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Original Article

Self-Reported Variables as Determinants of Upper Limb Musculoskeletal Symptoms in Assembly Line Workers

Marisa M. Guerreiro [1,*], Florentino Serranheira [2], Eduardo B. Cruz [3], António Sousa-Uva [2]

[1] NOVA National School of Public Health, Occupational Health and Environmental Health Department, Universidade NOVA de Lisboa, Lisbon, Portugal
[2] NOVA National School of Public Health, Public Health Research Centre, Universidade NOVA de Lisboa, Comprehensive Health Research Center (CHRC), Lisbon, Portugal
[3] School of Health Care, Department of Physiotherapy, Setubal, Portugal

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ABSTRACT

Background: Assembly lines work is frequently associated to work-related upper limb musculoskeletal disorders. The related disability and absenteeism make it important to implement efficient health surveillance systems. The main objective of this study was to identify self-reported variables that can determine work-related upper limb musculoskeletal symptoms—discomfort/pain—during a 6-month follow-up.
Methods: This was a prospective study with a 6-month follow-up period, performed in an assembly line. Upper limb musculoskeletal discomfort/pain was assessed through the presence of self-reported symptoms. Uni- and multivariate logistic regression analyses were used to evaluate which self-reported variables were associated to upper limb symptoms after 6 months at the present and to upper limbs symptoms in the past month.
Results: Of the 200 workers at baseline, 145 replied to the survey after 6 months. For both outcomes, "having upper limb symptoms during the previous 6 months" and "education" were possible predictors.
Conclusion: Our results suggest that having previous upper limb symptoms was related to its maintenance after 6 months, sustaining it as a specific determinant. It can be a hypothesis that this population had mainly workers with chronic symptoms, although our results give only limited support to self-reported indicators as determinants for upper limb symptoms. Nevertheless, the development of an efficient health surveillance system for high demanding jobs should implicate self-reported indicators, but also clinical and work conditions assessment should be accounted on the future.

1. Introduction

Highly repetitive work (the same movement two to four times a minute or in cycles below 30 seconds [1]), manual force application, and awkward postures are present in assembly line work [2,3]. These are some of the occupational hazards associated to work-related upper limb musculoskeletal disorders (WRULMSDs) [2–5], especially of the neck and upper limb and the most common in assembly lines [6].

Although the development of WRULMSD is related to duration, frequency, and magnitude of the exposure [7,8], assembly lines are high demanding jobs, addressed as standardized jobs [9] with low job control. It is usual, not only due to the physical demands, but also to insufficient recovery time [7], to occur cumulative biomechanical loading, leading to muscular fatigue and causing reduced functional capacity to continue performing a task and maintaining force [10]. This makes it difficult to reduce the high frequency of WRULMSD in these settings. The WRULMSD easily become chronic conditions, not only because its diagnosis is difficult to achieve, as most of the cases are only determined after a second episode [11]. Along with pain and dysfunction, also reduced quality of life and reduced mental well-being are some of the consequences, with impact either in workers as in organizations [12,13].

Taking all this into account, one of the strategies of WRULMSD's prevention relies on the success of a health surveillance system [14]. This should be a multilevel system, divided into quick risk

* Corresponding author. NOVA National School of Public Health, Occupational and Environmental Health Department, Avenida Padre Cruz, 1600 – 560, Lisboa, Portugal.
E-mail address: mm.guerreiro@ensp.unl.pt (M.M. Guerreiro).

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assessment tools (as questionnaires) and clinical examinations concerted with job-specific analysis [14]. This system must be cost effective and capable to identify potential problems in the workplace, as to determine where is necessary to allocate more investigation and/or intervention [1]. This is the so called *meso* level, for active occupational health surveillance, in which the periodic assessment of symptoms is an important piece to prevention. Overall, the health surveillance strategy should be able to identify workers at risk of developing WRULMSD's or at risk of worsening their symptoms [15].

Self-reported factors can make it possible to assess musculoskeletal symptoms or work physical hazards and have been widely used on occupational health studies. As observed physical exposure, self-reported factors are the basis of most of the knowledge on work-related musculoskeletal disorders [16,17]. Individual factors and physical work exposure are both important predictors of self-reported symptoms [18], being discomfort and pain the first musculoskeletal symptoms reported by workers and also the most prevalent [11]. Discomfort can be a predictor of pain [19] and the relations and transitions among them are important to understand the setting of WRULMSD [20,21]. Its assessment, as the identification of the determinants of symptomatic episodes, are important steps toward WRULMSD's prevention.

Individual risk factors (such as gender, age under 40 years, or education), work risk factors (e.g., physically demanding tasks, with repetitiveness, force and awkward postures) and psychosocial risk factors (e.g., satisfaction at work or working hours) have been related to WRULMSD's occurrence [8,22,23]. However, regardless if we are considering WRULMSD or a previous stage as an episode of discomfort or pain, to determine which factors are more important to their development is quite difficult because of the variability of risk factors and its combinations, making it complicated to isolate one risk factor [24].

Assuming that work-related musculoskeletal upper limb symptoms are related to high physical work demands, it is an expectation that assembly line workers have a high frequency of reported upper limb symptoms. This is an occupational health issue, once the disability and absenteeism are significant [25]. Taking this into account and that the determinants of the first upper limb symptoms could be different from those related to chronic symptoms, the present study followed a group of Portuguese automotive assembly line workers during 6 months, with the following main goal: to identify which self-reported variables (demographic/individual, health- and work-related) can possibly determine upper limb musculoskeletal discomfort and pain.

2. Materials and methods

2.1. Study design

This was a prospective study with a 6-month follow-up period, performed at an automotive industry in Portugal, more specifically in the assembly line. This study followed the recommendations of the Declaration of Helsinki and was submitted and accepted by the Portuguese Data Protection Authority (authorization nr 8602/2014).

2.2. Assembly line work

In the assembly shop, the car is assembled with other parts into a complete vehicle. The car comes elevated from the painting and goes down to the assembly line. Protections to the body of the car are placed and then it goes through different areas of assembly such as cockpit, motor, doors, and benching. Each area has a unit, constituted by different stations. There are stations with power tools and handling devices, others requiring snap-fits, and in several positions, it is necessary to work underbody, above shoulder's line. It is usual to acknowledge an assembly line as a workplace with noise, vibrations, and machines.

Generally, the cycle for a car is short, which means that every 90 seconds a new car comes down to the line. In a typical 8-hour working day, the worker changed to other station every 2 hours. The present industry had a morning shift (from 7.00 AM to 3.30 PM) and an evening shift (3.30 PM to 11 PM). The lunch/dinner break was of 30 minutes and for both shifts there were two additional breaks of 7 minutes each.

2.3. Participants

The participants were assembly line workers who attended an informative session to invite them to participation. From an initial population of 1,100 workers, 400 agreed to participate and signed an informed consent, providing their email address and number of employees. There was no compensation for participating in this study; the company allowed the participation during working hours.

The eligibility criteria for the present study was (1) working at the assembly line (operator), (2) age between 18 and 65 years, (3) workers performing the same activity in the last 3 months, (4) currently not having a clinical diagnosed pathology and/or medical restrictions, and (5) currently not using any medical services.

2.4. Data collection and measures

Data collection occurred in October 2014 and April 2015, with October being the baseline survey (T0) and March the end of the follow-up (T1).

In both collection moments (T0 and T1), the same procedures of data collection were implemented: a link for the online survey was available during 15 days. If the participant failed to return a completed questionnaire within 10 days after the initial email, a second email with the link to the questionnaire was sent to increase the response rate. When this reminder did not succeed, a text message was sent to inform that the survey was closing in 24 hours and the participation was important.

Each time point collected information through the SurveyMonkey.inc platform.

2.4.1. The baseline survey

A baseline survey questionnaire was developed by the authors. The selection of the items/questions considered the Nordic Musculoskeletal Questionnaire [26], the SALTSA criteria document for WRULMSDs [1] and a survey developed by Bohr [27], which were adapted regarding this study's objectives.

To test the level of understanding and comprehension, as the time consumption of the survey, a pilot test was carried out with 15 volunteers. Accordingly, amendments to the final survey were made: the body map was replaced [28,29] and the introduction to the symptoms section (Section 4) was reviewed.

The final questionnaire contained 36 items, grouped in five sections: (1) sociodemographic data; (2) health data; (3) general health status perception; (4) work-related musculoskeletal symptoms; and (5) work-related information.

Section 1 included questions about age, gender, weight, height [to calculate the body mass index (BMI), where BMI < 25 kg/m^2 is normal weight, BMI 25–30 kg/m^2 is overweight, and BMI > 30 kg/m^2 is obese [30]], education, smoking, alcohol consumption, and regular exercise ("do you practice exercise—at least 2 to 3 times a week?"—*yes/no*).

Section 2 reported previous musculoskeletal injury (existence—*yes/no*—if yes, when occurred the last episode and the anatomical area), diseases (yes/no; if yes, "do you have any of the following diseases: (1) diabetes; (2) hypertension; (3) gout; (4) osteoporosis; (5) osteoarthritis; (6) herniated disc; (7) carpal tunnel syndrome; and (8) other—please specify") and medication data—"Do you take any medication regularly?—yes/no."

Section 3 gathered information on self-rated health, concerning the first single item of the Portuguese version of the 12-item short form Health Survey (Sf-12:v2) [31]. The workers should reply to the question "How do you rate your overall current health?" on a five-point Likert scale ranging from 1 (excellent) to 5 (poor).

Section 4 comprised the questions about the presence, intensity, and location of work-related musculoskeletal symptoms—discomfort/pain—assessed through a dichotomic question (yes/no answer). The worker should answer to two different moments: (1) *during the past month* and/or (2) *at the present*. If the worker reported having symptoms, the affected area should be selected in a body chart and then the intensity should be rated (0—no pain; 10—worst pain ever imagined). In the case there was more than one symptom, the participant should select the highest intensity symptom.

Finally, Section 5 was about job designation and perceived physical hazards—*manual material handling, repetitive movements, force, static work, and use of power tools/exposure to vibration*—its existence and the daily percentage for each situation (Table 1). Answer as *never/not applicable* and 25% of the day were considered as low physical exposure, as the other possibilities were considered as high physical exposure.

After 6 months (T1), the survey only collected data of Sections 3 and 4.

In addition, to the online survey, data as job tenure was collected through the company records.

2.4.2. Outcomes at 6-month follow-up: work-related musculoskeletal discomfort and pain

Musculoskeletal discomfort/pain was assessed through the presence of self-reported symptoms. For the present study, there were two outcomes of interest: work-related upper limb musculoskeletal symptoms (1) *during the past month* and (2) *at the present* (Table 2). These outcomes could help us to understand which musculoskeletal symptoms were maintained, and possibly distinguish, after 6 months, between the "new episodes" and the "chronic ones." We took into consideration the concept of *chronic health condition* as a subjective experience of a long-term disease with more than 3-month duration [32].

The referential from the SALTSA criteria document was adapted for this survey. This criteria takes into account the timeframe (symptoms at the present, within the past week, or within the last 12 months), duration (during at least 1 week), and frequency (at least 4 days during the last 7 days) [1,33]. Because we pretend to collect self-reported data on possible early episodes and also on chronic conditions (not diagnosed disorders), the question regarding the past month adapted the proposal of the SALTSA criteria from "symptoms present on at least 4 days during at least 1 week in the last 12 months" to "symptoms present during the past month at least 4 days during at least 1 week" (Table 2). Using the *past month* and *the present* could provide us a more explicit idea of the current cases.

Table 1
Baseline survey: explanatory of the physical hazards

	Question	Possible answers for each hazard:
Physical hazards	*Considering your daily work activities:* *Please identify the main characteristic(s) that describe your function by referring the average time you spend in the following situation(s):* 1. Manual material handling 2. Repetitive movements/gestures 3. Force application 4. Static work 5. Use of power tools	1. 100%/d 2. 75%/d 3. 50%/d 4. 25%/d 5. 0%/not appliable

Table 2
Primary outcomes in study

Outcome variable	Definition	Possible values
Symptoms past month	*During the past month, did you have musculoskeletal discomfort or pain present at least 4 d during at least 1 wk?*	1—yes; 2—no
Symptoms at the present	*At the present, or at least during 4 d during the last 7 d, have you experienced any musculoskeletal discomfort or pain?*	1—yes; 2—no

To determine the intensity of musculoskeletal symptoms, the pain intensity–numeric rating scale (PI-NRS) was used, validated to measure both discomfort and pain [34–36] and a body chart to determine the affected body area.

2.5. Statistical methods

Descriptive statistics were used to describe the participants' characteristics, as well as the outcomes after the 6-month period (presence of symptoms, location, and intensity, in the past month and at the present). Baseline differences were assessed using the independent *t* test and Chi-squared test for continuous and categorical variables, respectively. The McNemar test was used to test the tendency of having upper limb symptoms after 6 months and the paired sample *t* test was used to analyze mean intensity differences over time. An alpha level of 0.05 or less was accepted as statistically significant.

Logistic regression models were constructed using baseline variables as potential determinants for the outcomes in study. Bivariate analyses were conducted using *t* tests and Chi-squared analysis to identify statistically significant variables for inclusion in the multivariate model, considering a significance level of less than 0.20 [37,38]. Separate multivariate models, using backward conditional elimination method, were then built for each outcome status (at 6 months follow-up). Odds ratios and corresponding 95% confidence intervals were calculated for all variables in the bivariate and multivariate analyses. All variables remaining in the final model had an odds ratio with a *p* value less than 0.05. Participants with missing data (non-respondents or survey not completed) were excluded from the logistic regression analyses.

All statistical analyses were performed using SPSS software (IBM SPSS Statistics for Windows, version 22.0; IBM Corp., Armonk, NY, USA).

3. Results

3.1. Participants

From those 400 workers who accepted to participate, 200 replied to the baseline survey and complied with the inclusion criteria (Fig. 1).

After 6 months, 145 workers were in study (27.5% loss to follow-up)—Fig. 1—being these the participants included for analysis.

Taking into account the baseline (200), no significant differences were observed among the “respondents” ($n = 145$) and “no respondents” ($n = 55$), considering **gender** ($p = 0.702$), **age** ($p = 0.657$), **BMI** ($p = 0.177$), or **job tenure** ($p = 0.134$), although the group of missing data had higher BMI and lower tenure (26.25, standard deviation (*SD*) = 4.3; 13.98, *SD* = 6.8, respectively) (Table 3). Regarding **education**, participants reporting “secondary school” or greater represented the majority at baseline, existing a statistical difference for respondents and non-respondents ($p = 0.019$).

No statistically significant difference was verified for **diseases** ($p = 0.212$), **previous musculoskeletal injury** ($p = 0.627$), **exercise** ($p = 0.447$), or the **self-reported general health status** ($p = 0.676$). There was not also no statistically significant difference observed for the work-reported physical hazards **manual material handling** ($p = 0.653$), **repetitive movements** ($p = 0.103$), **force application**

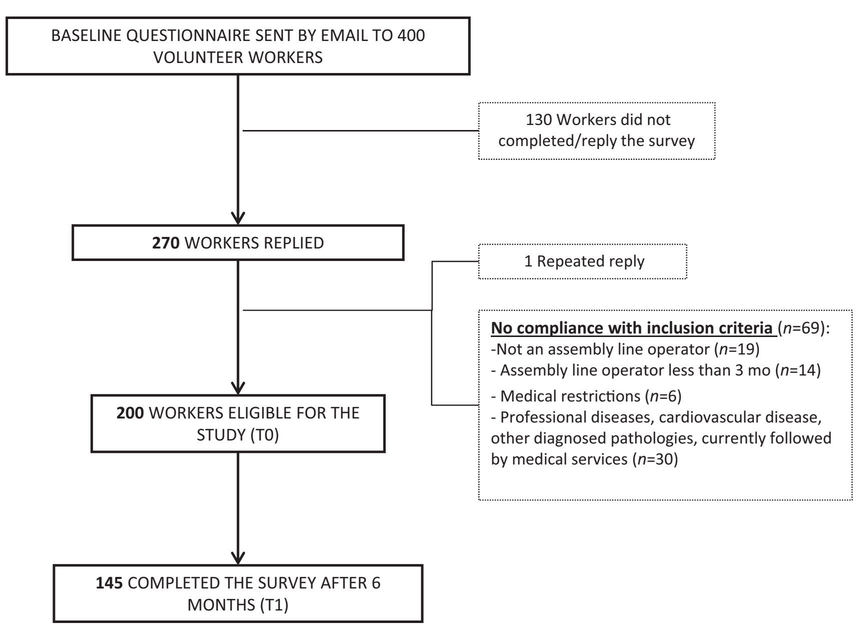

Fig. 1. Flowchart of participants.

Table 3
Baseline characteristics: all ($n = 200$) and the respondents ($n = 145$)

	Baseline ($n = 200$)			Respondents T0 and T1 ($n = 145$)		
Variable	N (%)	Mean	SD	N (%)	Mean	SD
Gender (male)	183 (91.5)	—	—	132 (91)	—	—
Age (y)	—	36.07	5.03	—	35.97	5.16
20–30	21 (10.5)	—	—	15 (10.3)	—	—
31–40	149 (74.5)			109 (75.2)		
41–50	29 (14.5)			20 (13.8)		
>50	1 (0.5)			1 (0.7)		
BMI (kg/m^2)		25.63	3.41		25.39	3
Normal (<25)	79 (39.5)	—	—	60 (41.4)	—	—
Overweight (25–30)	108 (54)			78 (53.8)		
Obese (>30)	13 (6.5)			7 (4.8)		
Education		—	—		—	—
Basic	55 (27.5)			34 (23.4)		
Upper secondary	134 (67)			101 (69.7)		
Higher school	11 (5.5)			10 (6.9)		
Tenure (y)	—	15.12	6.13	—	15.55	5.82
0–5	33 (16.5)	—	—	20 (13.8)	—	—
6–10	12 (6)			8 (5.5)		
11–15	21 (10.5)			16 (11)		
16–20	130 (65)			97 (66.9)		
21–25	4 (2)			4 (2.8)		
Diseases *(Yes)*	26 (13)	—	—	22 (15.2)	—	—
Diabetes	1 (0.5)			1 (0.7)		
Hypertension	4 (2)			3 (2.1)		
Other	21 (10.5)			18 (12.4)		
Previous musculoskeletal injury *(Yes)*	111 (55.5)	—	—	82 (56.6)	—	—
Last episode (y)						
<1	21 (10.5)			14 (9.7)		
1–5	34 (17)			25 (17.2)		
6–10	13 (6.5)			11 (7.6)		
>10	14 (7)			12 (8.3)		
NA	29 (14.5)			20 (13.8)		
Anatomical area						
Cervical	4 (2)			3 (2.1)		
Lumbar	11 (5.5)			9 (6.2)		
Upper limb	37 (18.5)			25 (17.2)		
Lower limb	36 (18)			27 (18.6)		
Other/NA	23 (11.5)			18 (12.4)		
Medication *(Yes)*	43 (21.5)	—	—	33 (22.8)	—	—
Regular exercise *(Yes)*	96 (48)	—	—	72 (49.7)	—	—
General health status		—	—		—	—
Excellent	12 (6)			10 (6.9)		
Very good	37 (18.5)			24 (16.6)		
Good	116 (58)			85 (58.6)		
Fair	34 (17)			25 (17.2)		
Poor	1 (0.5)			1 (0.7)		
Work-reported risk factors (yes)		—	—		—	—
Manual material handling	125 (62.5)			92 (63.4)		
Low physical exposure (0–25% d)	135 (67.5)			97 (66.9)		
High physical exposure (50–100% d)	65 (32.5)			48 (33.1)		
Repetitive movement	190 (95)			140 (96.6)		
Low physical exposure (0–25% d)	44 (22)			29 (20)		
High physical exposure (50–100% d)	156 (78)			116 (80)		
Force application	173 (86.5)			129 (89)		
Low physical exposure (0–25% d)	83 (41.5)			63 (43.5)		
High physical exposure (50–100% d)	117 (58.5)			82 (56.5)		
Static work	153 (76.5)			108 (74.5)		
Low physical exposure (0–25% d)	116 (58)			84 (57.9)		
High physical exposure (50–100% d)	84 (42)			61 (42.1)		
Power tools	120 (60)			82 (56.6)		
Low physical exposure (0–25% d)	118 (59)			88 (60.7)		
High physical exposure (50–100% d)	82 (41)			57 (39.3)		
Musculoskeletal symptoms (yes)		—	—		—	—
Past month	132 (66)			97 (66.9)		
Present	133 (66.5)			95 (65.5)		
Upper limb musculoskeletal symptoms (yes)		—	—		—	—
Past month	62 (31)			48 (33.1)		
Present	65 (32.5)			52 (35.9)		

SD, standard deviation; NA, no answer.

Table 4
Musculoskeletal symptom frequencies during 6 months: past month and present ($n = 145$)

Variable	T0	T1
	N (%)	N (%)
Musculoskeletal symptoms		
Past month	97 (66.9)	107 (73.8)
Present	95 (65.5)	109 (75.2)
Upper limb musculoskeletal symptoms		
Past month	48 (33.1)	70 (48.3)
Present	52 (35.9)	73 (50.5)

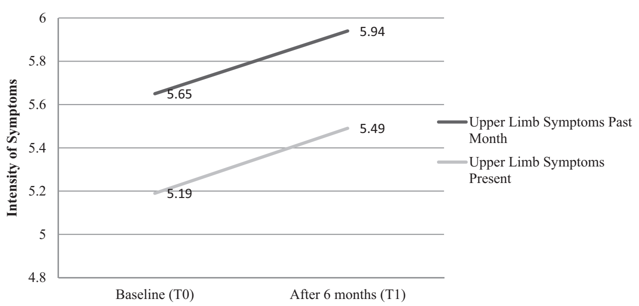

Fig. 2. Self-reported upper limb musculoskeletal symptoms' mean intensity for the past month and at the present (T0 and T1).

($p = 0.106$), **static work** ($p = 0.275$), and **power tools** ($p = 0.106$) (Table 3).

Finally, and regarding the self-reported musculoskeletal symptoms, no statistical significant difference was found between respondents and no respondents considering the **musculoskeletal symptoms presence past month** ($p = 0.664$) and **at the present** ($p = 0.194$); similar situation was verified for the **upper limb symptoms past month** ($p = 0.633$) and **at the present** ($p = 0.099$).

3.2. Baseline

Table 3 shows the results of the participants in study.

Having work-related musculoskeletal symptoms both past month and at the present was the most frequently reported (Table 3). From the 132 workers having symptoms past month, 115 (87%) were also reporting symptoms at the present. Considering the upper limb, similar reports were found for both past month and at the present: 62 (31%) and 65 (32.5%), respectively. From these 62 workers with symptoms past month, 51 (82.3%) reported also symptoms at the present.

3.3. Work-related upper limb musculoskeletal symptoms

After 6 months, the self-reported symptoms increased 6.9% for the past month and 9.7% for at the present (Table 4). Considering the upper limb, there was a significant increase of the number of reported upper limb musculoskeletal symptoms after 6 months: 15.2% the past month ($p = 0.001$) and 14.6% at the present ($p = 0.001$). From those 70 cases past month and 73 cases at the present (Table 4), 66 workers (45.5%) reported upper limb symptoms in both moments.

After the 6-month follow-up period, for the *past month*, the most reported upper limb anatomical areas were as follows: the shoulder (31.4%), the hand (20%), the cervical, and the wrist (17.1% each); for the *present*, the same anatomical areas were the most reported. Analyzing the baseline and the data after 6 months, a small change was observed regarding both past month and at the present: wrist complaints were higher than the hand symptoms at baseline, but not after 6 months. Shoulder was in all assessments the most reported anatomical area.

The upper limb musculoskeletal symptoms (discomfort/pain) mean intensity showed a nonsignificant increase for the past month [T0: M = 5.65, $SD = 2.026$; T1: M = 6.17, $SD = 1.730$; $t(47) = -1.506$, $p = 0.069$] and for the present [T0: M = 5.19, $SD = 0.269$; T1: M = 5.62, $SD = 2.069$; $t(51) = -1.144$, $p = 0.129$] (Fig. 2).

3.4. Determinants for having work-related upper limb musculoskeletal symptoms after 6 months

3.4.1. The upper limb musculoskeletal symptoms past month

The presence of upper limb symptoms past month after 6 months was statistically significant determined by "basic education" and "having upper limb musculoskeletal symptoms during the past month" at baseline (Table 5).

Table 5
Uni- and multivariate analyses: upper limb symptoms during the past month

Variable		Unadjusted OR		Adjusted OR
	p	OR (95% CI)	*p*	OR (95% CI)
Education				
Basic	**0.009**	0.053 (0.006–0.474)	**0.016**	0.056 (0.005–0.578)
Upper secondary	**0.060**	0.133 (0.016–1.088)	0.145	0.188 (0.020–1.782)
Higher*	**0.010**			
Diseases (yes)	**0.123**	2.094 (0.819–5.351)		
Type of disease	**0.081**	0.903 (0.804–1.013)		
Musculoskeletal symptoms past month (yes)	**0.012**	2.512 (1.221–5.168)		
Intensity musculoskeletal symptoms past month	**0.079**	0.909 (0.816–1.011)		
Upper limb symptoms past month (yes)	**<0.001**	9.226 (3.978–21.394)	**<0.001**	10.051 (4.153–24.326)
Intensity upper limb symptoms past month	**<0.001**	0.714 (0.619–0.825)		
Physical exposure/d_repetitive movements (high)	**0.041**	2.465 (1.036–5.865)		
Physical exposure/d_force (high)	**0.033**	0.482 (0.246–0.941)		
Use of power tools (yes)	**0.140**	1.648 (0.849–3.199)		
Physical exposure/d_power tools (high)	**0.028**	0.468 (0.238–0.923)		

CI, confidence interval; OR, odds ratio.
Level of significance <0.2 and <0.05 values are highlighted in bold.
* Reference category.

Table 6
Uni- and multivariate analyses: upper limb symptoms during at the present

Variable		Unadjusted OR		Adjusted OR
	p	OR (95% CI)	*p*	OR (95% CI)
Education				
Basic	**0.010**	0.104 (0.019–0.579)	**0.027**	0.116 (0.017–0.787)
Upper secondary	**0.126**	0.287 (0.058–1.420)	0.189	0.303 (0.051–1.802)
Higher*	**0.011**			
Diseases (yes)	**0.180**	1.898 (0.743–4.850)		
Type of disease	**0.121**	0.913 (0.813–1.024)		
Musculoskeletal symptoms present (yes)	**0.005**	2.787 (1.365–5.691)		
Intensity musculoskeletal symptoms present	**0.011**	0.858 (0.762–0.966)		
Upper limb symptoms present (yes)	**<0.001**	10.033 (4.333–23.235)	**<0.001**	9.728 (4.111–23.022)
Intensity upper limb symptoms present	**<0.001**	0.675 (0.572–796)		
Physical exposure/d_repetitive movements (high)	**0.138**	0.532 (0.231–1.226)		
Physical exposure/d_force (high)	**0.115**	0.587 (0.303–1.139)		
Physical exposure/d_power tools (high)	**0.145**	0.606 (0.309–1.188)		

CI, confidence interval; OR, odds ratio.
Level of significance <0.2 and <0.05 values are highlighted in bold.
* Reference category.

Considering education, there is not a significant difference between the reference category and the upper secondary education. Basic education, on the opposite, shows a significant difference suggesting approximately 50% of probability on developing upper limb symptoms past month (Table 5).

3.4.2. The upper limb musculoskeletal symptoms at the present

The multivariate analysis suggests as determinants for having upper limb musculoskeletal symptoms at the present, the variables “basic education” and “having upper limb musculoskeletal symptoms at the present” at baseline (Table 6).

4. Discussion

The main objective of this study was to determine which self-reported measures were related to work-related upper limb musculoskeletal symptoms—discomfort/pain—from data collected in two different moments: T0 and T1 (6 months of follow-up).

The participants selected for this study had similar characteristics to several studies in these type of settings: mostly men [39–41], with age mainly in the 31–40 years band [40,42], most in the 16–20 years of job tenure [2,39], and overweight [2,37,40,42]. When analyzing other characteristics of our population, we realize that from those workers reporting a previous musculoskeletal injury in the past, the upper and lower limb had similar frequencies. It is a fact that automotive assembly line workers frequently perform repetitive movements in static positions, which can explain the lower limbs reference. Other papers have advanced back, neck, shoulder, and leg as the anatomical areas with more reported symptoms [2,3,5,41]. On the other hand, the upper limb symptoms reported during 6 months by our population are slightly lower when comparing with what has been advanced in other studies in industry workers [7,23,43]. This means that the expectation regarding the number of workers with upper limb symptoms, which is that at least 50% would have self-reported complaints at any point of time [18], was lower in this population, especially at baseline. The frequency of upper limb musculoskeletal discomfort/pain increased significantly after the 6 months and only then it represented approximately half of the complaints reported. It could be the case that the date of the first survey (early October) can have an important part in these results, once the workers returned from vacations by the end of August. If this relation exists, 1-month working was not enough to match the expectation of 50% of reported upper limb symptoms.

Two multivariate analyses were obtained according to the presence of upper limb symptoms “past month” and “at the present,” being the reference the moment of the data collection. These models pointed out, for both outcomes, that having upper limb symptoms 6 months before and education were possible predictors. Although our study population reported, for both physical hazards “repetition” and “force,” a high physical exposure (over 50%/d), there were no significant relations between the work risk factors and the outcomes in study.

Considering that the reported upper limb symptoms increased significantly in 6 months, the multivariate analysis show two situations: (1) there was no resolution for most of the symptoms, especially taking into attention the fact that most workers with upper limb symptoms past month had also at the present and (2) new cases were reported. It can be advanced for this setting that once having upper limb symptoms, it would be maintained on time (persistence). As earlier reported [14], previous upper limb symptoms seem to be a specific risk factor.

Education, determinant for having symptoms past month and at the present, was the only statistically significant difference between groups (respondents vs. nonrespondents)—basic education had a higher representation in the data of the nonrespondents. The multivariate analysis can suggest higher school as a protective factor and, as already evidenced [37,44,45], lower education levels as basic education, a determinant of upper limb symptoms after 6 months.

The frequencies of reported symptoms *past month* and *at the present* are almost at the same number after 6 months and for both a significant increase was found during this period. To be able to make a distinction between a symptom present *past month* and *at the present* in each collection point could give us more information to the prior history of each worker. This subjective experience seems to be important and an essential part of the health surveillance in high demanding jobs [14]. Perhaps those results could suggest that after 6 months, there was no need to distinguish the presence of symptoms in those different periods. Instead, make us question if the determinants found would be site-specific—shoulder area. This was the most reported body region in all moments and for both outcomes, consistent with the published evidence for this setting [7,13,41,44,46].

To the best of our knowledge, this is the first study conducted in Portuguese assembly line workers concerning upper limb musculoskeletal symptoms determinants. There are some limitations regarding our results; this is a small population with missing data after 6 months. Although the missing data were 27.5%, in long-term follow-up studies, this could represent a low significant risk of bias [47]. Nevertheless, our results should be addressed carefully, once a preventive power analysis was not possible to perform. Instead, an analysis on the differences at baseline from all participants ($n = 200$) and those who maintained the reply after 6 months ($n = 145$) was performed. The fact that there were not significant differences for the demographic factors and the outcomes in study between the respondents and no respondents should also be considered.

On the other hand, our results give only limited support to self-reported variables as determinants of work-related upper limb musculoskeletal symptoms. Although self-reported factors can be significant predictors [48], clinical and work conditions assessment should be taken into account in future studies—quantitative measures would be necessary to analyze possible exposure–response associations [49].

Further investigation on health surveillance systems should consider that it is essential to find as many cases as possible and for that include assessment tools that are sensitive and symptom-based [50]. In addition, it would also be important to understand if shorter periods—weekly and monthly, for instance—could determine other relations. This can be decisive when developing a health surveillance system continuous in time.

Finally, another possible pitfall of data collected from self-reported is that this could lead to a possible misclassification bias and underestimation of the associations [32,51], especially when we are following a group of workers through time. This takes into consideration that the follow-up studies are more likely to maintain the workers with complaints [52].

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Conflicts of interest

All authors have no conflicts of interest to declare.

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