Risk of WMSDs in monofunctional and multifunctional workers in a Brazilian footwear company

Wilza Karla dos Santos Leite[a]*, Luiz Bueno da Silva[a], Erivaldo Lopes de Souza[a], José Guilherme Barbosa Fernandes[a], Geraldo Alves Colaço[b]

[a]Universidade Federal da Paraíba, João Pessoa, PB, Brazil

[b]Universidade de Santo Amaro, São Paulo, SP, Brazil

*wilzakarlas@yahoo.com.br

Abstract

This study aimed to analyze the risk of musculoskeletal disorders in monofunctional and multifunctional workers in a footwear company. The sample comprised 114 workers in the shoe production sector. The method Occupational Repetitive Actions was used to assess the risk of work-related musculoskeletal disorders (WMSDs). Proportional odds models were constructed, relating the risk of WMSDs to the type of work and the worker's level of multifunctionality. For monofunctional workers, exposure to the higher risk was related to cycle time and the technical actions within their activities, whereas for multifunctional workers, it was related to the range of motion, use of gloves and precision needed in activities. For monofunctional workers, greater risks were associated with a short activity cycle, whereas for multifunctional workers, they were associated with complementary and organizational factors. Moreover, workers whose intracellular activities were less than 30% of the total appeared to be less exposed to the risk of WMSDs.

Keywords

Footwear industry. Monofunctional. Multifunctional. WMSDs.

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1. Introduction

Risk refers to the probability of a serious or harmful event occurring that results in the accident or injury and that relates to the level and time of exposure to which the worker is subjected. Risk can also occur in combined form, increasing the probability of occurrence of the event (Jaffar et al., 2011). Therefore, assessing work-related risk is part of health and safety management process, both when targeting immediate action and when being proactive (Mahdevari et al., 2014). Around 1700, the Italian physician Bernardino Ramazzini already affirmed that exposure to risks from work was the cause of many diseases – and today it's called work-related musculoskeletal disorders (WMSDs) – in several professions, among them, that of producers of footwear (Franco & Fusetti, 2004). In Brazil, studies on WMSDs were intensified with the restructuring of productive processes, which led to changes in the organization and management of work (Chiavegato Filho & Pereira Júnior, 2004).

Multiple risk factors – physical, mechanical, psychosocial, organizational and individual – are associated with the WMSDs (Yu et al., 2012; Koukoulaki, 2014), and the etiology of these disorders is therefore complex (Pontonnier et al., 2014). The effect on the musculoskeletal system results from the sum of these factors and the length of time exposed to the risk (Roman-Liu, 2013), which is exacerbated in the event of more than one of these factors occurring (Niu, 2010). In fact, Widanarko et al. (2014) conducted a study to assess the impact of physical, psychosocial, organizational and environmental factors on the occurrence of symptoms linked to WMSDs and their work-related consequences. The authors concluded that a reduction in symptoms related to WMSDs and the consequences thereof are associated with a combination of physical, psychosocial, organizational and environmental risks.

Ergonomic risk is prominent among the risk factors for WMSDs and occurs when there is an imbalance between the work and the individual (Niu, 2010; Luz et al., 2013). The main risk factors relating to ergonomics include repetitiveness, use of force, exposure to vibration, awkward postures, contact stress, extreme temperatures and static overload (Jaffar et al., 2011). In addition, experimental and epidemiological studies include increased work pace, lack of recovery periods, physical overload, anatomical compression and a demand for the large joint range of motion (Hansson et al., 2010; De Magistris et al., 2013). Thus, by virtue of the characteristics of activity and the nature of the tools used, a particular type of work may require a capacity beyond the performance threshold and ability of the musculoskeletal system, contributing to the occurrence of WMSDs (Gallagher, 2005; Oakman et al., 2014), which reduce working capacity and increase additional medical costs (Halim et al., 2014).

Specifically, workers in the footwear industry are subject to a significant risk of developing WMSDs due to the characteristics of the activities performed (Roquelaure et al., 2002). In this regard, Dianat & Salimi (2014), in a study with 180 workers in the footwear industry in Iran, analyzed WMSD risk levels, the frequency and severity of musculoskeletal symptoms and the association between these symptoms and demographic and work factors. Rapid Upper Limb assessment (RULA) was used to assess the positions adopted when performing activities. It was found that work experience, daily working hours, continuous working hours without breaks, feeling pressure from work and postures employed for the execution of activities, along with age, educational level and marital status, were significant factors in the occurrence of musculoskeletal symptoms, the prevalence and severity of which were high in the neck, shoulder, back and knees. The researchers concluded that related risk factors, especially work organization and posture, were prevalent in the development of musculoskeletal symptoms, thus providing evidence of the need for ergonomic interventions in the analyzed workplaces and the introduction of preventive measures in health and safety domain.

To minimize the risk of WMSDs, shoe manufacturing companies have adopted principles based on multifunctionality and have introduced job rotation (Guimarães et al., 2012), hoping to ensure a balance between health, performance and labor requirements (Seçkiner & Kurt, 2007). Job rotation is a form of WMSD control based on the workload and the characteristics of each activity. It can significantly reduce monotony and repetitiveness and is an economical and effective strategy when compared to other types of implementation (Huang & Pan, 2014; Yoon et al., 2016).

In a job rotation system, each employee or team is responsible for an activity in a given time interval and then for a different activity, and so on (Michalos et al., 2011). According to Seçkiner & Kurt (2007), assignments are typically scheduled for combinatorial optimization and, according to Michalos et al. (2011), are organized into a format that permits the maintenance of a production rhythm. By alternating between physical demands, job rotation decreases exposure to risk and, as a result, the occurrence of injuries (Howarth et al., 2009). This is due to the use of different muscle groups, alternating periods of work and recovery (Jaffar et al., 2011). Furthermore, job rotation improves the overview of the process, conferring versatility and thus recognition of the company and its attractiveness in the labor market (Guimarães et al., 2012).

However, exposure to risk factors for WMSDs can become increasingly complex when workers perform tasks with varied loads and demands, and studies that address this complexity are necessary (Sato & Coury, 2009). The repercussions of job rotation on the musculoskeletal system and on the incidence of WMSDs are not yet sufficiently clear (Keir et al., 2011; Leider et al., 2015). Thus, this article aims to analyze the ergonomic risk for WMSDs in monofunctional and multifunctional workers who perform job rotation in production cells of a footwear company.

2. Mathematical modeling

2.1. Risk of WMSDs according to type of work performed

In Equations 1 and 2, β_{01}, β_{02} and β_1 are parameters estimated to obtain a probability measure according to the type of work performed – monofunctional or multifunctional, specified by the variable *M*. Thus, $M = 0$ is equivalent to monofunctional work, and $M = 1$ is equivalent to multifunctional work. Moreover, 'OCRA 1' corresponds to the first WMSD risk level, where the risk is considered acceptable; 'OCRA 2' corresponds to the second WMSD risk level, where the risk is very low; and 'OCRA 3' corresponds to the third WMSD risk level, where there is a potential risk of the occurrence of such disorders. Thus, Equations 1 and 2 represent the accumulated probabilities of different levels of WMSD risk.

$$p2 = P(FxOCRA \geq 2) = \frac{1}{1+e^{-(\beta_{01}+\beta_1 M)}} \quad (1)$$

$$p3 = P(FxOCRA \geq 3) = \frac{1}{1+e^{-(\beta_{02}+\beta_1 M)}} \quad (2)$$

Probability levels were determined by Equations 3, 4 and 5.

$$P(FxOCRA = 3) = P(FxOCRA \geq 3) \quad (3)$$

$$P(FxOCRA = 2) = P(FxOCRA \geq 2) \; - P(FxOCRA \geq 3) \quad (4)$$

$$P(FxOCRA = 1) = 1 - P(FxOCRA \geq 2) \quad (5)$$

Moreover, those equations can be represented by Equations 6 and 7, where $e\beta_1$ expresses the odds ratio (OR) relating to the type of work performed. Therefore, the OR indicates how many times a multifunctional worker has a chance of being at a higher WMSD risk level but inferior to the risk relating to the monofunctional worker.

$$\frac{P(Fx\_OCRA \geq 2)}{P(Fx\_OCRA < 2)} = e^{\beta_{01}+\beta_1 M} = e^{\beta_{01}} * \left(e^{\beta_1}\right)^M \quad (6)$$

$$\frac{P(Fx\_OCRA \geq 3)}{P(Fx\_OCRA < 3)} = e^{\beta_{02}+\beta_1 M} = e^{\beta_{02}} * \left(e^{\beta_1}\right)^M \quad (7)$$

Thus, the proportional odds model relating the WMSD risk level to the type of work allows us to estimate the probabilities of occurrence of each risk category contained in the OCRA method according to the type of work, whether monofunctional or multifunctional.

2.2. WMSD risk according to multifunctionality levels

Starting from the principle that the worker is multifunctional and considering that there are four levels of multifunctionality, it was necessary to build a model to establish how this relationship varies according to different levels of multifunctionality.

First, Equations 8 and 9 explain the probabilities of occurrence of the risk ranges for each of four levels. These equations were specified after estimating parameters β_{01}, β_{02}, β_1, β_2, β_3 and β_4. Variables L_1, L_2, L_3 and L_4 specify, respectively, the 1st, 2nd, 3rd and 4th levels of multifunctionality, for which the probability measures were sought. Considering that *j* corresponds to a given level of multifunctionality, $L_j = 0$ was attributed to workers who did not have a given level *j* of multifunctionality and $L_j = 1$ for workers who were allocated to the 1st, 2nd, 3rd or 4th the level of multifunctionality. Thus:

$$p2 = P(FxOCRA \geq 2) = \frac{1}{1+e^{-(\beta_{01}+\beta_1 L_1+\beta_2 L_2+\beta_3 L_3+\beta_4 L_4)}} \quad (8)$$

$$p3 = P(FxOCRA \geq 3) = \frac{1}{1+e^{-(\beta_{02}+\beta_1 L_1+\beta_2 L_2+\beta_3 L_3+\beta_4 L_4)}} \quad (9)$$

The same procedure used to write Equations 3, 4 and 5 from Equations 1 and 2 may be used to rewrite Equations 8 and 9 in the form of Equations 10, 11 and 12. These equations specify the probability of occurrence of each of the WMSD risk groups, indicating a multifunctionality level.

$$P(FxOCRA = 3) = \frac{1}{1+e^{-(\beta_{02}+\beta_1 L_1+\beta_2 L_2+\beta_3 L_3+\beta_4 L_4)}} \quad (10)$$

$$P(FxOCRA = 2) = \frac{1}{1+e^{-(\beta_{01}+\beta_1 L_1+\beta_2 L_2+\beta_3 L_3+\beta_4 L_4)}} - \frac{1}{1+e^{-(\beta_{02}+\beta_1 L_1+\beta_2 L_2+\beta_3 L_3+\beta_4 L_4)}} \quad (11)$$

$$P(FxOCRA=1)=1-\frac{1}{1+e^{-(\beta_{01}+\beta_1L_1+\beta_2L_2+\beta_3L_3+\beta_4L_4)}} \tag{12}$$

Thus, from Equations 10, 11 and 12, it is possible to construct Table 1, which corresponds to the estimated probabilities of the occurrence of a WMSD risk range for each multifunctionality level.

Table 1. Estimated probability measures for the WMSDs* risk levels at each multifunctionality level.

Risk level	Multifunctionality level			
	1	2	3	4
Acceptable	P_{11}	P_{12}	P_{13}	P_{14}
Very low	P_{21}	P_{22}	P_{23}	P_{24}
Risk	P_{31}	P_{32}	P_{33}	P_{34}

Source: Research data (2016). *Work-related musculoskeletal disorders.

3. Materials and methods

3.1. Company analyzed

The unit analyzed is located in northeastern Brazil and is responsible for the manufacturing of shoes for men and women of six of eight brands produced by the company. It has 2,300 employees, with approximately two thirds of this total being allocated to the shoe production sector and one third performing administrative and production support activities. The production sector has three plants: Plant I for the preparation of shoe components; Plant II, in which the shoe components are assembled; and Plant III for activities relating to shoe quality.

3.2. Sample selection

For the sample selection it was first necessary to identify and select the shoe production cells performing job rotation and those in which such rotation was not performed. For this purpose, the production leaders of each cell were interviewed using a checklist to discriminate between the types of work allocated and the rotation of tasks.

After identification of the cells, the following criteria were adopted: (1) for the assessment of monofunctional workers, only cells not performing task rotation were included; (2) for the assessment of multifunctional workers, only cells with task rotation implemented by the ergonomics' team and that performed such rotation every one or two hours were included; and (3) only monofunctional and multifunctional workers who performed the same or very similar functions in all the cells established by criteria 1 and 2 were assessed.

In regard to multifunctional workers, this study did not restrict the level of multi-functionality to which they were allocated and thus included workers belonging to four levels: the 1st level - workers at an early stage of multifunctional training, performing up to 30% of all activities contained in a cell unit; 2nd level - workers who had the knowledge and ability to perform 31-70% of all activities contained in a cell unit; the 3rd level - workers with partial efficiency to perform 71-90% of activities that make up a cell unit; and 4th level - workers with total efficiency to perform 91-100% of all activities contained in a cell unit. These multifunctionality levels (1st, 2nd, 3rd, and 4th) were defined as L_1, L_2, L_3 and L_4, respectively.

Thus, 114 workers of both genders, at least 18 years of age and performing the same or similar functions within the set of activities carried out in the shoe component preparation and assembly plants were selected (57 monofunctional and 57 multifunctional).

3.3. Data collection

To obtain the data, face-to-face individual interviews were performed with each cell unit production leader and with the monofunctional and multifunctional workers, who were also assessed for muscle/joint pain related to the performance of activities.

After the interviews, selected activities were filmed. To minimize variability, at least four complete work cycles were filmed from the front, back and side (left and right) views, in which the upper limbs and trunk were emphasized. A semiprofessional Fujifilm camera with 14-megapixel resolution was used for filming.

3.4. Assessment of muscle/joint pain

The Corlett and Manenica Diagram was used to identify the body segments affected by muscle/joint pain in both monofunctional and multifunctional workers. The dorsal regions (neck, upper back, middle back and lower back), upper limbs (shoulders, arms, elbows, forearms, wrists and hands) and lower limbs (hips, thighs, knees, legs and feet) were considered separately according to the body half (right or left), except for the cervical region.

3.5. Risk assessment for WMSDs

The method Occupational Repetitive Actions (OCRA) was used to assess the risk of WMSDs. To calculate the OCRA exposure index for each activity, the daily production target of each corresponding production cell and the number of workers who would perform the same activity within the specific cell unit were considered.

Factors relating to the joint range of motion (shoulders, elbows, wrists and fingers), complementary factors (precision, vibration, compression, impact, the sudden movement, temperature, use of gloves and nature of the surface), repetitiveness and use of force were considered. The risk level classification is shown in the Table 2.

Table 2. OCRA classification of risk of WMSDs*.

OCRA	Risk level
Until 2.2	Acceptable risk
2.3-3.5	Very low risk
3.6-4.5	Slight risk
4.6-9.0	Medium risk
≥9.1	High risk

Source: Adapted from Colombini et al. (2008). *Work-related musculoskeletal disorders.

3.6. Statistical analysis

R-Project software (version 3.2.1) was used to perform the statistical calculations. Fisher's exact test (α = 5%) was used to check for significant differences between monofunctional and multifunctional workers in regard to the individual, work and health variables. According Kvam & Vidakovic (2007), Fisher's exact test is used when you have two nominal variables and it's an important contribution new method for analyzing categorical data when the expected numbers are small.

According Dobson & Barnett (2008), "[...] for ordinal logistic regression, one of the measured or observed categorical variables is regarded as the response, and all other variables are explanatory variables". Thus, multinomial logistic regression models were then constructed to estimate the probabilities of risk for WMSDs, categorized by OCRA, according to the type of work performed and the worker's multifunctionality level. Two proportional odds models were therefore constructed: (1) relating the WMSD risk level to monofunctionality and (2) relating the WMSD risk level to the workers' multifunctionality level. It's, therefore, a stochastic model based on categories of responses.

The dependent variables related to the risk level ranges contemplated by OCRA, with (1) an acceptable risk being an index of up to 2.2, (2) a very low risk being an OCRA index ranging between 2.3 and 3.5 and (3) a potential WMSD risk being an OCRA index equal to or greater than 3.6. The independent variables in the first model related to the type of work performed - monofunctional or multifunctional. In the second model, they related to the four levels of worker multifunctionality - L_1, L_2, L_3 and L_4 - which corresponded to the 1st, 2nd, 3rd and 4th levels, respectively.

3.7. Ethical aspects

This study was approved by the Research Ethics Committee of the Health Sciences Center, Federal University of Paraíba, under CAAE number 46884715.7.0000.5188.

4. Results

4.1. Work in shoe production

The production plants are made up of different types of employees, namely supervisors, production leaders, monofunctional workers and multifunctional workers. Each sector is managed by a supervisor who is responsible for its organization and operation. Each cell unit is managed by a leader who is fully efficient, that is, is able to plan, execute and control the work of the entire production cell. The work of each cell unit is performed by workers who may perform one or more functions within a given production cell.

The analyzed industrial unit is responsible for manufacturing of the footwear for men and women. This currently corresponds to 24,000 pairs of shoes per day. The products are detailed in Table 3.

Table 3. Footwear produced in the plant analyzed according to the category: sports, professional or casual.

Brand	The type of shoes
A	Running, soccer, volleyball and handball.
B	Tennis, running, training, soccer, basketball, outdoor and casual.
C	Training (tech and gym) and casual (retro and trend).
D	Professional line of safety boots for the manufacturing sectors.
E	Casual boots, adventure boots, casual sneakers, adventure sneakers, sandals and shoes.
F	Rubber sandals.

Source: Research data (2016).

4.2. Study participants

In total, 178 footwear company employees were interviewed, including 1 doctor, 63 footwear production leaders and 114 workers from the preparation and assembly plants. Of these 114, 57 workers were monofunctional, i.e., they performed only one function within one footwear production cell unit; 57 workers were multifunctional, performing two or more different functions in the same cell unit.

Of the monofunctional workers, 29.8% were allocated to the 1st production shift and 70.2% to the 2nd shift. Most were male (64.9%), had completed secondary education (87.7%) and had a mean age of 31.1 (±8.3). Regarding multifunctional workers, 77.2% were allocated to the 1st production shift and 22.8% to the 2nd shift. Most of these workers were male (63.2%), had completed secondary education (84.2%) and had a mean age of 27 (±5.9). These general characteristics are detailed in the Table 4.

Table 4 shows that no significant differences were observed between monofunctional and multifunctional workers regarding the variables 'gender' ($p=0.5563>0.05$) and 'education' ($p=0.6189>0.05$). However, differences were identified for the 'age' variable ($p=0.0038<0.01$), with 35.1% of the monofunctional workers interviewed being 36 or over as opposed to 8.8% of the multifunctional workers.

The majority of monofunctional workers interviewed had worked in the company for more than three years and less than or equal to six years (33.3%), and 29.8% had worked in the sector for between three and six years. Regarding time in the function, most workers had been in the same function for one to three years.

Regarding the multifunctional workers, most had worked in the company between one and three years (43.9%), and 35.1% had worked in the sector between one and three years. Regarding time in the function, the majority had performed the same combination of functions for a maximum of six months (36.8%). However, 31.6% had performed the same combination of functions for a period of one to three years. Table 5 shows in detail the length of service of the monofunctional and multifunctional workers interviewed.

Table 4. General characteristics of the monofunctional (MN) and multifunctional (MT) workers.

Variables	MN n (%)	MT n (%)	p
Gender			0.5563
Male	37 (64.9)	36 (63.2)	
Female	20 (35.1)	21 (36.8)	
Age (years)			**0.0038**
18 to 20	5 (8.8)	11 (19.3)	
21 to 25	13 (22.8)	15 (26.3)	
26 to 30	13 (22.8)	12 (21.1)	
31 to 35	6 (10.5)	14 (24.5)	
36 to 40	12 (21.1)	5 (8.8)	
Over 40	8 (14)	0 (0)	
Education			0.6189
Incomplete primary	0 (0)	1 (1.8)	
Complete primary	3 (5.3)	4 (7)	
Incomplete secondary	3 (5.3)	2 (3.5)	
Complete secondary	50 (87.7)	48 (84.2)	
Incomplete higher	1 (1.8)	2 (3.5)	
Complete higher	0 (0)	0 (0)	

Source: Research data (2016).

Table 5. Length of service in the company, in the sector and in the function of monofunctional (MN) and multifunctional (MT) workers.

Variables	MN n (%)	MT n (%)	p
Time in company			**0.0236**
Up to 6 months	5 (8.8)	11 (19.3)	
6 months –| 1 year	1 (1.8)	0 (0)	
1 year –| 3 years	14 (24.6)	25 (43.9)	
3 years –| 6 years	19 (33.3)	11 (19.3)	
6 years –| 9 years	8 (14)	7 (12.3)	
9 years –	10 (17.5)	3 (5.3)	
Time in the sector			0.0788
Up to 6 months	9 (15.8)	16 (28.1)	
6 months –| 1 year	6 (10.5)	6 (10.5)	
1 year –| 3 years	15 (26.3)	20 (35.1)	
3 years –| 6 years	17 (29.8)	11 (19.3)	
6 years –| 9 years	2 (3.5)	3 (5.3)	
9 years –	8 (14)	1 (1.8)	
Time in function/functions			0.0640
Up to 6 months	12 (21.1)	21 (36.8)	
6 months –| 1 year	9 (15.8)	5 (8.8)	
1 year –| 3 years	17 (29.8)	18 (31.6)	
3 years –| 6 years	14 (24.6)	9 (15.8)	
6 years –| 9 years	1 (1.8)	4 (7)	
9 years –	4 (7)	0 (0)	

Source: Research data (2016).

According to Table 5, there were no differences with regard to 'length of time in the sector' (p=0.0788> 0.05) and 'time in function/functions' (p=0.0640>0.05) between monofunctional and multifunctional workers. However, 'length of time in the company' showed a significant difference (p=0.0236 <0.05); 33.3% of monofunctional workers had worked in the company for a period greater than three years and less than or equal to six years, whereas 43.9% of multifunctional workers had worked for a period greater than one year and less than or equal to three years. This fact is intertwined with the recent introduction of a multifunctional work perspective in the company, which had the work organization strictly based on monofunctionality.

4.3. Assessment of muscle/joint pain

Of 57 monofunctional workers, 49.1% had already experienced work-related health problems. Of these, 75% had impaired musculoskeletal systems. As for 57 multifunctional workers, 21.1% had already experienced work-related health problems. Of these, 58.3% had impaired musculoskeletal systems. In Figure 1, the gray areas represent the body segments most affected in the dorsal region, upper limbs and lower limbs, according to the workers. For both monofunctionals and multifunctionals, the right shoulder and the left foot were the most affected segments in the upper and lower limbs, respectively. The segment most affected in the dorsal region was the lower back for the monofunctionals and the upper back for the multifunctionals.

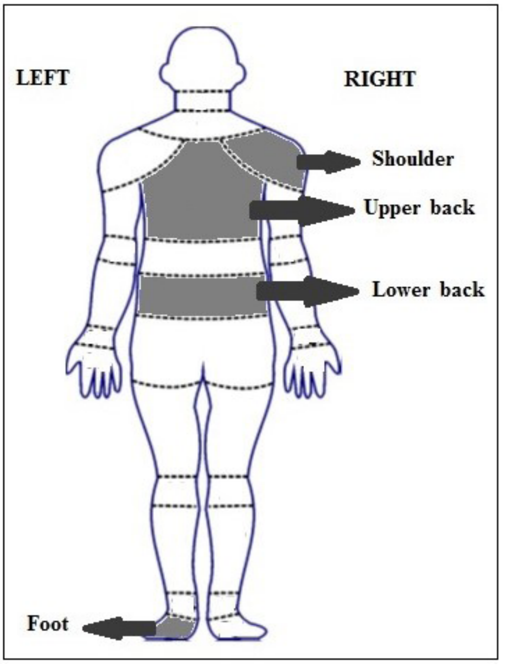

Figure 1. Body areas most affected by musculoskeletal pain, according to workers. Source: Research data (2016).

Table 6 shows the percentage of workers with muscle/joint pain in the dorsal region, upper limbs and lower limbs. For the monofunctional workers, the most affected body regions were the left and right lower back, with 22.8% each, the right shoulder (47.4%) and the left foot (52.6%). With regard to the multifunctional workers, the areas covering the upper left and right back were the most impaired, with 26.3% each, along with the right shoulder (40.4%) and left foot (22.8%).

Significant differences were found between monofunctional and multifunctional workers regarding the occurrence of muscle/joint pain in the 'cervical spine' ($p=0.0155<0.05$), 'left foot' ($p=0.0018<0.01$) and 'right foot' ($p=0.0016<0.01$). Such differences refer to the fact that compared to the multifunctional workers, the monofunctional workers presented more complaints in the cervical spine and foot areas (left and right). According to Table 6, this difference was 7.5% to the cervical spine, 29.8% for the left foot and 29.8% for the right foot.

Regarding the occurrence of muscle/joint pain in the upper limbs, no significant differences were found between the monofunctional and multifunctional workers; however, there was a slight tendency for the highest percentages to be associated with monofunctional workers.

Table 6. Frequency of muscle/joint pain in the monofunctional (MN) and multifunctional (MT) workers interviewed.

Body region	MN	MT	p
	n (%)	n (%)	
Dorsal			
Cervical	11 (19.3)	2 (3.5)	**0.0155**
Left upper back	8 (14)	15 (26.3)	0.1605
Right upper back	7 (12.3)	15 (26.3)	0.0952
Left middle back	8 (14)	9 (15.8)	0.9999...
Right middle back	10 (17.5)	9 (15.8)	0.9999...
Left lower back	13 (22.8)	12 (21.1)	0.9999...
Right lower back	13 (22.8)	12 (21.1)	0.9999...
Upper limbs			
Left shoulder	24 (42.1)	21 (36.8)	0.9999...
Right shoulder	27 (47.4)	23 (40.4)	0.7018
Left arm	6 (10.5)	4 (7)	0.5715
Right arm	7 (12.3)	5 (8.8)	0.7424
Left elbow	3 (5.3)	2 (3.5)	0.7616
Right elbow	7 (12.3)	7 (12.3)	0.9999...
Left wrist	10 (17.5)	10 (17.5)	0.9999...
Right wrist	10 (17.5)	13 (22.8)	0.6413
Left hand	14 (24.6)	13 (22.8)	0.9999...
Right hand	12 (21.1)	13 (22.8)	0.9999...
Lower limbs			
Left hip	1 (1.8)	2 (3.5)	0.9999...
Right hip	1 (1.8)	2 (3.5)	0.9999...
Left thigh	9 (15.8)	7 (12.3)	0.7883
Right thigh	6 (10.5)	7 (12.3)	0.9999...
Left knee	4 (7)	1 (1.8)	0.3638
Right knee	4 (7)	2 (3.5)	0.6790
Left leg	20 (35.1)	10 (17.5)	0.0545
Right leg	21 (36.8)	11 (19.3)	0.0597
Left foot	30 (52.6)	13 (22.8)	**0.0018**
Right foot	29 (50.9)	12 (21.1)	**0.0016**

Source: Research data (2016).

4.4. Assessment of the WMSD risk level

Plant I (Preparation Plant) consists of five sectors, and Plant II (Assembly Plant) has seven production sectors, as shown in the Table 7.

Table 7. Production sectors of shoe component preparation and assembly plants.

Plant	Sector	Functions performed
Preparation		
	A	PVC Injection
	B	Preparation of crude rubber
	C	Sole pressing
	D	Preparation of rubber sandals
	E	Manufacture of rubber boots
Assembly		
	F	Assembly of soles and outsoles
	G	Assembly of cemented shoes
	H	Assembly of vulcanized shoes
	I	Assembly of waterproof shoes
	J	Shoe sewing
	K	Assembly of rubber sandals
	L	Shoe finishing and packing

Source: Research data (2016).

The activities performed by monofunctional workers interviewed were allocated into sectors B, E, F, G, H, I and J. The multifunctional workers' activities were allocated into sectors A, D, F, G and I. The functions performed by monofunctional and multifunctional workers were related to the preparation, assembly and finishing of sports, casual and safety shoe components, including outsoles, midsoles, insoles, uppers and laces.

Regarding the activities performed by monofunctional workers, there was an average activity cycle time of 27.63 seconds (±29.59). The mean OCRA index was 5.09 (±4.18) for the left upper limb and 6.75 (±6.91) for the right. Regarding the activities performed by multifunctional workers, there was a mean activity cycle time of 38.98 seconds (±30.61). The weighted mean OCRA index was 4.75 (±2:20) for the left upper limb and 5.24 (±3.18) for the right upper limb.

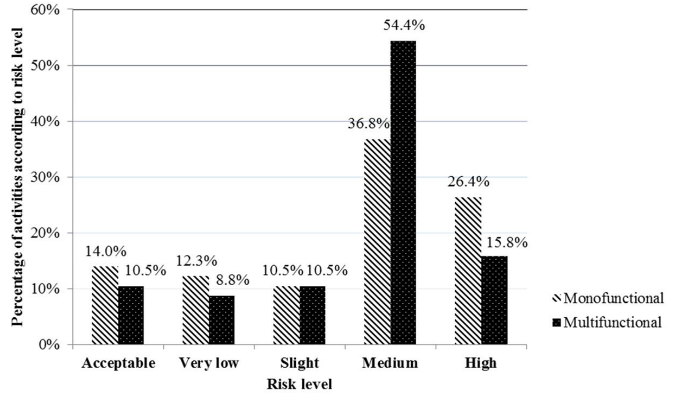

Figure 2. Percentage of activities performed by monofunctional and multifunctional workers according to risk level. Source: Research data (2016).

According to the OCRA results, most activities performed by monofunctional workers were in the WMSD risk range, which corresponded to 73.7% of the total. Of these, 10.5% had slight risk, 36.8% had medium risk and 26.4% had high risk. The rest, representing 26.3%, were classified as having an acceptable risk (14%) or very low risk (12.3%).

With regard to the activities performed by the multifunctional workers, 80.7% had the potential risk of WMSD development, 10.5% were within the acceptable limit, and 8.8% had a very low risk. Of the activities with potential risk, 10.5% were classified as low-risk activities, 54.4% as medium-risk activities and 15.8% as high-risk activities. These findings are shown in Figure 2.

4.5. Odds ratio relating WMSD risk level to the type of work

To estimate the *OR* according to the type of work performed, models were fitted separately for the monofunctional workers and then for the multifunctional workers.

To assess monofunctional work, the model was adjusted for 'gender' (G), 'work plant' (WP), 'work sector' (WS), 'work shift' (WSH), 'cycle time' (CT), the 'number of actions per cycle' (NAC) and 'OCRA index' (OI).

Thus, we have Gi, i = 1 (male); i = 2 (female); WPi, i = 1 (preparation plant) and i = 2 (assembly plant); WSHi, i = 1 (1st shift) and i = 2 (2nd shift); WSi, i = 1 (waterproof shoes), i = 2 (sports shoes type 1),

Table 8. Results for WMSDs* risk in monofunctional work.

Variable	p	Odds ratio
Cycle time	0.0075	0.92
Number of actions per cycle performed by the left upper limb	0.0044	1.21

Source: Research data (2016). *Work-related musculoskeletal disorders.

i = 3 (sports shoes type 2), i = 4 (shoe finishing and packing), i = 5 (rubber), i = 6 (rubber boots), i = 7 (shoe sewing) i = 8 (preparation of soles and outsoles); NACi, i = 1 (number of actions per cycle performed by the left upper limb) and i = 2 (number of actions per cycle performed by the right upper limb); OIi, i = 1 (OCRA index for the left upper limb) and i = 2 (OCRA index for the right upper limb). The probabilistic risks established by the multinomial logistic regression model (χ^2, p=0.0006<0.05) are shown in Table 8.

According to Table 8, for every one-second increase in cycle time, the chance of the monofunctional worker rising to a higher WMSD risk level decreases by 8%. Additionally, for every action performed per cycle by the left upper limb, there is approximately 21% chance of this worker rising to a higher WMSD risk level.

To assess multifunctional work, the model was adjusted for 'gender' (G), 'work plant' (WP), 'work sector' (WS), 'work shift' (WSH), 'multifunctionality level' (ML), 'mean cycle time of each set of functions' (MCT), 'mean the number of actions per cycle in each set of functions' (MNAC) and the 'weighted mean OCRA index for each set of functions' (MOI).

Thus, we have Gi, 1 = 1 (male); i = 2 (female); WPi, i = 1 (preparation plant) and i = 2 (assembly plant); WSHi, i = 1 (1st shift) and i = 2 (2nd shift); WSi, i = 1 (waterproof shoes), i = 2 (sports shoes type 1), i = 3 (preparation of rubber sandals), i = 4 (preparation of soles and outsoles) and i = 5 (injection); MLi, i = 1 (worker

Table 9. Results of WMSDs* risk in multifunctional work.

Variable	p	Odds ratio
Weighted mean OCRA index for the left upper limb	0.0076	$1.22x10^2$

Source: Research data (2016). *Work-related musculoskeletal disorders.

performs up to 30% of all activities contained in a cell unit), i = 2 (worker has knowledge and ability to perform 31-70% of all activities contained in a cell unit), i = 3 (worker has partial efficiency to perform 71-90% of all activities that make up a cell unit) i = 4 (has total efficiency to perform 91-100% of all activities contained in a cell unit); MNACi, i = 1 (mean number of actions per cycle of each set of functions performed by the left upper limb) and i = 2 (mean number of actions per cycle of each set of functions performed by the right upper limb); MOIi, i = 1 (weighted mean OCRA index for the left upper limb) and i = 2 (weighted mean OCRA index for the right upper limb). The result for the probabilistic risk obtained from the multinomial logistic regression model (χ^2, p=0.0001<0.05) is shown in Table 9.

Thus, according to Table 9, the chance of the multifunctional worker rising to a higher WMSD risk level increases 122-fold for every unit increase in weighted mean OCRA index for the multifunctional the worker's left upper limb.

The risk factors established by the OCRA method were then assessed separately to check for possible influences of such factors on the chance of a monofunctional or multifunctional worker being at a higher WMSD risk level according to the type of work. In this sense, models were adjusted separately according to 'joint range of motion,' the 'type of grip,' 'complementary factors' and 'repetitiveness of actions,' considering the left and right upper limbs independently. Complementary factors include the use of vibrating resources; the need for extreme precision; the presence of anatomical compression (hands or forearms); exposure to cold temperatures or cold contact surfaces; the use of gloves that interfere with manual dexterity; the handling of slippery objects; performing sudden movements and experiencing backlash, repeated impacts or using one hand as a hammer. Furthermore, for the assessment of complementary factors, the variables were categorized according to the worker's exposure time (one third, two thirds or throughout the activity cycle).

No significant results were found for monofunctional workers in any of the assessed factors, which provides evidence that the risk of WMSDs is related to the activity development cycle and the number of actions that must be performed in a one-cycle interval.

With regard to multifunctional workers, the results suggest a relationship between WMSD risk level and both 'joint range of motion' and 'complementary factors'. Regarding the joint range of motion, there were significant results regarding movements of the shoulder (abduction, flexion-abduction), forearm (supination and pronation) and the wrist (flexion, radial deviation and ulnar deviation). Complementary factors included the use of gloves and the need for precision in the performance of activities. The probabilistic risk results from the multinomial logistic regression model (χ^2, p=0.0001<0.05) are shown in Table 10.

According to Table 10 and the characteristics of the complementary factors relating to OCRA, the following evidence may be noted regarding the left upper limb: (1) multifunctional workers performing shoulder abduction

Table 10. Estimation of the chance of WMSDs* risk in multifunctional workers considering the WMSDs* risk factors established by OCRA.

The variable	p	Odds ratio
Abduction of left shoulder	0.0002	8.53
Flexion/abduction of left shoulder	0.0066	3.55
Supination of left forearm	0.0141	2.31
Pronation of right forearm	<0.0001	0.15
Flexion of left wrist	0.0315	2.52
Right radial or ulnar deviation	0.0079	2.62
Use of gloves on left hand	0.0002	0.09
Precision required by right hand	0.0218	5.75

Source: Research data (2016). *Work-related musculoskeletal disorders.

at ranges above 45° were eight times more likely to rise to a higher WMSD risk level than multifunctional workers who did not perform this abduction; (2) with respect to shoulder flexion and abduction, for multifunctional workers who exceeded the 80° joint range of motion limit or who remained in isometric contraction for 10 to 20% of the total activity cycle time, even at a lower range, this chance was three times higher; (3) regarding forearm supination, where there were movements with a range greater than 60°, the chance was two times greater, and (4) with respect to wrist flexion, the chance was two times greater when the movement had a joint range of motion greater than 45°.

Thus, for the right upper limb of multifunctional workers, the evidence suggests that (1) performance of the pronation movement during activities reduced the chance of rising to a higher WMSD risk level by 85%; (2) analysis of radial and ulnar deviation revealed that multifunctional workers performing activities with a range exceeding 15° had a two times greater risk of rising to a higher WMSD level than those who did not; (3) regarding wrist flexion, multifunctional workers performing activities in which flexion was over 45° had a five times greater chance of rising to a higher WMSD risk level.

Other WMSD risk factors established by OCRA with significant results were the ‘use of gloves’ and the ‘precision’ required to execute the activities by multifunctional workers. In this case, the ‘use of gloves’ was related to the left upper limb and ‘precision’ to the right upper limb. The ‘use of gloves’ over a third of the activity cycle reduced the chance of exposure to higher WMSD risk levels by 91% when compared to activities that used gloves for two-thirds of the cycle or the whole cycle. With respect to ‘precision,’ multifunctional workers performing precision functions during a third of the cycle were five times more likely to rise to a higher WMSD risk level.

4.6. Odds ratio relating WMSD risk level to multifunctionality level

The model was adjusted for ‘gender’ (G), ‘work plant’ (WP), ‘work sector’ (WS), ‘work shift’ (WSH), ‘mean cycle time’ (MCT), ‘mean the number of actions per cycle’ (MNAC), ‘multifunctionality level’ (ML) and ‘weighted mean OCRA index for each set of functions’ (MOI).

Thus, we have Gi, 1 = 1 (male); and i = 2 (female); WPi, i = 1 (preparation plant) and i = 2 (assembly plant); WSHi, i = 1 (1st shift) and i = 2 (2nd shift); WSi, i = 1 (waterproof shoes), i = 2 (sports shoes type 1), i = 3 (preparation of rubber sandals), i = 4 (preparation of soles and outsoles) and i = 5 (injection); MLi, i = 1 (worker performs up to 30% of all activities contained in a cell unit), i = 2 (worker has knowledge and ability to perform 31-70% of all activities contained in a cell unit), i = 3 (worker has partial efficiency to perform 71-90% of all activities that make up a cell unit), and i = 4 (has total efficiency to perform 91-100% of all activities contained in a cell unit); MNACi, i = 1 (mean number of actions per cycle of each set of functions performed by the left upper limb) and i = 2 (mean number of actions per cycle of each set of functions performed by the right upper limb); and MOIi, i = 1 (weighted mean OCRA index for the left upper limb) and i = 2 (weighted mean

Table 11. Results of WMSDs* risk according to multifunctionality level.

Variable	p	Odds ratio
First multifunctionality level	0.0431	6.76×10^{-2}
Weighted mean OCRA index for the left upper limb	<0.0001	6.13
Mean number of actions per cycle performed by the right upper limb	0.0010	1.35

Source: Research data (2016). *Work-related musculoskeletal disorders.

OCRA index for the right upper limb). The probabilistic risk results from the multinomial logistic regression model (χ^2, p=0.0001<0.05) are shown in Table 11.

Table 11 demonstrates that (1) the fact that the multifunctional worker was at the 1st level of multifunctionality reduced the chances of exposure to WMSD risk by approximately 93%; (2) for each increase in the weighted mean OCRA index relating to the left upper limb in a unit, there was an approximately six fold increased chance of a multifunctional worker rising to a higher level of ergonomic risk; (3) each increase in the mean number of actions per cycle performed by the right upper limb increased the chance by 35% when compared to the mean number of actions performed by the left upper limb.

5. Discussion

The assessment of workers at the footwear company established that the functions vary depending on the type of plant, with Plant I concentrating on preparation activities for the components making up the shoes and Plant II concentrating on the assembly of such components.

The work organization in the plants is based on the distribution of tasks, in which production sectors are managed by the supervisor, production cells by the leaders and intracellular activities mostly by workers who perform a single function. Thus, the shoe manufacturing process is founded, above all, on labor segmentation.

Although most workers are multifunctional and have the knowledge and ability to perform almost all activities in the production cell to which they are allocated, most of these cells do not have a properly functioning job rotation system in place. That is, approximately 80% of the cell units do not perform rotation; when they do, there is no schematic standardization according to the risks arising from the work and according to the specific characteristics of intracellular activities.

Regarding the occurrence of muscle/joint pain in the cervical spine, the right middle back, lower back, shoulders, arms, left elbow, thighs, knees, legs and feet due to the activities performed, the frequencies among monofunctional workers were slightly higher than those among multifunctional workers. Monofunctional and multifunctional workers were similar regarding the areas most affected in the upper and lower limbs, including the right shoulder and left foot, respectively. However, there was a tendency toward higher percentages in the monofunctional worker's group. In relation to the dorsal region, the region most affected in the monofunctional workers was the lower back, while it was the upper back for the multifunctional workers. Furthermore, when assessing the activities, a tendency to use the same muscle groups in both types of work was identified. The most frequent movements for the elbow (flexion-extension), forearm (pronation), wrist (extension) and finger (flexion, extension and abduction) were identical in the two groups.

When the WMSD risk levels were analyzed, it was observed that the activities performed by both the multifunctional and monofunctional workers had a representative risk of developing WMSDs. However, the multifunctional workers tended to be concentrated on activities in the range corresponding to the medium risk level, while the monofunctional workers were more often involved in the medium to high range.

Considering the WMSD risk level ranges contained in OCRA, some peculiarities relating to monofunctional and multifunctional work can be inferred. The WMSD risk assessment according to type of work showed that for the monofunctional workers, representative variables are related to the time required to perform a complete cycle of the task and the number of actions performed by the upper limbs during this cycle, wherein the shorter the cycle time and the greater the number of actions, the higher the risk of developing WMSDs.

For the multifunctional workers, the model provided evidence that excessive and inappropriate use of the left upper limb is associated with exposure to higher WMSD risk levels. Based on the assessment of the risk factors contained in OCRA, it was observed that the occurrence of WMSDs may be based on joint movement performed above the normal movement range, with the use of gloves, and with the need for precision when performing an activity.

When analyzing the WMSD risk level related to workers' multifunctionality level, three variables were found to be significant. The first corresponds to the fact that workers allocated to the '1st level of multifunctionality' had a lower risk of WMSDs than multifunctional workers who performed the same set of functions over a longer period. Furthermore, starting from the principle that workers allocated to the 1st level of multifunctionality performed up to 30% of all intracellular activities, it can be assumed that multifunctional workers performing a greater number of activities are more exposed to the risk of WMSDs. This finding may be related to the physical and psychosocial demands of activities.

The second representative variable refers to the 'weighted mean OCRA index for the left upper limb'. In this case, an increase in the weighted mean index, according to the time that each worker performed a particular activity, substantially increased the chances of WMSD risk. Finally, the third variable refers to the 'mean number of actions per cycle performed by the right upper limb', where it can be inferred that an increase in the mean generates an increase in the chance of a multifunctional worker rising to a higher WMSD risk level.

6. Conclusion

For monofunctional workers, there is evidence that higher risk levels are associated with activity cycle time. For multifunctional workers, there is evidence that such levels are related to excessive or inappropriate application of the left upper limb in a combination of activities. Specifically, for multifunctional workers, the activity's kinesiological and organizational aspects may be associated for the development of WMSDs.

Thus, the evidence suggests that both monofunctional and multifunctional workers are at risk of WMSDs. Some considerations regarding the job rotation performed by multifunctional respondents should be highlighted: (1) the programming of job rotation may be concentrating activities with considerable risk of WMSDs for the same multifunctional worker; (2) higher level multifunctional workers can be subjected to successive activities with a high work load; (3) even when allocated to different activities, according to the required demand, this workload may be concentrated on the same muscle group of the upper limb; and (4) the same sequence of activities is performed daily and therefore becomes monotonous.

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