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Ergonomic Work Analysis in the Production of Interiors for the Transport Industry

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ABSTRACT

An Ergonomic Work Analysis (EWA) was carried out to understand the working conditions of workers at the transportation factory unit, making part of the metalworking industry, in Portugal. The objectives of the study were: the characterization of the metalworking industry regarding the risk of developing musculoskeletal disorders (MSDs), the characterization of musculoskeletal symptoms (MSS) self-reported by workers, the identification of the most relevant risk factors concerning each task assessed, and the definition of an action plan to mitigate the identified problems. To assess and qualify the risk of developing MSDs, different methods, such as Rapid Entire Body Assessment (REBA), Rapid Upper-Limb Assessment (RULA), Revised NIOSH lifting equation, and Revised Strain Index (RSI) were used, to accommodate the specificities of each task. The ErgoWeb Enterprise™ software was used to apply the above-mentioned methods. All workers ($N = 18$), agreed to participate in the study. Ten workstations were analyzed and assessed. There was a statistic association between work demands and MSS, in various body regions. Considering the postural assessment methods, all tasks presented a risk of developing musculoskeletal injuries (Risk level > 2). Also, the application of the manual handling of loads assessment method highlighted that the tasks presented a risk of developing injuries at the level of the lumbar spine (IL > 1). All these results show that investigations and measures to improve working conditions must be carried out in the near future.

Keywords: Ergonomic work analysis (EWA), Metalworking industry, Musculoskeletal disorders (MSDs), Musculoskeletal symptoms (MSS), REBA, RULA, Revised NIOSH equation, Revised Strain Index (RSI)

INTRODUCTION

MSDs represent a significant global health problem affecting around 1.71 billion people globally (GBD 2019 Diseases and Injuries Collaborators 2020; EU-OSHA 2022), and low back pain remains the leading cause of disability since 1990 (Russo et al. 2020). MSDs represent one of the most important causes of chronic disability, sick leave absence, reduced work productivity, and quality of life (Briggs et al., 2018; Crawford et al., 2020 cited by EU-OSHA 2022) being recognized as a major occupational health issue. Despite the slightly decreasing prevalence, according to data obtained by the European Agency for Safety and Health at Work, more than half of workers appear to suffer from this health problem (EU-OSHA 2020). These disorders affect the locomotor apparatus involving muscles, nerves, tendons, the skeleton, joints, cartilage, spinal discs, and the localized vascular system (EU-OSHA 2022), caused or aggravated mainly by work and the effects of the environment in which it is performed (EU-OSHA 2020).

MSDs are diseases or injuries where professional risk factors contribute, in some way, to the etiology, predisposition, or worsening of pathological situations. The risk of developing MSDs is related to the "exposure dose" which is determined by dimensions such as intensity, duration, and frequency. The risk factor is only relevant for the genesis of the injury if the worker is exposed above the values considered acceptable (Serranheira et al. 2008). The main physical risk factors for MSDs are handling loads, posture, repetitive movements, strength, physical exertion, mechanical pressure on body tissues, exposure to vibrations, heat, or cold, and high noise levels (Serranheira et al. 2008; EU-OSHA 2022).

MSDs are identified as the disease that most contributes to the increase in health problems among workers in manufacturing industries (Halim et al. 2013). MSDs in the upper limbs and trunk are the most frequent among operators in the industrial sector (Serranheira et al. 2008) because there is exposure to risk factors of work activity, such as standing postures for long periods of time (EU-OSHA 2021), extreme posture (outside of intersegmental joint comfort angles), identical movement throughout the work cycle, frequent gestures, application of hand and finger force, exposure to vibrations, absence of recovery periods between tasks and manual handling of loads. Additionally, organizational factors and some aspects of a psychosocial nature also contribute to the development of MSDs (Serranheira 2007).

The main objective of this study is to develop an Ergonomic Work Analysis (EWA) for workstations of the teams that operate in the production of interior systems for the transport industry, with particular emphasis on the assessment of the risk of developing MSDs. To achieve the main objective, specific objectives were defined, such as the characterization of the metal working industry regarding the risk of developing MSDs, characterization of musculoskeletal symptoms self-reported by workers, identification of the most relevant risk factors, and definition of an action plan to mitigate the identified problems. The study was carried out at the transportation factory unit (named Metal V), making part of the metalworking industry, in Portugal.

MATERIALS AND METHODS

The study was divided into 4 stages: 1) Characterization of the work situation, 2) Identification, evaluation, and quantification of exposure to occupational risk factors, and assessment of development MSDs, 3) Data analysis and processing, and 4) Elaboration of improvement proposals. To carry out steps 1 and 2, the most appropriate methods/techniques were selected. This article presents the results concerning the first two stages.

To characterize the work situation (stage 1) methods/techniques were used such as document analysis, observations, non-structured interviews with workers, image/video recording, and a questionnaire, adapted from the Nordic Questionnaire (Kuorinka et al. 1987), and specifically developed for this context. The applied questionnaire was adapted from other studies (Carvalho et al. 2022) and, integrated the information provided by the company. The purpose of applying this questionnaire was to characterize the workers, assess the workers' perception of working conditions, and identify self-reported symptoms. Participation in the study was voluntary and confidential, concerning the privacy of each participant. Informed written consent was previously obtained by all participants.

The questionnaire consists of four parts. Parts A and B, it was intended to collect sociodemographic data and the health status and lifestyle of workers, respectively. Parts C and D, it was intended, respectively, to characterize the work activity and the working conditions, considering the perspective of the workers, and to characterize the self-reported musculoskeletal symptomatology. In section C a Likert scale with 5 levels (in which 1 means absence of discomfort/more frequent and 5 means unbearable discomfort/less frequent) was used to assess pain levels associated with the task or workstation occupancy, respectively. For the frequency and intensity assessment of pain, a four-level Likert scale was used in section D (where 1 means 1X per year/low intensity and 4 means more than 6X per year/very high intensity). Subjects were asked to answer about their MSS (annoyance, discomfort, and physical pain) over the last 12 months and the last 7 days, and to mark the affected areas on the body discomfort chart. Additionally, they were requested to report if they were prevented from carrying out the usual daily work (a 4-level Likert scale was used, in which 1 means 0 (zero) days and 5 means all days). Symptoms of pain or discomfort were recognized as the presence of pain. Image and video recording of working postures resorted to a digital Phone (Samsung – S7 Edge 32 GB).

For the evaluation and qualifictaion of the MSDs risk associated with the performance of the tasks (step 2), the following methods were used: Rapid Entire Body Assessment (REBA), Rapid Upper-Limb Assessment (RULA), Revised NIOSH lifting equation, Revised Strain Index. A complete description of the methods can be found in the literature (Hignett and McAtamney 2000; Garg et al. 2017; Gómez-Galán et al. 2020; Waters et al. 2021).

A total of 18 workers, of which 16 production operators, 1 team leader, 1 production supervisor, and 10 workstations were part of the study. The manufacturing unit where the study was carried out (Metal V) is made up of 16 production operators, distributed over 10 workstations: Cutting/Preparation, Machining, Collage I, Collage II, Cleaning I, Cleaning II, Assembly I, Assembly II, Quality Inspection, and Packaging. The Cutting/Preparation, Cleaning II, and Assembly I workstations are operated by one worker; Machining, Cleaning I, and Quality Inspection are operated by two workers each; Collage I and II are operated by the same four workers; Assembly II and Packaging are operated by the same three workers.

For data processing, the SPSS© software (version 28) was used and descriptive analyses were performed using measures of location and dispersion.

The Chi-square test and Cramer's V coefficient were used to assess associations between variables (demographic/work-related characteristics) and reported MSS, per body region. The Cramer's V interpretation adopted the following assumptions: 0-0.30, no association - weak association; 0.31-0.70, moderate association, and 0.71-1.0, strong association. Table 1 shows the variables considered for the Chi-square association tests. A significance level of 0.05 was adopted as a criterion to reject the null hypothesis. The ErgoWeb Enterprise™ software was used to apply the above-mentioned methods.

Table 1. Variables (socio-demographic or work-related characteristics) used in the association test.

Socio-demographic	Work-related characteristics
– Gender (F/M) – Age: <40; ≥40 – BMI (Normal Weight; Overweight; Obesity) – Marital status (Married; Single, Divorced, widower) – Second job (Yes/No) – Regularly exercise (Yes/No) – Smoking habits (No/Yes) – Alcohol consumption (Yes/No) – Caffeine consumption (Yes/No) – Sleep quality (Little/not at all regular; Regular/very regular) – Medical history of systemic illness (No/Yes)	– Seniority (Metalworking industry and Metal V): <5 or ≥ 5 – Workstation (Cutting/Preparation; Machining; Collage I; Collage II; Cleaning I; Cleaning II; Assembly I; Assembly II; Quality inspection; Packing) – Additional service hours (Yes/No) – Work accident: (Yes/No) – Work requirements (Nothing present; little present; present; very present) – Working environment conditions (Nothing bothersome; little bothersome; very annoying) – Tools/Equipment (Absence/low effort; average effort; high/extreme effort)

RESULTS AND DISCUSSION

Demographic Data and Job Characteristics

Eighteen workers with an average age of 41.83 years (Sd = 9.61 years; range 25- 56 years) and an average weight of 80.06 kg (Sd = 18.42; range: 51–117 kg) participated in the study. Most workers are male (66.7%) and are married (55.6%). Most workers (55.6%) are overweight (BMI > 25 Kg/m^2), of which 16.7% have type 1 obesity (BMI = [30-34.9 Kg/m^2]) and 6.7% have type 2 obesity (BMI = [35-39.9 Kg/m^2]). Fifty percent of the operators reported that they were not involved in regular physical activities. Forty-four percent of the participants were smokers and about 89% of workers consumed caffeine daily. In terms of Seniority, about 44% of the workers have more than 5 years of experience in the metalworking industry but, in Metal V most of the workers (66,7%) have between 1 to 3 years of experience and ≈27% have less than 1 year of experience. In terms of working time organization, all workers should complete 8 hours daily in two available shifts (8h-16h or 16h-24h) with a 30 min. break for lunch; 50% of workers work additional hours due to the need for the service, of which 27.8% only work in occasional situations and the remaining 22.2% work a few times a week or a month; about 38% of the respondents had suffered an accident at work, of which ≈16% occurred in Metal V.

Working Conditions

When evaluating the environmental conditions at work, ≈6% of the workers considered the noise from the machines and the stacker to be uncomfortable, also the lighting and the hand/arm vibration from vibrating tools are annoying; ≈28% of workers consider the thermal environment in summer and winter uncomfortable. Regarding the use of personal protective equipment (PPE), 5.6% of workers consider the use of ear plugs/protectors uncomfortable, and 11.1% consider the use of glasses/visors and masks uncomfortable because they do not fit or are uncomfortable. At the end of the working day, 33.4% of workers rate their general fatigue as high and/or maximum, and 22.3% rate their visual fatigue as high.

The work characteristics classified as very demanding were *working on your feet for long periods and traveling frequently, the high visual demand, handling loads over 10 kg, lifting and unloading loads over 20 kg, application of force with the arms, the repetitiveness of arms and hands/fingers, frequent use of tools and application of force with hands/fingers*.

The Prevalence of Musculoskeletal Symptoms

About ninety-four percent of the 18 study participants reported a complaint in at least one body region. The body regions with the highest percentage of complaints were the lower back (83.3%), neck (50%), and upper limbs (hand/wrist (50%) and shoulder (44.5%)), whereas the lower limbs (27.8%) and elbows (22.3%) were the regions with the lowest percentage of complaints. Several studies carried out in the metallurgical industry (Choobineh et al. 2016; Ayub and Shah 2018; Russo et al. 2020) concluded that the prevalence of pain complaints among workers is high (> 81.1%), which pains are higher in the lumbar region and upper limbs, corroborating the results found in our study. The presence of pain in these regions may be related to the presence of one or more than one of the following factors: permanence in the standing position, use of equipment, adoption of inappropriate postures, application of force, and manual handling of loads. In our study, most reported pain complaints presented a high and/or very high pain intensity, with a prevalence of 14.9% and 11.2%, respectively, with emphasis on the lower back, neck, and hand/wrist. For most pain complaints, the frequency is greater than 4 times a year. It was observed that in the body regions where the frequency of pain complaints is higher, the intensity of pain was high and/or very high, as well.

Associations Between Socio-Demographic/Job Characteristics and MSS by Body Region

Table 2 shows the statistically significant associations found between the MSDs symptoms (by body region) and the variables (demographic/work-related

Table 2. Socio-demographic/job characteristics and body region MSDs symptoms association (N = 18).

Independent Variable	Body Region	Chi-Square Test	p-value	Crame' V
Gender	Thigh	χ^2 (2) = 7,010	0.022	0.624
	Knee	χ^2 (2) = 7,615	0,025	0,650
BMI	Foot/ankle	χ^2 (6) = 11,596	0,048	0,568
Seniority (metalworking industry)	Foot/ankle	χ^2 (3) = 6,785	0,023	0,614
Additional hours	Shoulder	χ^2 (3) = 9,600	0,009	0,730
Side bending of trunk	Neck	χ^2 (3) = 11,244	0,003	0,790
Applying force with your arms	Shoulder	χ^2 (9) = 18,785	0,017	0,590
Handling loads between 5 and 10 Kg	Shoulder	χ^2 (9) = 17,262	0,050	0,565
Handling loads over 10 Kg	Hand/wrist	χ^2 (6) = 12,823	0,035	0,597
Lifting and moving loads under 20 Kg	Hand/wrist	χ^2 (6) = 13,200	0,035	0,606
Lifting and moving loads over 20 Kg	Hand/wrist	χ^2 (6) = 16,583	0,005	0,679
Use of supports to improve reach	Lower back	χ^2 (3) = 13,200	0,005	0,856
X-act	Hand/wrist	χ^2 (6) = 12,708	0,027	0,594

characteristics) ($p \leq 0.05$). It is important to highlight that for all these cases Cramer's V test revealed moderate and strong associations (> 0.50). Through the Chi-square test, the existence of an association was verified between the sociodemographic variable sex and the musculoskeletal symptoms for the thigh and knee with prevalence for female workers. The BMI variable presents a positive association with the prevalence of musculoskeletal symptoms in the foot/ankle, for workers with obesity. For the variable seniority in the metalworking industry, an association is verified between musculoskeletal symptoms in the foot/ankle, for workers with more than 5 years in the company. Working additional hours at the service is positively associated with the prevalence of musculoskeletal symptoms in the shoulder region.

Regarding work demands, there is a positive association between BMI is recognized as a variable that influences individual susceptibility and is related to a higher likelihood of developing LMERT (Anandacoomarasamy et al., 2009; DGS, 2008). Similarly, cumulative exposure to various risk factors, as a consequence of seniority, is also considered to facilitate its development (DGS, 2008). i) lateral inclination of the trunk and musculoskeletal symptoms in the neck region when this is classified as being present, in the work activity; ii) exertion of force with the arms and musculoskeletal symptoms in the shoulder region when this is classified as being very present; iii) handling loads between 5 and 10 kg and musculoskeletal symptoms in the shoulder region when classified as being very present; iv) handling loads over 10 Kg and musculoskeletal symptoms in the hand/wrist region when classified as being very present; v) lifting and moving loads (below and above 20 kg) and musculoskeletal symptoms in the hand/wrist region, when classified as being very present; vi) use of supports to improve reach and musculoskeletal symptoms in the lower back, when classified as being present or very present. In the use of tools/equipment, there was a positive association between the use of x-act and musculoskeletal symptoms in the hand/wrist region, when the associated effort is considered high/extreme.

MSDs Risk Assessment

The REBA method was applied to 31 postures associated with the performance of tasks in 6 workstations (Collage I, Collage II, Cleaning I, Assembly I, and Packing), where it was verified that the risk of developing MSDs, for all the evaluated tasks, is found mostly between high-risk level (35.5%) and very high risk (54.8%), as can be seen in Table 3, but being present in all postures evaluated (Risk level ≥ 2).

Through the results obtained by the REBA method, it is verified: i) a risk level ≥ 2 in the neck score for 80.6% of the cases; these results indicate that most of the evaluated tasks involve flexion < 20 combined with a lateral flexion or rotation. ii) a risk level ≥ 4 on the Trunk score for 71% of cases; these results show that the assessed tasks involve flexion > 60^0, being combined with rotation and lateral flexion. iii) a risk level = 3 in the Legs score for 83.9% of the cases; these results show that the assessed tasks involve flexion >60^0; iv) a risk level ≥ 4 in the Upper Arm score for 80.7% of the evaluated cases, which shows that most of the evaluated tasks imply flexion > 45^0, being combined with an abduction, for 87.1% of the cases and v) a risk level = 2 in the wrist score for 90.3% of cases; the results obtained show that the assessed tasks involve flexion between 15^0, combined with wrist rotation and deviation. On the other hand, the RULA method was applied in 272 postures associated with carrying out various tasks in 10 workstations (Cutting/Preparation, Machining, Collage I, Collage II, Cleaning I and II, Assembly I and II, Quality Inspection, and Packaging) and the risk of developing MSDs, for all the evaluated tasks, is between the medium (30.5%) and high (27.2%) risk levels, as can be seen in Table 4. Quality Inspection and Machining were the jobs where the level of risk associated with them is no

Table 3. Distribution of REBA scoring (n = 31 postures assessed for tasks in 6 workstations).

	REBA Score											Mean (SD)
	1 n(%)	2 n(%)	3 n(%)	4 n(%)	5 n(%)	6 n(%)	7 n(%)	8 n(%)	9 n(%)	10 n(%)	11 n(%)	
Neck	6(19.4)	16(51.6)	9(29)	-	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2.10(0.70)
Trunck	1(3.2)	2(6.5)	6(19.4)	11(35.5)	11(35.5)	-	n.a.	n.a.	n.a.	n.a.	n.a.	3.94(1.06)
Legs	-	5(16.1)	26(83.9)	-	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2.84(0.37)
UpperArm	-	2(6.5)	4(12.9)	22(71)	3(9.7)	-	n.a.	n.a.	n.a.	n.a.	n.a.	3.84(0.69)
LowerArm	3(9.7)	28(90.3)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1.90(0.30)
Wrist	-	28(90.3)	3(9.7)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	2.10(0.30)
Posture Score A	-	-	2(6.5)	2(6,5)	6(12.9)	4(12.9)	2(6.5)	11(35.5)	4(12.9)	n.a.	n.a.	6.65(184)
Posture Score B	-	-	1(3.2)	-	5(16.1)	21(67.7)	1(3.2)	3(9.7)	-	n.a.	n.a.	5.97(0.94)
REBA *Score*	-	-	-	-	-	1(3.3)	2(6.5)	2(6.5)	1(3.2)	8(25.8)	17(54.8)	10.06(1.41)
Risk Level	-	-	3(9.7)	11(35.5)	17(54.8)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	4.45(0.68)

Table 4. Distribution of RULA scoring (n = 272 postures assessed for tasks in 10 workstations).

	RULA									Mean (SD)
	1 n(%)	2 n(%)	3 n(%)	4 n(%)	5 n(%)	6 n(%)	7 n(%)	8 n(%)	9 n(%)	
Upper Arm	23(8.5)	97(35.7)	58(21.3)	46(16.9)	40(14.7)	8(2.9)	n.a.	n.a.	n.a.	3,03(1.31)
Lower Arm	102(37.5)	156(57.4)	14(5.1)	-	n.a.	n.a.	n.a.	n.a.	n.a.	1,68(0.57)
Wrist	6(2.2)	20(7.4)	75(27.6)	155(57)	16(5.9)	n.a.	n.a.	n.a.	n.a.	3,57(0.80)
Neck	112(41.2)	69(25.4)	14(5.1)	64(23.5)	13(4.8)	-	n.a.	n.a.	n.a.	2,25(1.33)
Trunk	7(2.6)	51(18.8)	116(42.6)	68(25)	30(11)	-	n.a.	n.a.	n.a.	3,23(0.97)
Legs	231(84.9)	41(15.1)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	1,15(0.36)
***Posture Score* A**	-	12(4.4)	47(17.3)	127(46.7)	36(13.2)	22(8.1)	18(6.6)	4(1.5)	6(2.2)	4,40(1.43)
***Posture Score* B**	4(1.5)	36(13.2)	54(19.9)	45(16.5)	42(15.4)	35(12.9)	42(15.4)	14(5.1)	-	4,57(1.85)
RULA *Score*	-	5(1.8)	56(20.6)	54(19.9)	32(11.8)	51(18.8)	74(27.2)	n.a.	n.a.	5,07(1.57)
Risk Level	5(1.8)	110(**40.4**)	83(**30.5**)	74(27.2)	n.a.	n.a.	n.a.	n.a.	n.a.	2,83(0.85)

risk and low, respectively. Assembly II was the workstation where there was a higher level of risk. The remaining jobs have a medium risk level associated with them.

In the results obtained from the application of the RULA method, it is concluded that: i) there is a risk level $\geq$ 2 in the arm score for 91.5% of cases; these results indicate that the evaluated tasks require flexion > 20^0, in combination with shoulder abduction or elevation; ii) a risk level $\geq$ 2 in the lower arm score for 62.5% of the evaluated cases, which corresponds to flexion greater than 100^0; iii) a risk level $\geq$3 on the wrist score for 90.5% of cases; these results are a consequence of the fact that, in the assessed tasks, wrist extension > 20^0 is verified, in combination with wrist rotation and deviation; iv) a risk level $\geq$ 2 on the neck score for 59.1% of the evaluated cases; these results show that the evaluated tasks involve flexion among the 10^0, in combination with rotation or lateral flexion of the neck; v) a risk level $\geq$3 in the trunk score for 78.6% of cases; these results result from the tasks evaluated involving flexion > 20^0, in combination with rotation or lateral flexion of the trunk and, finally, vi) a risk level = 1 for 84.9% of the cases evaluated in the legs score, indicating that in the evaluated tasks, the legs are well supported on the ground, during the performance of the tasks. Table 5 shows the distribution of RULA scoring and REBA scoring by specific tasks. Through the RULA method, it is verified that most of the evaluated tasks of the Assembly II, Packing, Cleaning II, and Collage II workstation, are rated at medium and high-risk levels. The REBA method, on the other hand, shows a high/very high-risk level for all the tasks evaluated (Collage I, Assembly, and Packaging).

When assessing the risk of developing MSDs associated with tasks involving manual lifting of loads (Collage I, Collage II, Cleaning I, Assembly I, and Packing), it appears that, for all the assessed tasks, the level of risk is found to be between medium (48.5%) and high (39.4%) levels. These results

Table 5. Distribution of RULA scoring and REBA scoring by task.

Tasks	RULA Score Low Risk n(%)	RULA Score Moderate risk n(%)	RULA Score High risk n(%)	REBA Score Low Risk n(%)	REBA Score Moderate risk n(%)	REBA Score High risk n(%)	REBA Score Very High Risk n(%)
Cutting/Preparation	19(59.4)	6(18.8)	6(18.8)	n.a.	n.a.	n.a.	n.a.
Machining	14(100)	0(0)	0(0)	n.a.	n.a.	n.a.	n.a.
Collage I	23(48.9)	6(12.8)	18(38.3)	0(0)	0(0)	0(0)	5(100)
Collage II	22(36.1)	21(34.4)	18(29.5)	0(0)	0(0)	0(0)	2(100)
Cleaning I	2(28.6)	3(42.9)	2(28.6)	0(0)	0(0)	0(0)	3(100)
Cleaning II	1(11.1)	4(44.4)	4(44.4)	n.a.	n.a.	n.a.	n.a.
Assembly I	18(30.5)	23(39.0)	18(30.5)	0(0)	2(16.7)	5(41.7)	5(41.7)
Assembly II	5(22.7)	15(68.2)	2(9.1)	n.a.	n.a.	n.a.	n.a.
Quality inspection	3(42.9)	0(0)	0(0)	n.a.	n.a.	n.a.	n.a.
Packing	3(21.4)	5(35.7)	6(42.9)	0(0)	1(11.1)	6(66.7)	2(22.2)

are due to the high weight of the load handled and the vertical distance involved during the task. These results show that investigations and measures to improve working conditions must be carried out.

The Strain index method indicates that the tasks of cutting *syllomers* with a width of 75mm, cleaning the panels, and placing articles on the panels with the aid of tools present a high-risk level. The NIOSH method identifies the removal tasks (Collage I and II), placing the panel on the worktable (Cleaning I and Assembly I), placing the panel on the lift table (Cleaning I), placing the panel on the floor for floorcovering assembly (Assembly I) and placement of panels inside the packaging box (Packaging) as being the tasks that are rated at medium and high-risk levels.

CONCLUSION

This study was carried out at the transportation factory unit, making part of the metalworking industry, in Portugal. According to the results obtained, a high number of workers reported complaints of musculoskeletal symptoms, for the lower back, neck, and upper limbs (shoulder, elbow, and hand/wrist), where the risk factors of work seem to contribute to their development. These results are like those of other studies (Halim et al. 2013). The tasks performed at Metal V involve adopting inappropriate postures, performing repetitive movements, applying force to the arms and hand/wrist, manual handling of loads, and exposure to noise and vibrations, which justifies the high levels of risk identified by the various methods applied, as reported in the literature (Nunes 2009; Marques et al. 2018; EU-OSHA 2022). The results obtained in this study show that investigations and measures to improve working conditions must be carried out.

In summary, organizational measures must be taken, complemented by technical and/or constructive measures. Organizational measures are important in order to make workers aware of: i) the issue of work-related MSDs, namely the risk factors existing in the tasks they perform and what measures to adopt to prevent the occurrence of accidents at work or the development/worsening occupational diseases associated with its realization; ii) the risks associated with the use of work tools and equipment, iii) the importance of using PPE correctly; iv) regular short-term breaks, especially when performing tasks that involve high physical effort and/or inappropriate postures, and thus minimize the effects of some risk factors on workers' health; v) promote a rotation plan, since there were differences related to the level of risk associated with different tasks. Complementarily, technical, and constructive measures must be adopted, which include the acquisition of new work tools to minimize the risks associated with some tasks and allow the reorganization of the workstations.

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