Occupational risk factors for shoulder diseases in the Spanish automotive manufacturing sector: a case-control study.

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Abstract

Background: Musculoskeletal Diseases (MSDs) are among the most prevalent health problems encountered in the workforce in Europe. Multiple risk factors contribute to their onset. In the present study, different individual risk factors for MSDs affecting the shoulder were analysed in a sample of workers from the automotive manufacturing sector.

Methods: An observational retrospective study was conducted with 73 cases of officially recognised occupational diseases and 94 cases of healthy workers. The experimental group comprised individuals with shoulder impingement disease. Another group of healthy individuals working in the same jobs was included as a control group. Multiple variables that identified the risks present in the job were assessed along with participants’ evaluation of said risks. Furthermore, two standardised information sources: the Spanish National Institute of Social Security (INSS) and the American Occupational Information Network (O*Net), were used to evaluate the risk factors present in each job. Both descriptive and multivariate statistical analyses were performed.

Results: The use of hand tools, exposure to mechanical pressure in the upper limbs and awkward postures were the most prevalent risk factors. The multivariate analysis revealed that pressure on the palm of the hand and the hand tool impacting the hand were the most important risk factors, alongside handling loads and certain awkward postures. Longer exposure times also increased the risk of injury, as did psychosocial factors such as lack of autonomy and mental workload.

Conclusions: Both ergonomic and psychosocial factors were present and increased the risk of developing occupational diseases of the shoulder in this sample of workers. Greater knowledge of how risk factors interact would facilitate the design of better preventive workplace strategies.

Introduction

Musculoskeletal disorders (MSDs) constitute a broad and complex occupational health problem in Europe, affecting a considerable portion of the working population in different sectors and occupations every year [1]. MSDs cover a wide range of conditions, from minor complaints and pains to more serious injuries requiring medical treatment and sick leave [2]. In some cases, the chronicity characteristics of MSD may even lead to permanent disabilities that prevent active work. The two
main groups of MSDs are back pain/injuries and work-related upper limb disorders (commonly known as ‘repetitive strain injuries’).

Most work-related MSDs develop over time [1].

There is usually no single cause of MSDs; rather, various factors often work in combination, with multiple risk factors contributing to the onset of these conditions. These factors are classified by the European Agency for Safety and Health at Work (EU-OSHA) as physical, organisational, psychosocial and individual risk factors [2]. Physical causes and organisational risk factors include handling loads, especially when bending and twisting, repetitive or forceful movements, awkward and static postures, vibrations, poor lighting or cold working environments, fast-paced work and prolonged sitting or standing in the same position.

The latest report issued by the European Agency for Safety and Health at Work (EU-OSHA) revealed a growing incidence of MSDs distressing millions of workers and an increasing impact on costs for employers [1]. Data from the European Survey on Working Conditions (ESWC) reveal that the most widely-reported health problems are MSDs in the form of backache (reported by 43%) and muscular pains in the neck or upper limbs (42%) [3]. Reported health problems vary according to occupation. Skilled agricultural workers report the highest incidence of backache (57%) and muscular pains in the arms and legs. Craftspeople and workers in related trades, as well as plant and machine operators and assemblers, also report significant complaints, with more than 40% of workers in these occupations suffering from MSDs.

In Spain, and according to the Health Authorities, MSDs represent over 80% of all occupational diseases [4]. Workers in the manufacturing industry report the highest incidence rate (87.7%). The most frequent occupational diseases are overuse MSDs related to physical risk factors (group II), mainly affecting the shoulder and the elbow [5]. More than 30% of permanent work disabilities in Spain are related to MSDs [6].

To overcome this health challenge, a wide range of legislative measures, policies and global strategies have been developed by international and national institutions. In addition to improving workers’ quality of life, the fight against MSDs also has economic benefits. To tackle MSDs, employers
must combine a serious risk analysis which assesses the full range of possible causes of injury, with the involvement of workers’ representatives in finding solutions to minimise said risks.

Over recent decades, the implementation of injury prevention policies has become obligatory for companies. Solutions are sometimes complex, requiring expert advice, but in many cases they are simple and inexpensive, such as, for example, using a trolley to help workers handle goods.

Preventive actions may involve changes at different levels, including workplace layout (adopting an ergonomic perspective in relation to equipment or tasks) and job organisation (rest breaks, job rotation or reallocation of work), while other solutions may involve the workers themselves (improving risk awareness, providing training on good work methods, etc.). Health monitoring, health promotion and the rehabilitation and reintegration of workers already suffering from MSDs also need to be considered in the management approach to MSDs. However, despite all the preventive efforts made by institutions, companies and different stakeholders working in the occupational healthcare field, the incidence of occupational diseases remains almost unchanged [3].

In the present study, different individual risk factors for MSDs affecting the upper extremities were analysed in a sample of workers employed in the same area of activity. The study focuses particularly on shoulder injuries, which are the most common among workers in Group 8 of the International Standard Classification of Occupations (ISCO). We hypothesise that age and exposure to the risk factors described will increase the risk of injuries, along with time employed at one’s current company. Knowledge of these risk factors and how they interact in the onset of the resulting pathologies may help develop better preventive strategies.

Methods
Sample
The study comprised a group of 73 cases of occupational MSDs recognised by the regulatory health authorities between 2009 and 2014. Only cases with diagnosis code 2D0101 (shoulder impingement syndrome) according to the national classification of occupational diseases [7] were included in the study. A control group of 94 healthy workers was also established, including only workers doing the same job under similar conditions during the same period as those already diagnosed with the
shoulder impingement syndrome.

Data extraction

Worker profiles and different clinical variables were retrieved from three different sources of information, the first being the clinical records of the workers included in the study, which also specified the characteristics of their different work activities. Variables such as sex, age, time employed at the company, time in current job, previous history of sickness, physical exercise and national occupation code (CNO) [7] were also recorded. Risk factors related to the type of job, such as manual handling of loads, repetitive movements, awkward postures (hands and arms above shoulder level), exposure to vibrations, mechanical pressure from using handheld tools, and use of personal protective equipment were analysed.

The second source of information was the 2nd Guide published by the Spanish National Institute of Social Security (INSS) [8]. This guide evaluates the intensity of the exposure to risk factors in the most common occupations and jobs. Physical workload, biomechanical load (repetitive movements and awkward postures), mental load and autonomy are all evaluated in this guide.

The third source of information was the American Occupational Information Network (O*Net), whose purpose is to provide information about standardised and occupation-specific descriptors for the majority of current occupations [9]. Data on awkward postures, repetitive movements, physical workload, manual handling of loads, mechanical pressure from using handheld tools, use of personal protective equipment and mental workload were registered from this source.

Information regarding the presence or absence of each factor was converted into dichotomised variables to enable comparisons and statistical analyses.

Using the information provided by the Spanish INSS Guide and the O*Net network was a means of obtaining standardised measurements of occupational risk factors, which were then used as variables in the study and compared with the information given by participants. In other words, it was a means of minimising potential memory bias from participants regarding job conditions.

Statistical analysis

First of all, a descriptive study of all the variables was carried out to determine the impact and
extension of exposure to the different risk factors. The means and standard deviations of continuous variables were calculated, as well as the absolute and relative frequencies of categorical ones. Differences in means were calculated using one-way analysis of variance (ANOVA) tests. Categorical variables were compared using Chi-squared tests. Odds ratios with 95% confidence intervals were obtained considering the occupational disease as a dependent variable. All analyses were performed using the SPSS 21 statistical package (IBM, Corp, Armonk, NY). For all comparisons, a two-tailed p-value lower than 0.05 was considered to indicate statistical significance.

Results
The majority of those participating in the study were male (90.4% of the total participants in the study; 93% in the cases group and 88% in the control group); the mean age is 47.5 years among the cases and 38.4 years in the control group. The most frequent CNO was 7323 (adjuster and operator of machinery and tools), accounting for 50.9% of all participants, and the second most common code was 7401 (motor vehicle mechanic and fitter), accounting for 21%; in relation with this variable there are no significative differences between groups.

As for time employed at the company, there are some differences between groups, almost 80% of cases worked more than 10 years in the company but only 27% of the participants in the control group worked so long in the company; a similar result was obtained when focusing on the time spent doing the same job.

In relation to risk factors, awkward postures were the most frequent when performing work activities. In 98.6% of cases, awkward postures meant keeping one’s arms above shoulder level, and almost 99% of cases were related to repetitive forced flexion-extension movements of the shoulders. These percentages are similar to the results obtained in the control group. Furthermore, 99% of participants with a diagnosed MSD were exposed to mechanical pressure, and 77.2% engaged in manual handling of loads.

When using standardised sources of information, the INSS shows as one of the main risks factors involved, the manual handling of loads. Physical workload was present in 65.8% of the cases at level 3, which means an intense activity equivalent to 9–12 METS, and biomechanical loading was found in
63.1% of cases (once again at level 3, meaning that it occurs during almost 60% of their working time); although physical and biomechanical workload are present in the 80% of participants that belong to the control group. Mental workload was frequently present in different ways, with lack of autonomy being present in 83% of cases and a high level of task complexity present in 98% of all participants in the study.

The O*Net network describes the manual handling of loads as the main risk factor involved in the different job descriptions reviewed along with the presence of awkward postures. The second most common risk factor was the use of handheld tools that was found in 79% of the work task descriptions. Similarly, to the Spanish INSS, the American network also explored mental workload, with the most important risk factor being lack of autonomy at work, present in 100% of job descriptions. A high level of precision tasks was present in 76.7% of job descriptions, being the second most frequent risk factor in this area. Percentages are similar in both groups.

The analysis of the association between risk factors and pathology revealed that time in job or at the company were the personal risk factors that most impacted the risk of developing an occupational disease. Thus, workers employed at the same company for between 13 and 60 months had a higher risk of developing an occupational disease, as did those who had been doing the same job for less than 3 months. A previous history of pathology and engagement in physical exercise outside work were not found to be risk factors (Table 1).
Table 1
Odds ratio for participants’ individual characteristics and occupational risk factors

| Risk factor                | OD 2D0101 (n:73) | CG (n:94) | OR  | 95% C.I.     | p   |
|----------------------------|-------------------|-----------|-----|--------------|-----|
| Previous History (yes/no)  | 14/59             | 14/80     | 0.73| 0.32-1.66    | 0.46|
| Physical Activity          | 31/42             | 43/51     | 1.14| 0.61-2.11    | 0.67|
| Time at the company        |                   |           |     |              |     |
| < 3 months                 | 0/73              | 11/83     | Not calculated | Not calculated |     |
| 3–6 months                 | 0/73              | 1/93      | Not calculated | Not calculated |     |
| 7–12 months                | 0/73              | 2/92      | Not calculated | Not calculated |     |
| 13–60 months               | 5/68              | 35/59     | 8.06| 2.96-21.92   | 0.00**|
| 61–120 months              | 9/64              | 19/75     | 1.80| 0.76-4.25    | 0.17|
| > 121 months               | 60/13             | 26/68     | 0.08| 0.03-0.17    | 0.00**|
| Time in current job        |                   |           |     |              |     |
| > 3 months                 | 1/72              | 11/83     | 9.54| 1.20-75.71   | 0.01*|
| 3–6 months                 | 5/68              | 3/91      | 0.44| 0.10-1.94    | 0.27|
| 7–12 months                | 3/70              | 3/91      | 0.76| 0.15-3.92    | 0.75|
| 13–60 months               | 16/57             | 30/64     | 1.67| 0.82-3.37    | 0.15|
| 61–120 months              | 16/57             | 17/77     | 0.78| 0.36-1.68    | 0.53|
| > 121 months               | 32/41             | 31/63     | 0.63| 0.33-1.18    | 0.15|

(OD = occupational disease; CG = control group; n = number of cases; OR = odds ratio; 95% CI = 95% confidence interval; p = p value).

*: p < 0.05; **: p < 0.01

The analysis of the work-related risk factors revealed that awkward postures and repetitive movements were not associated with the onset of the occupational disease. However, the manual handling of loads at the second weight level (between 3 and 15 kg) did emerge as a risk factor, as did the use of light hand tools, which was found to significantly increase the risk of overuse injury.

The same result was observed in relation to exposure to mechanical pressure on the arm. When focusing specifically on concrete areas of the arm, mechanical pressure on the palm of the hand was found to pose the highest risk, followed by exertion of mechanical pressure on the fingers. Impact by a hand tool on the heel of the hand was found to significantly increase risk, and exposure to vibrations increased the risk nearly twofold (see Table 2).
According to the Spanish INSS Guide, the risk factors that most increased the risk of overuse injuries were biomechanical and physical workload, and lack of autonomy was found to be the most statistically significant psychosocial risk factor (see Table 3).
Table 3
Odds ratio for occupational risk according to the INSS and the O*Net network

| Risk Factor                         | OD 2D0101 (n:73) | CG 18/76 76/18 | INSS OR 2.06 0.48 | 95% C.I. 1.01–4.2 0.23–0.98 | p 0.04 | O*Net OR 0.48 0.45 | 95% C.I. 0.22–0.92 | p 0.02 |
|-------------------------------------|------------------|----------------|-------------------|-----------------------------|--------|-------------------|-------------------|--------|
| Biomechanical Workload (yes/no)     | Level 2          | 24/49          | 18/76 76/18       | 2.19 0.45                   | 1.08–4.45 | 0.02             | 0.62              | 0.18–2.14 | 0.45 |
| Physical Workload Level 2           | 48/25            | 18/76 76/18    | 1.47 0.67         | 0.64–3.37                   | 0.35   | 0.55              | 0.48–0.63          | 0.21  |
| Manual Handling of loads            | Level 2          | 59/14          | 81/13 13/81       | 1.29 0.50                   | 0.17–9.42 | 0.45             | 0.89              | 0.42–1.85 | 0.75 |
| Mental Workload Level 2             | 35/38            | 46/48 48/46    | 0.96 1.04         | 0.52–1.77                   | 0.89   | 0.82              | 0.40–1.70          | 0.60  |
| Precision Tasks Level 2             | 2/71             | 2/92 92/2      | 1.29 0.50         | 0.17–9.42                   | 0.79   | 0.89              | 0.42–1.85          | 0.75  |
| Autonomy Level 2                    | 12/61            | 28/66 66/28    | 0.46 2.15         | 0.21–0.99                   | 0.04   | 0.04              | -                 | -     |

According to the data provided by the American Occupational Information Network (O*Net), exposure to precision tasks was the most important risk factor, followed by a heavy mental workload.

Discussion
At the beginning of our study we hypothesised that age and exposure to certain occupational risk factors would increase the risk of developing an MSD.

Our main results show that mean age is higher among participants in the cases group. Time at the company and time doing the same job increased the risk too. In relation to the occupational risk factors considered the main ones appeared to be awkward postures, manual handling of loads and the exposure to mechanical pressure exerted by tools.

One of the potential bias of the study is common to most of the occupational health studies, it’s the one of the healthy patient, that it means that when someone is doing a job and has health problems related to it, he is not normally working or he must be moved to another job, so individuals in this kind of studies are normally healthy people. In this study this bias is addressed by the inclusion of officially diagnosed people in the experimental group.

Another possible bias is in relation with the perception of their jobs risks by individuals participating in the study is addressed by the use of the two standardized sources of information, fact that enhances the validity of our results.
In the present study, different individual factors were found to increase the risk of pathology. As in previous reports, ageing is a factor that increases the risk of overuse injuries in the upper extremities [10-12]. Upon analysing pooled results in this sample, it becomes clear that duration of employment increased the risk among those who had worked at the same company for more than five years. These findings are consistent with those reported by other authors, who reached similar conclusions [13-15].

In relation to work-related risk factors, and unlike that reported in previous studies, our results indicate that while repetitive movements and awkward postures did increase the risk slightly, the difference was not statistically significant [16-17]. The use of hand tools (weighing more than 3 kg) increased the risk 9.03 times, a result that clearly differs from those obtained by other authors who found an OR of 1.4 [18]. Specifically, the largest OR was found when the hand tool put pressure on the palm, followed by when the mechanical pressure was exerted on the fingers [19-20]. In any case, the use of hand tools deserves further study in order to determine its impact more precisely.

The manual handling of loads had an OR of 1.96 when the weight was between 3 and 15 kg, but the risk increased drastically (OR of 9.6) when the weight was more than 15 kg. The OR reported by the INSS was 0.67, but only for heavy loads (over 15 kg). Other authors found that the risk only increased twofold [21-22].

Mental workload was analysed using only the information provided by the INSS and the O*Net network. Although both sources offer independent and standardised information, one of the study's limitations is that it did not record mental workload from the workers’ perspective. Consequently, the impact of this factor on the onset of occupational disease could not be analysed. In the present study, the risk for MSDs in the shoulder induced by mental workload was slightly higher according to the INSS data, and lack of autonomy had an OR of 2.15. This result is fairly similar to those reported in other studies, and the results obtained using the O* Net information were similar to those found by authors such as Roquelaure [18], Haar [23] and Haanan [24].

While many studies have analysed exposure to the different risk factors affecting the working population, only a very few have focused on workers with an occupational pathology officially
recognised by the public health system [25]. This is one of the strengths of the present study. All participants in the experimental group had been diagnosed by the public health authorities as having one of the occupational MSDs recognised by Spanish legislation. Furthermore, all participants in the study worked in the same area of activity, i.e. were automotive assembly employees, meaning that their work conditions and exposure to risk factors were fairly similar. Therefore, although the study includes a relatively limited number of participants, the similarity of the conditions under which they work increases the validity of the findings.

Conclusion
Exposure to the different risk factors analysed in this study increases the risk of developing occupational diseases. Ergonomic risk factors were found to be important, although not as important as expected. The use of light hand tools and the exertion of mechanical pressure on the palm of the hand were the factors that most increased the risk of occupational disease, followed by the manual handling of loads, mental workload and lack of autonomy. Further studies are required with more subjects diagnosed with occupational diseases to confirm our findings. In the meantime, however, certain measures should be taken, including organisational changes at work, the use of other types of hand tools and the establishment of a time limit for their use by workers.

Availability Of Data And Materials:
The datasets used and/or analysed during the present study are available from the corresponding author upon reasonable request.

Abbreviations
MSDs
Musculoskeletal Disorders
INSS
National Institute of Social Security
EU-OSHA
European Agency for Safety and Health
ESWC
European Survey on Working Conditions
ISCO
International Standard Classification of Occupations
CNO
National Occupation Code
Declarations

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Authors’ contributions:
B.R.D-C, conceived the idea, recorded all data and took the lead in writing the manuscript. J.A.B and C.B contributed to the design and implementation of the research, provided critical feedback, performed the analysis of the results and contributed to the final version of the manuscript.

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ETHICS DECLARATIONS:
At the time of initiating the project there was no Ethics in Research Review Board at our institution.
Data were collected from an anonymized database provided by the health services of the automotive company and the details of the study were revised and approved by the Doctorate Commission of the
Valencia Catholic University.

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