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ABSTRACT

Background: To compare risk factors for shoulder pain without and with rotator cuff syndrome (RCS).

Methods: A total of 3710 workers of a French region were randomly included in the cross-sectional study between 2002 and 2005. Personal and occupational risk factors were assessed during a physical examination and by a self-administered questionnaire. Multinomial logistic modeling was used for the following outcomes: no shoulder pain and no RCS (reference), shoulder pain without RCS (called 'shoulder pain') and RCS, separately for men and women.

Results: The prevalence rates of 'shoulder pain' for men and women were 28.0% and 31.1%, respectively, and the prevalence rates of RCS were 6.6% and 8.5%, respectively. In men, 'shoulder pain' and RCS were associated with age, high perceived physical exertion and arm abduction. Automatic work pace and low supervisor support were associated with 'shoulder pain', and high psychological demand and low skill discretion with RCS. In women, 'shoulder pain' and RCS were associated with age, repetitiveness of tasks, and low supervisor support. High perceived physical exertion and exposure to cold temperatures were associated with 'shoulder pain'.

Conclusions: Age was more strongly associated with RCS than with shoulder pain without RCS for both genders. Biomechanical and psychosocial factors were associated with 'shoulder pain' and RCS and differed between genders.

KEY WORDS. shoulder pain; rotator cuff syndrome; personal factors; work-related factors

INTRODUCTION

Shoulder disorders include both unspecific shoulder pain and specific disorders, in particular rotator cuff syndrome (RCS). The 12-month prevalence in the general population ranges between 7 and 47% for shoulder pain [Luime et al., 2004] and between 2 and 7% for clinically-diagnosed RCS [Roquelaure et al., 2006; Silverstein et al., 2006; Silverstein et al., 2008], depending on the population studied and the definition used. Because of the number of workers involved and the resulting high economic costs [Silverstein et al., 2006], information regarding the risk factors for shoulder disorders in the working population would help policy makers to implement preventive intervention in the workplace.

Several studies have identified risk factors associated with shoulder pain [Van der Windt et al., 2000] and with RCS [Van Rijn et al., 2010], but few have studied both disorders simultaneously [Miranda et al., 2005]. The main work-related biomechanical factors associated with shoulder pain and RCS are shoulder abduction and flexion, heavy lifting, forceful manual exertion, repetitive movements, use of vibrating hand tools and cumulative exposure to these factors [Bernard, 1997; Van der Windt et al., 2000; Malchaire et al., 2001; Miranda et al., 2001; Cassou et al., 2002; Frost et al., 2002; Leclerc et al., 2004; Svenden et al., 2004; Miranda et al., 2005; Miranda et al., 2008; Silverstein et al., 2008; Van Rijn et al., 2010]. Work-related psychosocial factors have been found to be associated with higher risk of shoulder pain [Van der Windt et al., 2000; Cassou et al., 2002; Leclerc et al., 2004; Bongers et al., 2006] but contradictory results have been reported for RCS [Malchaire et al., 2001; Silverstein et al., 2008; Van Rijn et al., 2010]. The risk of shoulder disorders related to the work organization has rarely been studied [Silverstein et al., 2008]. Although biomechanical factors are strongly associated with shoulder pain and RCS, several individual factors can increase the risk of shoulder pain and RCS (e.g., age) [Miranda et al., 2001; Leclerc et al., 2004; Miranda et al., 2005; Silverstein et al., 2008]. Women are considered to be at higher

risk of shoulder pain than men [Cassou et al., 2002; Leclerc et al., 2004; Miranda et al., 2005] and this could reflect both biological predisposition, overexposure to repetitive biomechanical work-related constraints and more intensive home activities [Malchaire et al., 2001; Miranda et al., 2005; Silverstein et al., 2009]. But there was no significant difference with respect to physical examination findings or clinically verified RCS [Miranda et al., 2005; Silverstein et al., 2009]. Diabetes mellitus, obesity and overweight, and several other medical conditions (e.g., rheumatoid arthritis) are known to increase the risk of shoulder pain and RCS [Miranda et al., 2001; Miranda et al., 2005]. Psychological distress, depression and anxiety have been associated with chronic shoulder pain [Miranda et al., 2001; Cassou et al., 2002; Leclerc et al., 2004; Miranda et al., 2005; Bongers et al., 2006].

The relative importance of personal and work-related factors for shoulder pain and RCS is still a matter of debate [Silverstein et al., 2008] It could be hypothesized that the relative importance of the risk factors differs between shoulder pain and RCS, with a stronger influence of individual factors, in particular, age, for RCS because, of the degenerative nature of the disorders. Psychosocial factors may be more often associated with shoulder pain because of the non-specific nature of the disorders [Miranda et al., 2005]. However, selection bias may have influenced the balance between personal and work-related factors in workers who are highly exposed to work constraints and/or those seeking treatment for shoulder disorders in the clinical setting [Frost et al., 2002; Leclerc et al., 2004; Svenden et al., 2004; Silverstein et al., 2006; Silverstein et al., 2008]. Since estimates of the risk of shoulder pain and RCS associated with biomechanical, psychosocial and work organization factors have often been assessed in highly exposed workers, this may bias generalization to the whole working population subjected to various levels of exposure to work-related shoulder constraints.

The surveillance program for upper-extremity musculoskeletal disorders (UE-MSD) implemented by the National Institute for Public Health Surveillance in the Loire Valley region in France has previously reported that RCS was the most frequently diagnosed UE-MSDs in a large study sample exposed to various levels of work-related constraints [Roquelaure et al., 2006]. The aim of the present study was therefore to assess the personal and occupational risk factors for unspecific shoulder pain and RCS and to compare their relative importance in both disorders in a large sample of workers representative of the regional working population.

MATERIALS AND METHODS

Study population

The study was based on the results of the surveillance program for UE-MSDs over a three-year period in the working population of the Loire Valley region (West-Central France) [Roquelaure et al., 2006]. All salaried workers in France, including temporary and part-time workers, undergo a mandatory annual health examination by an occupational physician (OP) in charge of the medical surveillance of a group of companies. Between April 2002 and April 2005, all OPs who practised in this region were invited to participate, and 83 of them (18% of OPs of the region) volunteered to take part in the study.

Subjects were selected at random, following a two-stage sampling procedure: first, 15 to 30 half-days of scheduled examinations for each OP were chosen for sampling by the investigators. Next, each OP was asked to randomly select from the schedule 1 out of 10 workers on the selected half-days of worker examinations. The selected workers were then recruited to the study by the OPs. A total of 3,710 workers (2,161 men (58.2%) with a mean age of 38.5+/-10.4 years and 1,549 women (42.8%) with a mean age of 38.9 ± 10.3 years) were included (2.0% of workers surveyed by the 83 OPs). Few workers failed to participate

(less than 10%: no shows, refusals, and duplications). Subjects worked mainly in the service industry (58.7%), the meat and manufacturing industry (34.0%) sectors, and more rarely in the construction (5.8%) and agriculture (1.5%) sectors. Men were mainly skilled and unskilled blue collar workers (56.0%), associate professionals and technicians (25.0%), and managers and professionals (9.7%). Most women were low-grade white collar workers (51.7%), skilled and unskilled blue collar workers (24.4%), and associate professionals and technicians (18.7%). Comparison of their socio-economic status with the last available French census (1999) (http://www.insee.fr) showed no major differences for either gender. Overall, the distribution of occupations was close to that of the regional workforce, except for the rare occupations not surveyed by OPs (e.g., shopkeepers and independent workers) [Roquelaure et al., 2006].

Outcomes

The two outcomes established for this study were shoulder pain during the preceding 12 months without diagnosed RCS and shoulder pain during the preceding 12 months with diagnosed RCS (Figure 1). In the remaining part of the report, the former will be called ‘shoulder pain’ and the latter RCS.

Musculoskeletal symptoms in the neck, shoulders and upper-limbs (aching, pain, discomfort etc.) were assessed using a modified version of the standardized Nordic-style questionnaire [Hagberg et al., 1995; Franzblau et al., 1997; Palmer et al., 1999; Crawford, 2007; Descatha et al., 2007]. The question “At any time during the last 12 months/7 days have you had trouble (ache, pain, discomfort) in the shoulders?” is asked for each anatomical area. A mannequin was used to denote the different anatomical regions and data for shoulders and neck were assessed independently of each other. The duration of symptoms during the last 12 months was asked (<24 hours, 1-7 days, 8-30 days, >30 days and permanently) and the intensity of

symptoms during the previous 7 days was assessed on a visual analog scale ranging from 0 to 10. If symptoms occurred in shoulders during the preceding 12 months, a physical examination was performed by the OP using a standardized clinical procedure based on the criteria document for the evaluation of work-related UE-MSDs [Sluiter et al., 2001] RCS was diagnosed if (i) there was currently intermittent pain in the shoulder region (without paresthesia), worsened by active elevation movement of the upper arm as in scratching the upper back, or for at least 4 days during the preceding 7 days; and (ii) at least one of the following shoulder tests was positive: resisted shoulder abduction, external or internal rotation; resisted elbow flexion; painful arc on active upper arm test (abduction-elevation) [Roquelaure et al., 2009].

Potential risk factors

The potential risk factors included personal factors, medical history, work history, and exposure to organizational, biomechanical and psychosocial work factors.

Personal factors and medical history, including information on age, BMI, diabetes mellitus and thyroid disorders, were collected during the physical examination and by a self-administered questionnaire.

Exposure related to work status and occupational risk factors were assessed with a self-administered questionnaire:

- Information was collected on the work history, namely length of service and the occupational category.
- The following characteristics were evaluated regarding work organization: time constraints (paced work, work pace dependent on automatic rate, other technical organization, colleagues' work, quantified targets, customers’ demand, permanent controls or surveillance), overtime hours, lack of prior information regarding the amount of work

to be done each day, work with temporary workers, job/task rotation and high visual demand.

- Several biomechanical risk factors for RCS were defined and quantified according to a European consensus [Sluiter et al., 2001]. The risk factors used for the criteria of the shoulder region were: repetitiveness of tasks, working with arms abducted, working with arms at or above shoulder level, holding the hand behind the trunk. Additional variables were considered such as high physical demand, use of handtools, use of vibrating handtools, keying and computer work, exposure to cold temperature and wearing gloves. Biomechanical factors were assessed for a typical working day in the past 12 months and using picture forms to facilitate workers' understanding. Response categories were presented on a 4-level Likert-type scale, as follows: never or practically never, rarely (less than 2 hours per day), often (2 to 4 hours per day) and always (more than 4 hours per day). Holding the hand behind the trunk, use of vibrating handtools and exposure to cold temperature were dichotomized because of the low number of exposed workers. Sustained or repeated arm posture in abduction was assessed by the combination of two questions and classified into four categories: no exposure, working with arms abducted alone (more than 2 hours per day), working with arms at or above shoulder level alone (more than 2 hours per day) and working with arms abducted and with arms at or above shoulder level. Perceived physical exertion was assessed for a typical workday using the Rating Perceived Exertion Borg scale (20-RPE) graduated from 6 ('very, very light') to 20 ('maximum exertion'). The Borg scale has been used in several ergonomic studies as a proxy for physical workload. In addition, it was demonstrated that the scale was correlated with heart rate [Daniels et al., 2005; Jang et al., 2007]. Workers with a high perceived physical exertion were dichotomized at the median.

- Psychosocial work factors (high psychosocial demand, low skill discretion, low decision authority, low supervisor support and low co-worker support) were assessed according to the Karasek Job Content Questionnaire, in its validated French version. Workers at risk were dichotomized using the median sum scores of SUMER, a national French study [Niedhammer et al., 2006].

Statistical analysis

Both outcomes were defined by subject, and thus bilateral shoulder pain or RCS counted as one case, not two. Analyses were performed separately for men and women to account for possible differences in exposure to work constraints between genders [Silverstein et al., 2009].

Firstly, relationships between the presence (or absence) of 'shoulder pain' and RCS and the potential risk factors were first studied by χ^2 or Fisher exact test.

Then, relationships between RCS and potential risk factors were studied by binary logistic regression according to a 3-stage process. In stage 1, univariate analyses were performed with each of the potential explanatory variables as independent variables and RCS as the dependent variable. Non-significant variables ($P > 0.20$) were excluded from further analyses, but age was retained regardless of statistical significance. In stage 2, the independent variables not excluded in stage 1 were grouped into five groups of potential determinants (personal factors and medical history, work history, factors related to work organization, biomechanical factors, and psychosocial factors at work). Backward multivariate logistic regression models were then applied for each group of variables in order to avoid colinearity between exposure variables in the final model (age was forced into the models). Non-significant variables ($P > 0.10$) were excluded after this stage. In stage 3, the remaining factors after these "within-group" models were entered into a final global multivariate logistic regression model and

manual backward selection retained only significant variables with a P-level at 0.05. In stage 2 and 3, if there was a change of at least 20% in the beta coefficients when a variable was deleted, this variable was considered as a confounder and was forced into the final model [Preux et al., 2005]. The same binary logistic regression was performed for shoulder pain according to several definitions: for more than 30 days during the preceding 12 months, daily during the preceding 12 months and during the preceding 7 days.

Next, multinomial models were built to examine the differences in the risk factors for shoulder pain without RCS and shoulder pain with RCS. The dependent variable comprised three categories: neither shoulder pain during the preceding 12 months nor RCS (reference), 'shoulder pain' and RCS. The independent variables included in the model comprised all remaining variables of the binary logistic regression. Only significant variables ($P < 0.05$) were included in the final models. Age was retained regardless of statistical significance. Each final multinomial model yielded an odds ratio (OR) associated with 'shoulder pain' and an OR associated with RCS for each risk factor. The two ORs associated with the same risk factor were compared with a Wald test.

All analyses were performed with the SAS statistical software package (version 9.2: SAS Institute. Inc., Cary. NC. US). All workers completed an informed consent form and the study received approval from France's National Committee for Data Protection (Commission Nationale de l'Informatique et des Libertés).

RESULTS

The prevalence of 'shoulder pain' was 28.0% for men and 31.1% for women, and the prevalence of clinically-diagnosed RCS was 6.6% for men and 8.5% for women. The corresponding values for carpal tunnel syndrome and lateral epicondylitis were 2.4% and 2.5% for men and 4.0% and 2.7% for women, respectively [Roquelaure et al., 2009]. The

average intensity among workers suffering from shoulder pain during the preceding 7 days was 4.1 ± 2.3 for men, and 4.6 ± 2.5 for women.

A comparison between the three categories (no shoulder pain and no RCS, 'shoulder pain' and RCS) is presented in Table 1, Table 2 and Table 3. The results showed that workers with RCS were significantly older (44.9 ± 8.3 years) than those suffering from 'shoulder pain' (39.4 ± 10.6 years) and those free from any shoulder disorder (37.6 ± 10.2 years). Moreover, workers with 'shoulder pain' and workers with RCS were more often exposed to biomechanical factors and psychosocial factors at work than workers without pain.

Binary logistic regressions showed that significant factors associated with shoulder pain and RCS were individual, organizational, biomechanical and psychosocial factors. Age, repetitiveness of tasks, high perceived physical exertion (RPE Borg scale ≥ 13), sustained or repeated arm posture in abduction (≥ 2 h/day) and low supervisor support were similar between men and women. However, others factors differed according to gender. For men, work pace dependent on automatic rate, high psychological demand and low skill discretion were significant in binary logistic models. Whereas, for women, work pace dependent on quantified targets, work pace dependent on permanent controls or surveillance, high visual demand, exposure to cold temperatures (≥ 4 h/day), wearing gloves and low co-worker support were significant.

The final multinomial models are presented in Table 4. For each gender, the relationship between age and RCS was significantly higher than for 'shoulder pain', whatever the age group. No association was observed for other individual factors (overweight, obesity and diabetes mellitus).

Work-related risk factors for men

Six work-related variables remained significant in the final multinomial model. The risk of 'shoulder pain' was higher among workers having a work pace dependent on an automatic

rate (OR 1.4). High perceived physical exertion appeared to be associated with both ‘shoulder pain’ (OR 1.4) and RCS (OR 2.2), without difference between ORs in the multinomial analysis. Moderate arm abduction (between 60° and 90°) for two hours or more per day was associated with ‘shoulder pain’ (OR 1.6) and greater abduction (over 90°) was a stronger risk factor for RCS (OR 2.4). The combination of sustained or repeated arm abduction over 60° and 90° was associated with both ‘shoulder pain’ (OR 1.8) and RCS (OR 2.6) (no difference between ORs). When considering exposure to psychosocial factors at work, ‘shoulder pain’ was associated with low supervisor support (OR 1.4) whereas RCS was associated with high psychological demand (OR 1.8) and low skill discretion (OR 1.7).

Work-related risk factors for women

None of the factors related to the work organization appeared to be significantly associated with both ‘shoulder pain’ and RCS in the final multinomial model. High perceived physical exertion appeared to be associated only with ‘shoulder pain’ (OR 1.3). A dose-response relationship was found with daily exposure to high repetitiveness of tasks, with ORs ranging from 1.1 to 1.5 for ‘shoulder pain’ and 1.1 to 2.3 for RCS. The differences between ORs for ‘shoulder pain’ and RCS were not significant. Moreover, exposure to cold temperatures increased the risk of ‘shoulder pain’ (OR 2.2). Low supervisor support was related to ‘shoulder pain’ (OR 1.3) and RCS (OR 1.6) without difference between ORs.

DISCUSSION

The study showed that the risk factors for ‘shoulder pain’ and RCS differed in a representative sample of workers exposed to various levels of work constraints. In our study, women reported more shoulder pain and RCS than men. This phenomenon was a common finding for shoulder pain [Cassou et al., 2002; Leclerc et al., 2004; Miranda et al., 2005] and this can be explained by the differences in exposure at work and/or at home, low muscle strength in

women [Kim et al., 2009], and/or psychosocial risk factors such as low social support and perceived stress [Malchaire et al., 2001; Rollman and Lautenbacher, 2001; Silverstein et al., 2009]. In studies using physical examination, no major difference was observed between men and women [Miranda et al., 2008; Silverstein et al., 2009]. Moreover, in the final multinomial models, factors associated with 'shoulder pain' and RCS differed according to gender.

The most important finding of this study was that age had a greater role in RCS than 'shoulder pain'. This is consistent with the natural history of RCS which involves 'normal' degenerative changes in the ageing rotator cuff tendons supported by epidemiologic literature [Miranda et al., 2001; Svenden et al., 2004; Miranda et al., 2005; Silverstein et al., 2008]. In a prospective study Silverstein et al. [Silverstein et al., 2009] showed that workers with symptoms at baseline were much more likely to have RCS one year later. Moreover, age and length of service were highly correlated, making it difficult to disentangle the role of age from the effects of cumulative exposure to occupational hazards in the interpretation of our results. It is possible that 'shoulder pain' corresponded to an early stage of the tendon disorder and, consequently, it could be expected, according to this hypothesis, that 'shoulder pain' occurs in younger workers than RCS.

Several biomechanical factors were associated with 'shoulder pain' and RCS. The study showed an association between sustained or repeated arm abduction for two hours or more per day and 'shoulder pain' and RCS in men, which is consistent with the literature [Bernard, 1997; Van der Windt et al., 2000; Frost et al., 2002; Leclerc et al., 2004; Svenden et al., 2004; Miranda et al., 2005; Silverstein et al., 2008; Van Rijn et al., 2010]. Clinical and biomechanical evidence shows that the biomechanical constraints of the glenohumeral joint and rotator cuff increase with the angle of abduction, reaching significant values from 60° to 90° [Järvholm et al., 1988; Hagberg et al., 1995]. The association between high repetitiveness of tasks and both disorders agrees with epidemiologic literature [Bernard, 1997; Van der

Windt et al., 2000; Cassou et al., 2002; Frost et al., 2002; Leclerc et al., 2004; Miranda et al., 2008; Van Rijn et al., 2010], but few studies have shown a dose-response relationship with daily exposure to highly repetitive movements. Our study showed a relationship between high perceived physical exertion and both disorders [Van der Windt et al., 2000; Van Rijn et al., 2010]. Hand-arm vibration has been reported to be associated with shoulder pain and RCS in some studies, [Van der Windt et al., 2000; Leclerc et al., 2004; Miranda et al., 2008; Van Rijn et al., 2010] but not in our study.

Few epidemiological studies have identified work organization characteristics as risk factors for 'shoulder pain' and RCS. In our study, only one work organization factor (work pace dependent on an automatic rate) was identified. The work organization determines the work constraints (e.g., arm posture). It could be hypothesized that biomechanical factors masked the effects of organizational factors in the multivariate analyses.

Significant relationships were found using the Demand-Control-Support model of stress at work but they differed according to gender. This difference could reflect differences in jobs and tasks [Bongers et al., 2006]. In the literature, no dimension of the Karasek model has been shown to be more important than any other [Van der Windt et al., 2000; Bongers et al., 2006; Van Rijn et al., 2010].

In contrast to several epidemiological studies, this study showed the factors associated with 'shoulder pain' and RCS by using logistic multinomial regression. Moreover, this study reported prevalence data for musculoskeletal symptoms and clinically diagnosed UE-MSDs in a large sample of workers, representing a wide range of both physical and mental occupational tasks. Its good representativeness in relation to the regional salaried workforce [Roquelaure et al., 2006] allows greater generalization of the results than epidemiological studies conducted in selected occupational populations. Few workers failed to participate but the cross-sectional design of the study meant that only individuals who were healthy enough

to work were included. A healthy worker effect thus could have occurred and may have led to an underestimation of the risk estimates.

We studied shoulder pain by means of the Nordic questionnaire. It permits sensitive and reproducible assessment of prevalence rates of musculoskeletal symptoms [Hagberg et al.,1995; Franzblau et al., 1997; Palmer et al., 1999; Crawford, 2007; Descatha et al., 2007]. RCS was diagnosed by OPs who were trained by the investigators to perform a standardized physical examination, using the recommendations of a European consensus to standardize the diagnoses of specific UE-MSDs [Sluiter et al., 2001]. Personal factors and work exposure were assessed by a self-administered questionnaire and by the physical examination. As far as possible, standardized and validated instruments were used to minimize exposure classification errors such as the European consensus for biomechanical factors [Sluiter et al., 2001] and the Karasek Job Content Questionnaire for psychosocial factors [Niehammer et al., 2006]. Organizational factors were collected using similar questions to those asked in several French surveys [Guignon, 2001; Cohidon et al., 2004]. However, we cannot exclude the possibility that self-reporting of exposure may have biased risk estimates, since workers experiencing musculoskeletal pain may overrate their exposure levels [Punnett and Wegman, 2004].

The main potential personal and occupational risk factors for shoulder disorders described in the literature were taken into account [Van der Windt et al., 2000; Malchaire et al., 2001; Van Rijn et al., 2010]. We did not study perceived stress or psychological distress, despite their possible association with shoulder disorders [Miranda et al., 2001; Leclerc et al., 2004; Miranda et al., 2005; Bongers et al., 2006; Miranda et al., 2008]. Non-work-related activities, such as housework, leisure and sports, were not assessed, although they may increase the risk of shoulder pain and RCS [Malchaire et al.,2001; Miranda et al., 2001; Cassou et al., 2002; Miranda et al., 2008; Silverstein et al.,2008]. Nevertheless, Miranda et al. [Miranda et al.,

2001] showed that some sports activities like jogging decreased the risk of shoulder pain whereas dancing or volleyball increased the risk. Silverstein et al. [Silverstein et al., 2008] observed no significant relationship between RCS cases and hobbies or sports activities. Consequently, we believe that the influence of non-work-related activities is probably not sufficient to diminish the value of the study.

In conclusion, this study showed that age was more strongly associated with RCS than with 'shoulder pain' for both genders. Moreover, work-related factors were associated with 'shoulder pain' and RCS but differed between genders. In contrast to work-related factors, age is not modifiable, mechanical and psychosocial exposure should therefore be an important target for strategies aimed at the prevention of shoulder pain and RCS in the working population.

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Figure 1: Flow chart of subjects according to shoulder pain and RCS