariate analysis was conducted by means of unconditional logistic regression (LR). Modeling started by preselecting independent variables based on the biological plausibility of associations and on univariate LR. Variables were selected using the backward stepwise method. The likelihood ratio test and 95% confidence intervals were used. In the LR diagnosis, the Hosmer-Lemeshow goodness-of-fit test and residual analysis were used[29].

Several authors cited by Hosmer and Lemeshow[29] strongly recommended the use of an alpha between 0.15 and 0.20 for removing variables in regression and discriminant analyses, and there are grounds for also applying it to LR analysis. However, the present authors chose to use a more conservative alpha, i.e. 0.05.

The study was approved by the Research Ethics Committee of the Institute of Public Health of the Federal University of Bahia.

Results

The study population comprised 577 workers, 31% were women. Sixty-three percent of workers worked shifts and 70% reported working overtime. The workers had a mean length of employment of 14.3 years in the formal or informal labor market. The mean number of hours worked per week was 43.9 hours (Table 1).

Table 2 shows the distribution of 11 physical work demand variables. Repetitive movements were frequent, especially among women. With regard to general body posture while working, almost all the work was performed while standing. The tasks of men were more dynamic and as consequence they had to adopt a walking posture more often. Men spent almost all their time at work walking, whereas women reported much less movement away from their work stations. Load-lifting activities were more frequently mentioned by men.

Women reported they had less control over their work, suffered greater psychological demands and received less social support than men. They also showed greater job dissatisfaction (Table 3).

Prevalence of distal limb MSDs (elbow, arm, wrist, hands or fingers) was 35% among female workers and 12% among male workers. For neck, shoulders or upper back MSDs, the prevalence was 27% and 18% among female and male workers, respectively.

Factor analysis produced two principal components of the original set of 11 physical exposure variables. In a decreasing order of the weights presented by each variable, these components were as follows: variable 1 characterized the physical demands relating to load handling and related tasks, and included load lifting, standing posture while working, muscular exertion using arms or hands, working with arms raised above shoulder level, working with trunk rotated, physical hand pressure on the work object, and inclined trunk. Variable 2 characterized repetitive physical demands and included static postures of the trunk while working with the hands in a seated posture. These variables were used as the physical demand variables in the LR analysis. Furthermore, the demands/control/support model variables, which are described separately in Table 3, constituted a single variable that measured psychosocial exposure in the LR, in accordance with criteria already described.

Tables 4 and 5 present the results from the multiple LR analysis. The goodness-of-

Table 1 - Sociodemographic and occupational variables, according to gender.
Tabela 1 *– Variáveis sociodemográficas e ocupacionais, segundo sexo*

Variables	Study population n=577 (%)	Female n=179 (%)	Male 398 (%)
Age (mean of years± sd)	31.5 ± 8.2	31.6 ± 8.4	31.4 ± 7.7
Marital status*			
Married or living together	350 (61)	91 (51)	259 (65)
Single or living alone	226 (39)	88 (49)	138 (35)
Education Level			
≥ 11 years	240 (42)	74 (41)	166 (42)
<11 years	337 (58)	105 (59)	232 (58)
Double working shift*			
Yes	66 (12)	17 (10)	49 (12)
No	510 (88)	161 (90)	349 (88)
Working hours schedule*			
Shift work	362 (63)	101 (56)	261 (66)
Regular	214 (37)	78 (44)	136 (34)
Exceeding hours of work *			
Yes	406 (71)	146 (82)	260 (66)
No	170 (29)	33 (18)	137 (35)
Hours of housework per week *			
≥20	101 (17)	78 (44)	23 (6)
< 20	476 (83)	101 (56)	375 (94)
Years of formal or informal jobs (mean ± sd)*	14.3 ± 8.8	12.4 ± 8.3	15.1 ± 8.9
Years of employment in current job (mean ± sd)*	3.8 ± 4.3	3.6 ± 3.9	3.9 ± 4.5
Hours of work (in last week) in current job (mean ± sd)*	43.9 ± 8.6	45.5 ± 7,7	43.1 ± 8.9
Hours of domestic work in the last week (mean ± sd)*	8.8 ± 10.0	17.1 ± 11.4	5.0 ± 6.8

*P < 0.05 (comparisons of means by analysis of variance and comparisons of proportions by chi square test) / *comparações de médias por análise de variância e comparações de proporções pelo teste chi-quadrado*

fit test and residual analyses showed that the final models were a good fit. The independent variables in the complete models were age, sex, schooling, and marital status; overtime, length of service in the company, number of years of work (including formal and informal jobs), job dissatisfaction, physical demands consisting of manual handling, physical demands consisting of repetition, psychosocial demands; use of alcoholic drinks, smoking, physical fitness, overweight/obesity, number of hours of housework per week.

Gender, psychosocial demands, and job dissatisfaction all showed significant associations with MSDs of the distal upper limbs (Table 4). There were two variables that presented borderline results (with intervals including the unit), Physical Demands with Repetitiveness, OR 1.62 (95% C.I. 0.97 – 2.70), and Physical Demands with Manual Handling, OR 1.56 (95% C.I. 0.95 – 2.58) (data not shown).

The OR of neck, shoulders and upper back MSDs was 2.96 when comparing workers who were exposed to physical work demands related to manual handling to those with less exposure to such demands. MSDs of the neck, shoulders and upper back were also significantly associated with repetitive physical demands, psychosocial demands, job dissatisfaction and poor physical fitness (Table 5).

Discussion

Results revealed that women had greater exposure to repetitive hand movements and

Table 2 - Physical (postures and movements) work demands.
Tabela 2 – Demandas físicas (posturas e movimentos) no trabalho.

Physical demands (0 – 5 points)	Study population	Female	Male
		(mean ± sd)	
Repetitive gesture** 0=never 5=very frequent	3.7 ±1.5	4.2±1.4	3.5±1.6
Force with the arms or hands 0=very weak 5=very strong	3.4 ±1.4	3.4±1.4	3.4±1.4
Sitting posture** 0=not at all 5=all the time	1.0±1.5	1.3±1.7	0.9±1.3
Standing posture** 0=not at all 5=all the time	4.2±1.3	4.0±1.5	4.3±1.1
Walking** 0=not at all 5=all the time	3.3±1.7	2.5±1.8	3.7±1.4
Arms above the height of the shoulders* 0=not at all 5=all the time	1.7±1.6	1.5±1.6	1.8±1.5
Repetitive movements with the hands** 0=not at all 5=all the time	4.1±1.3	4.5±1.0	3.9±1.4
Bent trunk** 0=not at all 5=all the time	2.7±1.7	3.0±1.8	2.5±1.6
Turned trunk** 0=not at all 5=all the time	2.5±1.8	2.8±1.9	2.3±1.8
Lifting weights** 0=not at all 5=all the time	2.4±1.7	1.8±1.8	2.6±1.6
Mechanical pressure with the hands on the object of work 0=very weak 5=very strong	3.0±1.4	3.1±1.5	3.0±1.4

*P < 0.05; **P < 0.001 (comparisons of means by analysis of variance) / *(comparações de médias por análise de variância)*.

Table 3 - Psychosocial work demands.
Tabela 3 – Demandas psicossociais no trabalho.

Psychosocial demands	Study population	Female	Male
		(mean ± sd)	
Job control**	62.7±9.1	64.7±8,6	58.0±8.5
Psychological demands**	30.4±4.9	30.0±4.8	31.4±4.9
Social support**	22.7±3.2	23.0±3.3	22.1±3.1
Job dissatisfaction*	0.25±0.23	0.23±0.22	0.28±0.24

*P < 0.05; **P < 0.001 (comparisons of means by analysis of variance) / *[comparações de médias por análise de variância]*
Range of values for Job control= 96 – 24; Psychological demands= 48 – 12; Social support= 32 - 8; Job dissatisfaction= 1 - 0
Limites de valores para controle de trabalho=96 – 24; Demandas psicológicas= 48 – 12; Suporte social= 32 - 8; Insatisfação com o trabalho= 1 - 0

working in a general body static posture (more standing than seated). Men's work was characterized by slightly more load lifting and a general body posture of dynamic work that implied walking more during the working day. These different patterns of exposure reflect the different tasks assigned to men and women at the workplace.

The prevalence of MSDs was higher among women, particularly for distal upper limbs (35% versus 12%). Considering that this prevalence is related to symptoms

Table 4 - Distal upper limb MSDs and related predictors.
Tabela 4 – DMEs de extremidades superiores distais e preditores relacionados.

Independent variables	Odds Ratio (95% Confidence Interval)
Gender (female=risk)	2.25 (1.27 – 4.00)
Psychosocial demands[a] (PD)	2.08 (1.20 – 2.62)
Job dissatisfaction[b] (JD)	1.83 (1.10 – 3.04)

[b c d] JD, PDR, PDMH: 0= low exposure (<median), 1=high exposure (>median) / *0= baixa exposição (<mediana), 1=alta exposição (>mediana)*

[a] PD: 0=high social support (>median) and high job control (>median) and high psychological demand (>median) or high social support and high job control and low psychological demand (<median) or high social support and low job control (<median) and low psychological demand or low social support (<median) and high job control and low psychological demand; 1= low social support and low job control and low psychological demand or low social support and low job control and high psychological demand or low social support and high job control and high psychological demand or high social support and low job control and high psychological demand.

[a] PD: 0=suporte social elevado (>mediana) e controle do trabalho elevado (>mediana) e demanda psicológica elevada (>mediana) ou suporte social e controle do trabalho elevados e demanda psicológica baixa (<mediana) ou suporte social elevado e controle do trabalho baixo (<mediana) e demanda psicológica baixa ou suporte social baixo (<mediana) e controle do trabalho elevado e demanda psicológica baixa; 1= suporte social baixo e controle do trabalho baixo e demanda psicológica baixa ou suporte social baixo e controle do trabalho baixo e demanda psicológica elevada ou suporte social baixo e controle do trabalho elevado e demanda psicológica elevada ou suporte social elevado e controle do trabalho baixo e demanda psicológica elevada.

Table 5 - Neck, shoulder and upper back MSDs and related predictors.
Tabela 5 – DMEs de pescoço, ombro e coluna alta e preditores relacionados.

Independent variable	Odds Ratio (95% Confidence Interval)
Physical Demands with Manual Handling [a] (PDMH)	
Physical Demands with Repetitiveness[b] (PDR)	2.96 (1.81– 4.85)
2.01 (1.25 – 3.24)	
Fitness (precarious=risk)	1.94 (1.21 – 3.13)
Psychosocial demands[c] (PD)	1.69 (1.02 – 2.79)
Job dissatisfaction[d] (JD)	1.68 (1.03 – 2.74)

[a b d] PDR, PDMH and JD: 0= low exposure (<median), 1=high exposure (>median) / *0= baixa exposição (<mediana), 1=alta exposição (>mediana)*

[c] PD: 0=high social support (>median) and high job control (>median) and high psychological demand (>median) or high social support and high job control and low psychological demand (<median) or high social support and low job control (<median) and low psychological demand or low social support (<median) and high job control and low psychological demand; 1= low social support and low job control and low psychological demand or low social support and low job control and high psychological demand or low social support and high job control and high psychological demand or high social support and low job control and high psychological demand.

[a] PD: 0=suporte social elevado (>mediana) e controle do trabalho elevado (>mediana) e demanda psicológica elevada (>mediana) ou suporte social e controle do trabalho elevados e demanda psicológica baixa (<mediana) ou suporte social elevado e controle do trabalho baixo (<mediana) e demanda psicológica baixa ou suporte social baixo (<mediana) e controle do trabalho elevado e demanda psicológica baixa; 1= suporte social baixo e controle do trabalho baixo e demanda psicológica baixa ou suporte social baixo e controle do trabalho baixo e demanda psicológica elevada ou suporte social baixo e controle do trabalho elevado e demanda psicológica elevada ou suporte social elevado e controle do trabalho baixo e demanda psicológica elevada.

that had lasted for at least one week or had occurred at least once a month over the preceding twelve months, among workers who were actively engaged in work, we can conclude that there is significant morbidity among this population.

Psychosocial work demands were positively associated with MSDs in both body areas studied. Physical work demands were associated with neck, shoulder and upper back MSDs. Moreover, among non-occupational variables, an association was found between neck, shoulder and upper back MSDs and poor physical fitness as well as between distal upper limb MSDs and females.

The findings of greater morbidity in distal upper limbs of women are independent of the degree of job dissatisfaction and of psychosocial demands, for which the results were adjusted. Furthermore, neither physical demands at work nor housework explained this greater morbidity among women. Biological differences mediated by hormonal factors relating to the female reproductive system have already been mentioned as one of the possible explanations for greater morbidity among women[30,31]. Another explanation could be that women report symptoms more readily. However, such results have been inconsistent, with differences in the accuracy of responses from women in these studies[32]. Certainly, there are other explanations for gender differences in MSD occurrence[33]. Different tasks and working styles are some of them.

Psychosocial demands were found to be positively associated with MSDs. This result is compatible with reviews on this topic[13,19,25]. In some studies, job dissatisfaction has been associated with MSDs in the lumbar region, but few positive results associating job dissatisfaction with MSD of the upper limb have been found [1,12,13]. The study reveals a higher probability of distal upper limb MSDs among workers who were more dissatisfied at work, when compared to workers who were less dissatisfied. However, considering the study design, dismissing the idea of reverse causality is not possible.

Regarding neck, shoulder and upper back MSDs, there was a greater probability of their occurrence among workers who were more exposed to physical demands related to manual handling than among those who were less exposed. These demands incorporated not only load lifting but also the variables WORKING WITH ARMS ABOVE SHOULDER LEVEL and MUSCULAR EXERTION WITH ARMS AND HANDS, which have had both been cited in the literature as associated with shoulder and neck region MSDs. The probability of neck, shoulder and upper back MSDs was also greater among workers who were more exposed to repetitive physical demands, more exposed to psychosocial demands and more dissatisfied with work. Gender, housework and number of years of work were not predictors for MSDs in this body area.

The odds ratio of neck, shoulder and upper back MSDs was greater among workers who perceived they had poor physical fitness than among those who felt they were fitter. There is no consensus regarding the role of physical fitness in preventing MSDs [1,34]. Muscle strength training and physical exercise may prevent neck, shoulder and upper back MSDs among workers who are exposed to tasks that require high levels of muscular exertion. The difficulties of isolating the effect of physical exercise programs carried out at the workplace are a consequence of the fact that such programs often occur simultaneously with other non-controlled changes in work organization. These scenarios may limit the assessment of the role of physical exercise programs on MSDs[34].

The findings suggest that reducing neck, shoulder and upper back MSDs and reducing distal upper limb MSDs in workplaces require appropriate measures aimed at making the physical environment more suitable, with regard to equipment, machinery, tools and furniture, in order to reduce repetitiveness, the use of force and manual handling. They also suggest that organizational modifications should be made in order to reduce psychological demands, extend the degree of control workers have over their work and increase social support. These programs must also consider probable gender differences on occurrence of distal upper limb MSDs.

References

1. National Research Council & Institute of Medicine [NRC & IM]. *Musculoskeletal disorders and the workplace: low back and upper limbs.* Panel on musculoskeletal disorders and the workplace. Commission on behavioural and social sciences and education. Washington, DC: National Academy Press; 2001.

2. Punnet L, WEGMAN DH. Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *J Electromyogr Kinesiol* 2004; 14:13-23.

3. EASHW - European Agency for Safety and Health at Work. *Work-related musculoskeletal disorders: Back to work report.* Office for Official Publications of the European Communities. Luxemburg; 2008.

4. CESAT - Núcleo de Estudos e Análise em Saúde do Trabalhador/CESAT/SUS – Bahia; 2009. *Situação de saúde do trabalhador no Brasil e na Bahia – Perfil epidemiológico*. Available at http://www.saude.ba.gov.br/cesat/Informacoes/SituacaoST_2007.pdf. [Access on November 26, 2009.]

5. Buckle PW, Devereux JJ. The nature of work-related neck and upper limb musculoskeletal disorders. *Appl Ergon* 2002; 33: 207-17.

6. Bernard BP. *Musculoskeletal disorders and workplace factors: a critical review of epidemiologic evidence for work related musculoskeletal disorders of the neck, upper extremity, and low back*. NIOSH Publication Nº 97-141, DHHS: Cincinnati; 1997.

7. Kuorinka I, Forcier L. (sci. ed.) *Work related musculoskeletal disorders (WMSDs): a reference book for prevention*. Taylor & Francis; 1995.

8. Stocks S. Workplace Ergonomic Factors and the Development of Musculoskeletal Disorders of the Neck and Upper Limbs: A Meta-Analysis. *Am J Ind Med* 1991; 19: 87-107.

9. Hagberg M, Wegman DH. Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups. *Br J Ind Med* 1987; 44: 602-10.

10. Miranda H, Punnett L, Viikari-Juntura E, Heliövara M, Knekt P. Physical work and chronic shoulder disorder. Results of a prospective population-based study. *Ann Rheum Dis* 2008, 67(2): 218-23.

11. Huang GD, Feuerstein M, Kop WJ, Schor K, Arroyo F. Individual and combined impacts of biomechanical and work organization factors in work-related musculoskeletal symptoms. Am *J Ind Med* 2003; 43: 495-506.

12. Bongers PM, Kremer AM, ter Laak J. Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist? A review of the epidemiological literature. *Am J Ind Med* 2002; 41: 315-42.

13. Huang GD, Feuerstein M, Sauter SL. Occupational stress and work-related upper extremity disorders: concepts and models. *Am J Ind Med* 2002; 41: 298-314.

14. Devereux JJ, Vlachonikolis IG, Buckle PW. Epidemiological study to investigate potential interaction between physical and psychosocial factors at work that may increase the risk of symptoms of musculoskeletal disorder of the neck and upper limb. *Occup Environ Med* 2002; 59: 269-77.

15. Bongers PM et al. Psychosocial factors at work and musculoskeletal disease. *Scand J Work Environ Health* 1993; 19(5): 297-312.

16. Bongers PM, Ijmker S, van den Heuvel S, Blatter BM. Epidemiology of work related neck and upper limb problems: psychosocial and personal risk factors (part I) and effective interventions from a bio behavioural perspective (part II). *J Occup Rehab* 2006; 16(3): 279-302.

17. Buckle PW. Work factors and upper limb disorders. *Br Med J* 1997; 315 (22): 1360-3.

18. De Zwart Bch, Frings-Dresen MHW, Kilbom A. Gender differences in upper extremity musculoskeletal complaints in the working population. *Int Arch Occup Environ Health* 2001; 74: 21-30.

19. Silverstein BA, Fine LJ, Armstrong TJ. Hand wrist cumulative trauma disorders in industry. *Br J Ind Med* 1986; 43: 779-84.

20. Silverstein BA, Fine LJ, Armstrong TJ. Occupational Factors and Carpal Tunnel Syndrome. *Am J Ind Med* 1987; 11: 343-58.

21. Fernandes RCP, Assunção AA, Carvalho FM (2007). *Mudanças nas formas de produção na indústria e a saúde dos trabalhadores* (Changes in the forms of industrial production and their effects on workers´ health). Rev C S Col. Available at http://www.cienciaesaudecoletiva. com.br.

22. Fernandes RCP, Assunção AA, Carvalho FM (2007). *Tarefas repetitivas sob pressão temporal: os distúrbios músculo-esqueléticos e o trabalho industrial.* (Repetitive tasks under time pressure: the musculoskeletal disorders and the industrial work). Rev C S Col. Available at http://www.cienciaesaudecoletiva.com.br.

23. Karasek R. *Job Content Instrument: Questionnaire and User's guide*. Massachusetts: University of Massachusetts. Amherst; 1985.

24. Araújo TM, Karasek, R. Validity and reliability of the job content questionnaire in formal and informal jobs in Brazil. *Scand J Work Environ Health Suppl* 2008; (6): 52-9.

25. Kuorinka I, Johnsson B, Kilbom A, et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon* 1987; 18 (3): 233-7.

26. Baron S, Hales T, Hurrel J. Evaluation of symptom surveys for occupational musculoskeletal disorders. *Am J Ind Med* 1996; 29: 609-17.

27. Pinheiro FA, Tróccoli BT, Carvalho CV. Validação do Questionário Nórdico de Sintomas Osteomusculares como medida de morbidade. *Rev Saúde Pública* 2002; 36 (3).

28. Kleinbaum DG, Kupper LL, Muller KE. *Applied regression analysis and other multivariable methods.* PWS-KENT, Boston; 1988.

29. Hosmer DW, Lemeshow S. *Applied logistic regression*. Wiley – Interscience: New York; 2000.

30. Kelsh MA, Sahl JD. Sex differences in work-related injury rates among electric utility workers. *Am J Epidemiol* 1996; 143: 1050-8.

31. Kilbom A, Messing K (eds.). *Women's health at work*. National Institute of Working Life. Solna; 1998.

32. Gusbers Van Wijk CMT, Kolk AM. Sex differences in physical symptoms: the contribution of symptom perception theory. *Soc Sci Med* 1997; 45(2): 231-46.

33. Strazdius L, Bammer G. Women, work and musculoskeletal health. *Soc Sci & Med* 2004; 58: 997-1005.

34. Silverstein BA, Armstrong TJ, Longmate A, Woody D. Can in-plant exercise control musculoskeletal symptoms? J Occup Med 1988; 30(12).

Recebido em: 15/05/09
Versão final reapresentada em: 22/12/09
Aprovado em: 20/01/10