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Personal, biomechanical, and psychosocial risk factors for rotator cuff syndrome in a working population

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Objective Rotator cuff syndrome (RCS) is a major health problem among workers. The aim of the study was to examine the risk factors for RCS among workers exposed to various levels of shoulder constraints.

Methods From 3710 workers, representative of a French region's working population, trained occupational physicians diagnosed a total of 142 cases of RCS among men and 132 among women between 2002–2005. Diagnoses were established by standardized physical examination while personal factors and work exposure were assessed by self-administered questionnaires. Statistical associations between RCS and personal and work-related factors were analyzed for each gender using logistic regression modeling.

Results The personal risk factors for RCS were age [odds ratio (OR) for 1-year increment 1.07, 95% confidence interval (95% CI) 1.05–1.09, among men and 1.08, 95% CI 1.06–1.10, among women] and diabetes mellitus (OR 2.9, 95% CI 1.0–8.6, among women). The work-related risk factors were (i) sustained or repeated arm abduction (≥2 hours/day) >90° among men (OR 2.3, 95% CI 1.3–3.9) and >60° among women (OR 1.8, 95% CI 1.0–3.2) or both conditions among men (OR 2.0, 95% CI 1.1–3.7) and women (OR 3.6, 95% CI 1.8–7.3); (ii) high repetitiveness of the task (≥4 hours/day) among men (OR 1.6, 95% CI 1.0–2.4) and women (OR 1.7, 95% CI 1.1–2.5); (iii) high perceived physical demand among men (OR 2.0, 95% CI 1.3–3.1); (iv) high psychological demand among men (OR 1.7, 95% CI 1.2–2.5); and (v) low decision authority among women (OR 1.5, 95% CI 1.0–2.3).

Conclusion Personal (ie, age) and work-related physical (ie, arm abduction) and psychosocial factors were associated with RCS for both genders in this working population.

Key terms musculoskeletal disease; musculoskeletal disorder; MSD; physical exposure; RCS; tendinitis; work.

Rotator cuff syndrome (RCS) is a major cause of musculoskeletal pain and absence from work in the general and working populations (1–4). The shoulder girdle and the glenohumeral joint are exposed to considerable static and dynamic biomechanical constraints during manual work, especially during overhead work (5, 6). The physiopathology of RCS involves degenerative changes in the rotator cuff tendons with age, compression of the tendons between the humeral head and the coracoacromial arch, and ischemia by impingement or increased intramuscular pressure (5, 7). Shoulder biomechanical constraints are higher in the absence of arm or elbow support during sustained abduction (8). Epidemiological studies have demonstrated an increased incidence of RCS with age (2, 5, 9), but the natural history of the disorder may be difficult to predict among many workers (9). Women are considered to be at higher risk of RCS than men, and this could reflect both biological predisposition (sex-effect) and overexposure to repetitive biomechanical work-related constraints (gender-effect) (10). Diabetes mellitus, obesity, and several other medical conditions are known to increase the risk of RCS (11–13), but their impact on the working population is still not clear.

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Work-related biomechanical exposure has been associated with higher risk of RCS, especially repeated and sustained shoulder abduction and flexion (2, 11, 14–17), heavy lifting, forceful manual exertion (2, 11, 14–18), repetitive movements of the hands (2, 11, 14, 15), and cumulative exposure to these factors (2, 9, 11, 18). An association between RCS and the use of vibrating hand tools and trunk flexion has less often been reported (11, 18). The recent literature review of Van Rijn et al (19) confirmed the link between RCS and mechanical workload, but underlined the lack of information on exposure–response relationships between biomechanical factors and RCS.

Exposure to work-related psychosocial factors (eg, high psychological demand, low decisional latitude and low social support) has been found to be associated with higher risk of unspecific shoulder disorders (11, 17), but contradictory results have been reported for RCS, with some studies recording positive associations and others not (19). Selection bias may have influenced the balance between personal and work-related factors that probably revealed differences between exposed populations of workers and patients seeking care in a clinical setting compared to workers still at work systematically examined in an occupational health setting.

The relative importance of personal and work-related factors in RCS is still a matter of debate (14). Since estimates of the risk of RCS associated with biomechanical, psychosocial, and work organization factors have often been assessed among highly exposed workers (14–17), this may prevent generalization to the whole working population characterized by various levels of exposure to work-related shoulder constraints.

Using the data of the surveillance program for upper-extremity musculoskeletal disorders (UEMSD) in the working population of the Loire Valley region, we have previously reported that 13% of workers suffered from at least one clinically-diagnosed UEMSD (3, 20). Since RCS was the most frequent disorder, our aim in this study was to specifically examine the personal and work-related risk factors for RCS among workers exposed to various levels of shoulder constraints.

Methods

This study was based on surveillance data collected by a network of occupational physicians (OP) in the working population of the Loire Valley region (West-Central France) (21). The economic structure of this region (5% of the French working population) is diversified and similar to that of most French regions.

All French employees, including temporary and part-time workers, undergo a mandatory annual health examination by an OP in charge of the medical surveillance of a group of companies. The 83 OP out of 460 (18% participation) participating in the study were representative of the region's OP. All were trained by the investigators to randomly include workers undergoing a mandatory regularly-scheduled health examination between April 2002–2005. Fewer than 10% of the selected workers were not included (no shows, refusals, and duplications).

Study population

The study population comprised 3710 workers [2161 men (58%) and 1549 women (42%), mean age 38.7 years, standard deviation (SD) 10.3 years] out of 184 600 surveyed (sampling rate 2%) by the 83 OP. Comparison of their socioeconomic status with the last available French census in 1999 (http://www.insee.fr) showed no major differences with the regional workforce for either gender (21). Length of service in the current job was high for the majority of workers, whatever the gender. It was >10 years in 56%, >2 years in 84%, and >1 year in 94% of cases of RCS.

Outcomes

The presence of non-specific shoulder pain during the preceding 12 months and the preceding 7 days was identified using the Nordic questionnaire (5). In cases of shoulder symptoms occurring during the preceding 12 months, a physical examination was performed by the OP using a standardized clinical procedure that strictly applied the methodology and clinical tests of the European consensus criteria document for RCS and the five other UEMSD surveyed (lateral epicondylitis, ulnar tunnel syndrome, carpal tunnel syndrome, De Quervain's disease and flexor-extensor peritendinitis or tenosynovitis of the forearm-wrist region) (22).

RCS was diagnosed if (i) there was at least intermittent pain in the shoulder region (without paresthesia), worsened by active elevation movement of the upper arm, as in scratching the upper back, currently or for ≥4 days during the preceding 7 days; and (ii) if ≥1 of the following shoulder tests were positive: resisted shoulder abduction, external or internal rotation; resisted elbow flexion; painful arc on active upper-arm test (abduction–elevation).

Each OP received guidelines describing the clinical procedure (including diagnostic criteria charts and photographs of clinical tests) and underwent a 3-hour training program to standardize physical examinations.

Potential risk factors

Information was collected on personal and work-related factors known to be, or suspected of being, potential risk factors for shoulder disorders on the basis of epidemiological and ergonomic reviews (5, 7, 23–27). Medical history

was evaluated by interview during the physical examination. The personal and work-related factors were assessed using a self-administered questionnaire, which was filled out by workers just before the medical examination and then checked by the OP at the beginning of the medical examination. The response rate to all questions was >97%.

The personal factors assessed were age (1, 2, 5, 11, 23–25), body mass index (BMI) (2, 11, 18, 23), prior history and co-existence of other UEMSD (9, 14), diabetes mellitus (12, 13), and thyroid disorder (5). Age was considered as a continuous variable, after verification of the linearity of the logit, and then odd ratios (OR) were computed for 1-year increments. BMI was tested as categorical variable (normal, underweight, overweight, obese) for both genders. It was also considered as a continuous variable only among men, since the hypothesis of linearity of the logit was not verified among women.

Information was collected on the work history, namely, length of service (18, 24), and the occupational category (5, 19). The following characteristics in relation to work organization were evaluated: job title (5), main tasks, working time (24), repetitiveness of the task (11, 14, 15, 18, 23–25), time constraints (including paced work and norms of production) (5, 14, 18, 23, 26), visual load (5), daily and weekly job rotation and working with temporary workers. The psychosocial factors at work (psychological demand, decision latitude, and social support) were appraised with reference to the demand–control–support model (2, 11, 17, 19, 24–27), using the validated French version of the Job Content Questionnaire (28).

The working postures and biomechanical constraints taken into account were shoulder abduction and flexion (2, 11, 15–19, 24), shoulder extension (26), manual force and perceived physical demand of the task (11, 15–19, 24–25), use of vibrating hand tools (11, 19, 24–25), and exposure to cold (5, 11, 26). Posture and biomechanical constraints were quantified according to the European consensus criteria document (22), except for physical workload, which was assessed using a rating perceived exertion (20-RPE) Borg scale (3). Repeated and sustained shoulder abduction was assessed using two picture forms [one showing moderate arm abduction (60°) and another arm abduction above shoulder level] to facilitate workers' understanding. Response categories were presented on a 4-level Likert-type scale, as follows: "never or practically never", "rarely" (<2 hours/day), "often" (2–4 hours/day) and "always" (>4 hours/day).

Statistical methods

The outcome was defined by subject, and thus bilateral RCS counted as one case, not two. Analyses were performed separately for men and women to take into account possible differences in exposure to work constraints between genders (3, 5, 10, and 23). Relationships between RCS and potential risk factors were studied by binary logistic regression modeling according to a 3-stage process in order to reduce the risk of co-linearity between exposure variables in the final model. In stage one, univariate analyses were performed with each potential explanatory variable, and non-significant variables (P>0.20) were excluded from further analyses. In stage two, the remaining variables were grouped into five groups of potential determinants (personal factors and medical history, work history, factors related to work organization, psychosocial factors at work, working postures, and biomechanical constraints) and manual backward multivariate logistic regression models were performed within each group of factors. Prior history of at least one UEMSD and co-existence of other diagnosed UEMSD were not included in the model to avoid over adjustment since they share common risk factors with RCS. Age was forced into all models and non-significant variables (P>0.10) were excluded after this stage. In stage three, 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 stages two and three, any possible confounding effect of relevant variables was checked one by one and if a change of ≥15% in the beta coefficients occurred when a variable was deleted, this variable was considered as a confounder and forced into the final model. Finally, the personal and work-related variables not selected at these stages were put back into the final model to test whether these variables have an important impact on the presence of other variables (29).

Multiplicative interactions for the risk of RCS were assessed between (i) age and remaining variables, (ii) biomechanical and psychosocial variables, and (iii) BMI and biomechanical variables. Only interaction terms contributing to the final model with a P-value of <0.05 were retained in the model. Each model was tested with the Hosmer-Lemeshow goodness-of-fit test.

Results

The prevalence of uni- and bilateral RCS was 6.6% [95% confidence interval (95% CI) 5.5–7.6] among men (142 cases) and 8.5% (95% CI 7.1–9.9) among women (132 cases). At least one co-existing UEMSD of the elbow or wrist was diagnosed with RCS in 21.1% of men and 22.0% of women, mainly carpal tunnel syndrome (6.3% for men and 10.6% for women) and lateral epicondylitis (9.9% for men and 9.1% for women).

Analyses showed that numerous factors related to the personal characteristics and medical history, work history (table 1), work organization (eg, work pace) and psychosocial factors at work (table 2), and working postures and biomechanical constraints (table 3) were associated with

RCS after adjustment for age. The risk of RCS increased continuously with age between 20–59 years among men (1-year increment of age OR 1.07, 95% CI 1.05–1.09) and women (1-year increment OR 1.08, 95% CI 1.05–1.10). The risk increased also with length of service for each gender, with highest risks for length of service in the current job >10 years. However, age and length of service were highly related (Chi-square test, P<0.001 among men and women), and the association between RCS and length of service was statistically significant for younger workers (<45 years) (Chi-square test, P<0.01 among men and women), but not for older workers (≥45 yrs). Neither obesity (BMI ≥30 kg/m^2) [age-adjusted OR (OR_{adj}) 1.4, 95% CI 0.8–2.5, among men and OR_{adj} 1.2, 95% CI 0.6–2.2, among women] or overweight (BMI 25–29.9 kg/m^2) were associated with RCS after adjustment for age. However, the increased risk of RCS with BMI considered as a continuous variable [OR (for 1-kg/m^2 increment of BMI) 1.04, 95% CI 0.99–1.09; P=0.137], was of borderline significance among men after adjustment for age.

The final logistic risk models of RCS differed between genders and highlighted a limited number of factors (7 among men and 5 among women) (table 4). The risk of RCS increased consistently with age between 20–59 years, with OR for 1-year increment of 1.07 (95% CI 1.05–1.09) among men and 1.08 (95% CI 1.06–1.10) among women. Diabetes mellitus was related to RCS among women (OR 2.9, 95% CI 1.0–8.6), but not among men. On the other hand, the risk of RCS increased with BMI among men [OR (for 1-kg/m^2 increment of BMI) 1.04 (95% CI 0.99–1.10)], but not among women.

Neither the length of service in the current job nor the occupational category was associated with RCS in men or women, after adjustment for the other potential confounders. Performing highly repetitive actions (≥4 hours/day) was associated with RCS among men (OR 1.6, 95% CI 1.0–2.4) and women (OR 1.7, 95% CI 1.1–2.5). High perceived physical demand (RPE-Borg scale ≥13) was associated with RCS among men (OR 2.0, 95% CI 1.3–3.1), but not significantly among women. An important work-related risk factor for RCS for both genders was the occurrence of sustained and repetitive arm abduction during work, mostly with the arm unsupported (>90% for both genders). The strength of association was high for abduction >90° (≥2 hours/day) among men (OR 2.3, 95% CI 1.3–3.9), abduction >60° (≥2 hours/day) among women (OR 1.8, 95% CI 1.0–3.2), and arm abduction >60° (>2 hours/day) combined with arm abduction >90° (≥2 hours/day) among men (OR 2.0, 95% CI 1.1–3.7) and women (OR 3.6, 95% CI 1.8–7.3). No other shoulder working posture was associated with RCS for either gender. Neither use of vibrating hand tools nor exposure to cold environments or objects was related to RCS for either gender.

The statistical modeling highlighted different psychosocial risk factors for RCS according to gender: the high psychological demand of the task (OR 1.7, 95% CI 1.2–2.5) and low skill discretion (OR 1.4, 95% CI 1.0–2.1; P=0.066) among men, and low decision authority (OR 1.5, 95% CI 1.0–2.3, among women). No other factors related to the work organization remained in the final models.

No significant interaction was found between age and the other variables of the models. Considering the biome-

Table 1. Potential personal and occupational risk factors for rotator cuff syndrome (RCS) considered in the study and univariate analyses [N_{RCS}=number RCS cases; OR_{adj}=odds ratios adjusted for age; 95% CI=95% confidence interval; Ref=reference.]

	Men (N=2161)					Women (N=1549)				
	N	N_{RCS}	OR_{adj}	95% CI	P-value	N	N_{RCS}	OR_{adj}	95% CI	P-value
Personal factors										
Age			1.07	1.05–1.09	<0.20			1.08	1.05–1.10	<0.20
Body mass index (kg/m^2)										
Normal (18.5–24.9)	1173	63	Ref	..		984	74	Ref	..	
Underweight (<18.5)	34	0	.	..		90	4	0.8	0.3–2.2	
Overweight (25–29.9)	755	55	1.0	0.7–1.5		323	37	1.3	0.8–2.0	
Obese (≥30)	175	18	1.4	0.8–2.5		125	13	1.2	0.6–2.2	
Diabetes mellitus	40	4	1.0	0.3–2.8		21	5	2.8	1.0–8.1	<0.20
Thyroid disorders	33	2	0.7	0.2–3.2		102	10	0.9	0.4–1.7	
Occupational factors										
Current occupational category										
Managers, professionals, technicians	763	37	Ref	..	<0.20	370	24	Ref	..	<0.20
Low-grade white-collar	187	8	1.1	0.5–2.3		799	60	1.3	0.8–2.1	
Skilled blue-collar	832	69	2.0	1.3–3.0		111	15	2.2	1.1–4.5	
Unskilled blue-collar	377	28	2.1	1.2–3.5		266	33	2.1	1.2–3.7	
Number of years in the current job										
<1	270	6	Ref	..	<0.20	185	11	Ref	..	
1–2	334	18	2.2	0.9 – 5.7		257	10	0.6	0.2–1.4	
3–10	725	35	1.7	0.7 – 4.2		513	39	1.0	0.5–1.9	
>10	809	82	2.5	1.0 – 5.9		580	72	1.0	0.5–2.0	

Table 2. Factors related to work organization and psychosocial potential risk factors for rotator cuff syndrome (RCS) considered in the study and univariate analyses. [N_{RCS}=number RCS cases; OR_{adj}=odds ratios adjusted for age; 95% CI=95% confidence interval.]

Occupational factors	Men (N=2161)					Women (N=1549)				
	N	N_{RCS}	OR_{adj}	95% CI	P-value	N	N_{RCS}	OR_{adj}	95% CI	P-value
Factors related to work organization										
High repetitiveness of the task (≥4 hours/day)	477	51	2.3	1.6–3.3	<0.20	481	62	2.2	1.5–3.1	<0.20
Paced work	235	21	1.7	1.1–2.8	<0.20	148	17	1.7	1.0–3.0	<0.20
Work pace dependent on automatic rate	258	22	1.7	1.0–2.7	<0.20	142	18	1.9	1.1–3.3	<0.20
Work pace dependent on other technical organization	554	37	1.2	0.8–1.7		188	23	1.8	1.1–2.9	<0.20
Work pace dependent on customers' demand	928	55	0.9	0.6–1.3		715	54	0.9	0.6–1.3	
Work pace dependent on the colleagues' work	698	51	1.3	0.9–1.9	<0.20	411	33	1.0	0.6–1.5	
Work pace dependent on quantified targets	1122	74	1.2	0.8–1.7		607	66	1.8	1.2–2.6	<0.20
Job/task rotation (≥1 job rotation per week)	815	57	1.2	0.8–1.7		535	54	1.6	1.1–2.4	<0.20
Work with temporary workers	639	46	1.4	1.0–2.1	<0.20	467	35	1.0	0.7–1.5	
High visual demand	421	27	1.0	0.6–1.5		311	34	1.5	1.0–2.3	<0.20
Overtime hours	1376	83	0.8	0.6–1.2		810	60	0.8	0.6–1.2	
No prior knowledge of the daily workload	288	15	0.9	0.5–1.5		78	4	0.6	0.2–1.8	
Work pace dependent on permanent controls	575	37	1.1	0.7–1.6		361	38	1.6	1.1–2.4	<0.20
Psychosocial factors at work										
High psychological demand (score ≥22)	1050	83	1.6	1.1–2.3	<0.20	765	65	1.0	0.7–1.5	
Low skill discretion (score ≤34)	1060	87	1.7	1.2–2.5	<0.20	956	92	1.4	0.9–2.1	<0.20
Low decision authority (score ≤32)	652	41	0.9	0.6–1.3		624	69	1.8	1.2–2.5	<0.20
Low supervisor support (score ≤11)	850	64	1.4	1.0–1.9	<0.20	577	63	1.6	1.1–2.3	<0.20
Low coworker support (score ≤11)	406	28	1.0	0.7–1.6		302	33	1.3	0.9–2.0	<0.20

Table 3. Working posture and biomechanical constaints considered in the study and univariate analyses. [N_{RCS}=number RCS cases; OR_{adj}=odds ratios adjusted for age; 95% CI=95% confidence interval; RPE=rating perceived exertion]

Occupational factors	Men (N=2161)					Women (N=1549)				
	N	N_{RCS}	OR_{adj}	95% CI	P-value	N	N_{RCS}	OR_{adj}	95% CI	P-value
Working postures and biomechanical constraints										
High perceived workload (RPE–Borg scale)	1168	104	2.6	1.8–3.9	<0.20	688	76	1.6	1.1–2.4	<0.20
Sustained or repeated arm posture in abduction (≥2 hours/day)										
No	1621	85	Ref	..	<0.20	1222	86	Ref	..	<0.20
>60°	223	14	1.5	0.8–2.7		139	20	2.4	1.4–4.2	
>90°	168	25	3.2	2.0–5.2		109	12	1.7	0.9–3.3	
Both	137	18	3.1	1.8–5.5		72	13	3.9	2.0–7.7	
Holding the hand behind the trunk (≥2 hours/day)	110	9	1.2	0.6–2.5		77	10	2.1	1.0–4.2	<0.20
Use of handtools										
Never	668	33	Ref	..	<0.20	816	56	Ref	..	<0.20
<2 hours/day	323	23	1.7	1.0–3.0		166	11	0.9	0.5–1.8	
2–4 hours/day	518	38	1.7	1.1–2.8		260	27	1.5	0.9–2.5	
≤4 hours/day	641	48	1.8	1.2–2.9		292	37	2.0	1.3–3.2	
Use of vibrating handtools (≥2 hours/day)	407	35	1.7	1.1–2.5	<0.20	62	10	2.3	1.1–4.8	<0.20
Exposure to cold temperature (≥4 hours/day)	149	7	0.8	0.3–1.7		71	6	1.3	0.6–3.2	

chanical and psychosocial variables, an interaction was observed between high perceived physical demand and low skill discretion among men (P=0.016). High perceived physical demand was associated with higher risk of RCS, but the association was statistically significant only when (male) workers were exposed to low skill discretion opportunities (OR 3.6, 95% CI 1.8–7.0). Low skill discretion was significantly associated with RCS only when workers were exposed to a high perceived physical demand (OR 2.0, 95% CI 1.2–3.2) (data not shown in table 4).

The risk of RCS increased with the cumulative exposure to sustained and repetitive arm abduction, repetitiveness of the task and high perceived physical demand among men and the two former variables among women. Thus, the risk reached 2.3 (95% CI 1.4–3.7) for exposure to one or two out of three risk factors among men and 5.7 (95% CI 3.1–10.4) when all were accumulated, after adjustment for the other confounding factors. The corresponding values for women were 1.8 (95% CI 1.1–2.7) for exposure to one factor

Table 4. Multivariate model for risk factors of rotator cuff syndrome (RCS) in the male and female working populations [N_{RCS}=number RCS cases; OR=odd ratios; 95% CI=95% confidence interval.]

	Men (N=2078) N_{RCS}=135 [a]						Women (N=1504) N_{RCS}=126 [a]					
	N	N_{RCS}	$\%_{RCS}$	OR	95% CI	P-value	N	N_{RCS}	$\%_{RCS}$	OR	95% CI	P-value
Age (1-year increment)				1.07	1.05–1.09	<0.001				1.08	1.06–1.10	<0.001
BMI (1-kg/m² increment)				1.04	0.99–1.10	0.085						
Diabetes mellitus												
No							1483	121	8.2	Ref	..	
Yes							21	5	23.8	2.9	1.0–8.6	0.050
High repetitiveness of the task												
<4 hours/day	1622	87	5.4	Ref	..		1029	65	6.3	Ref	..	
≥4 hours/day	456	48	10.5	1.6	1.0–2.4	0.033	475	61	12.8	1.7	1.1–2.5	0.016
High perceived workload (RPE– Borg scale)												
<13	955	35	3.7	Ref	..							
≥13	1123	100	8.9	2.0	1.3–3.1	0.001						
Sustained or repeated arm posture in abduction (≥2 hours/day)												
No	1564	80	5.1	Ref	..		1196	83	6.9	Ref	..	
>60°	219	13	5.9	0.9	0.5–1.8	0.828	134	18	13.4	1.8	1.0–3.2	0.047
>90°	162	25	15.4	2.3	1.3–3.9	0.002	105	12	11.4	1.6	0.8–3.1	0.197
Both	133	17	12.8	2.0	1.1–3.7	0.024	69	13	18.8	3.6	1.8–7.3	<0.001
High psychological demand												
No	1056	55	5.2	Ref	..							
Yes	1022	80	7.8	1.7	1.2–2.5	0.005						
Low skill discretion												
No	1043	53	5.1	Ref	..							
Yes	1035	82	7.9	1.4	1.0–2.1	0.066						
Low decision authority												
No							892	59	6.6	Ref	..	
Yes							612	67	11.0	1.5	1.0–2.3	0.038

[a] 83 men (out of 2161) and 45 women (out of 1549) were excluded from analyses because of data missing for ≥1 variables included in the logistic models.

and 3.4 (95% CI 2.0–5.7) for exposure to both factors.

As shown in table 5, reporting the multivariate analyses stratified by age in both genders, increased risk of RCS related to sustained or repeated shoulder abduction was observed in both age groups (20–44 and 45–59 years) regardless of gender. However, the risk effect for high perceived workload remained considerably elevated only in older male workers, while the risk for the repetitiveness of the task was increased only among younger men and older women. Of the personal factors, diabetes mellitus remained greatly increased (but of borderline significance) only in younger women.

Discussion

This study involving a large number of cases of RCS confirmed by clinical diagnosis in a large representative sample of salaried workers showed the multifactorial origin of the disorder and highlighted a limited number of personal and work-related risk factors.

The risk models for RCS differed between genders, with the exception of age, repetitive movements and posture with sustained or repeated arm abduction, which were common for men and women. This gender difference more probably reflects differences in exposure to constraints at work than physiological differences (eg, body size) (10, 23).

Among the potential personal factors studied, ageing seemed to play a major role in this working population. This confirms previous findings in the general population (11), but contradictory results have been reported among selected working populations exposed to high constraints (2, 14). The increased risk of RCS with age is consistent with knowledge on the occurrence of "normal" degenerative changes in ageing rotator cuff tendons (12, 13, 30). However, age and length of service in the current job were highly correlated in our study. Consequently, although age seemed to play a higher role than length of service, its role is difficult to disentangle from the effects of cumulative exposure to occupational hazards in the interpretation of our results. The frequent co-existence of shoulder tendinopathy with other UEMSD that we found is often observed in clinical practice and epidemiological surveillance data (1, 3). However, this variable has not been taken into account in the risk models of RCS to avoid over-adjustment since the other

Table 5. Multivariate model for risk factors of rotator cuff syndrome stratified by age in the male and female working populations. All models adjusted for age (continuous). [N_{RCS}=number RCS cases; OR=odds ratios; 95% CI=95% confidence interval; Ref=reference]

	Men						Women					
	20–44 years (N=1413) N_{RCS}=61 [a]			45–59 years (N=665) N_{RCS}=74 [b]			20–44 years (N=1003) N_{RCS}=51 [c]			45–59 years (N=501) N_{RCS}=75 [d]		
	OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value	OR	95% CI	P-value
BMI (1-kg/m² increment)	1.07	1.00–1.15	0.070	1.02	0.95–1.09	0.619						
Diabetes mellitus												
No							Ref	..		Ref	..	
Yes							5.3	0.9–29.9	0.058	2.1	0.5–8.4	0.291
High repetitiveness of the task												
<4 hours/day	Ref	..		Ref	..		Ref	..		Ref	..	
≥4 hours/day	2.4	1.3–4.4	0.003	1.0	0.5–1.9	0.975	1.4	0.7–2.6	0.294	2.0	1.1–3.5	0.016
High perceived workload (RPE– Borg scale)												
<13	Ref	..		Ref	..							
≥13	1.3	0.7–2.3	0.482	2.8	1.5–5.2	0.001						
Sustained or repeated arm posture in abduction (≥2 hours/day)												
No	Ref	..		Ref	..		Ref	..		Ref	..	
> 60°	1.0	0.4– 2.3	0.974	0.9	0.3–2.4	0.763	2.2	1.0–5.1	0.065	1.5	0.6–3.3	0.365
> 90°	2.5	1.1–5.7	0.029	2.2	1.1–4.4	0.030	2.2	0.8–5.7	0.106	1.1	0.4–2.8	0.881
Both	2.6	1.1–6.3	0.029	1.7	0.7–3.9	0.249	3.1	1.1–8.7	0.033	4.5	1.6–12.5	0.004
High psychological demand												
No	Ref	..		Ref	..							
Yes	1.8	1.0–3.2	0.040	1.6	1.0–2.6	0.073						
Low skill discretion												
No	Ref	..		Ref	..							
Yes	1.8	1.0–3.3	0.058	1.2	0.7–2.0	0.540						
Low decision authority												
No							Ref	..		Ref	..	
Yes							1.3	0.7–2.3	0.425	1.7	1.0–2.9	0.054

[a] 46 observations excluded from analyses, because of data missing for ≥1 variables included in the logistic models.
[b] 36 observations excluded from analyses, because of data missing for ≥1 variables included in the logistic models.
[c] 23 observations excluded from analyses, because of data missing for ≥1 variables included in the logistic models.
[d] 22 observations excluded from analyses, because of data missing for ≥1 variables included in the logistic models.

UEMSD under study share several common risk factors with RCS. Our study did not find an association between high BMI and RCS among women, but an increased risk for each 1-kg/m² increment of BMI was of borderline statistical significance among men. Mechanical load and metabolic factors have been suggested to explain the relation between overweight and RCS (12, 13). Some epidemiological studies of clinically defined RCS have reported an association with overweight and obesity (12, 13, 18, 31) while others have not (11, 14). Methodological reasons, mainly a lack of statistical power, could explain why we cannot draw a clear conclusion from our results. Rechardt et al (13) recently reported that RCS in a large Finnish general population was associated with waist circumference among men but not BMI. This parameter is related to abdominal obesity and could provide a better measurement of weight-related factors of RCS than BMI. Our results showed an increased risk of RCS in cases of co-existing diabetes mellitus among women. However, our results were based on a small number of cases of RCS and this could be explained by the low severity of the shoulder disorders diagnosed among workers still at work, compared to possibly more severe disorders recruited from the general population and even more from orthopedic or rheumatology clinics. Our results agree with the epidemiological literature on clinically-diagnosed RCS which shows more consistent association with diabetes mellitus than obesity (11, 12, 18). This is also in accordance with clinical experience showing high prevalence of RCS and rotator tears in patients suffering from diabetes (13). Higher risk of RCS has been reported for type I than type II diabetes (11, 13). No information was available on patients' medication in our study and we could therefore not define the type of diabetes involved. However, although the risk effect was greater among women <45 years, it is likely that most of them were suffering from type II diabetes since this type is much more common in the population (12).

Sustained or repeated working posture with the arm abducted was the main work-related risk factor for RCS in this large representative working population, without modification of the effect by age. The strength of association was high (OR>2) for abduction >90° (>2 hours/day) among men and for arm abduction >60°

(>2 hours/day) combined with arm abduction >90° (>2 hours/day) among women. Strong biomechanical evidence supports these findings since the main pathophysiological mechanisms of RCS are compression of the tendons between the humeral head and the coracoacromial arch, and ischemia by impingement or increased intramuscular pressure following extreme arm abduction (5, 7, 32). Our results agree with those of Miranda et al (11) who reported an increased risk in cases of long duration of work with hand above shoulder level among the Finnish general population. Using more objective outcome and exposure measures, Svendsen et al (16, 17) reported an exposure–response relationship between lifetime upper-arm elevation (>90°) and MRI-diagnosed RCS among workers exposed to repetitive work. Our findings (for women) suggest that lower angles of arm abduction (60–90°) could be associated with RCS. This corroborates the previous results of Silverstein et al (14) suggesting that angles of arm flexion as low as 45° were associated with RCS in combination with forceful hand movements. This hypothesis is supported by physiological data showing significant biomechanical constraints and ischemia of the rotator cuff muscles for moderate angles of arm abduction (>30°) (5, 7, 32).

However, although our results are biologically plausible, no causal conclusion could be drawn due to the cross-sectional design of the study. Moreover, we cannot exclude the possibility that some workers suffering from RCS overrated their exposure to awkward working postures (33). Because moderate sustained shoulder abduction was most often unsupported, our results could have implications for prevention since the implementation of mechanical support, when possible (eg, arm rest or counterbalanced sling), could reduce shoulder biomechanical constraints (8). The high physical demand of the task was associated with RCS among men but not women (probably due to a lack of statistical power) and the risk effect was higher for older workers. This association is consistent with previous findings in the general population and among American and Danish manufacturing workers and services employees (11, 14, 15, 18). The association between RCS and the high repetitiveness of the task found in the French working population has already been reported for the Finnish general population and Danish manufacturing workers and services employees (11, 15, 18). The modification of the effect by age was divergent according to gender, since the risk effect was higher amongyounger men and older women. Our results showed that the risk of RCS associated with cumulative exposure to mechanical factors (high physical workload and/or high repetitiveness and/or arm posture) was higher than that of any specific physical risk factor under study among men, as previously observed by Miranda et al (11, 18) in the general population and by Frost et al (14) and Silverstein et al (15) among blue-collar workers.

Our study failed to reveal an association between RCS and factors related to the work organization, but several variables related to the technical aspects of the work organization, such as paced work, were associated with RCS in the univariate analysis. Since the organization of technical processes and workstations has a major influence on mechanical exposure, it can be hypothesized that the relationships between RCS and such factors could have been masked by the higher and more direct association between RCS and mechanical factors (14).

Using the demand–control–support model of stress at work, significant relationships were found with high levels of psychological demand among men and lack of supervisor support among women. This difference according to gender could reflect differences in jobs and tasks (5, 27). The association between RCS and high psychological demand agrees with the findings of Svendsen et al (16, 17) among blue-collar workers, and the OR we report was in the same order of magnitude as in the Finnish population (11). However, other studies of shoulder disorders have failed to report an association, and no single dimension of the demand–control–support model of stress at work seemed to be more important for RCS than others (27). In our study, the magnitude effect on the risk of RCS was weaker for psychosocial (with OR<2) than physical factors, which could be explained by the specific nature of the disorders that seems to be less related to psychosocial factors than non-specific disorders (11).

The large sample of workers was characterized by a wide variety of activity sectors and occupations, representing a broad range of both physical and mental occupational tasks. Its good representativeness in relation to the regional workforce allows greater generalization of the results than epidemiological studies conducted in selected occupational populations. Few workers (<10%) failed to participate but, due to the cross-sectional design of the study, a "healthy worker effect" could have occurred and caused an underestimation of the estimates of risk.

Outcomes were assessed clinically by trained physicians using a rigorous physical examination including standardized provocation tests, enabling more accurate diagnosis of RCS than the questionnaire (22). In contrast to several studies (19), our survey allowed assessment of the risk factors for specific UEMSD defined by objective criteria in a diversified working population. For most workers, length of service was longer than the previous 12-month period chosen for the assessment of work exposure and this reduced exposure classification errors. The main personal and occupational potential risk factors for RCS described in the literature were taken into account. While the potential determinants of RCS are numerous, few studies conducted among workers have taken personal, physical and psychosocial

factors into account together (19). However, we did not collect information on perceived stress or psychological distress, despite their possible association with shoulder disorders (25, 27). Non-work-related activity, such as housework, leisure, and sports were not assessed, although they may increase the risk of RCS (23–24). Nevertheless, although some sports activities requiring overhead work could increase the risk of shoulder pain (eg, volley ball), others (eg, jogging) could have preventive effects (2). Consequently, although non-work activities may represent important confounders in our study, we believe that their influence is probably not sufficient to diminish the value of the study.

As much as possible, standardized and validated instruments were used to reduce exposure classification errors (22). For example, awkward postures were presented in picture form to facilitate workers' understanding and increase the validity of posture self-assessment. The recall period of the last 12 months that was chosen limited recall errors regarding self-reported exposure (34). Few subjects (<5%) were excluded from analyses because of missing data. The most serious drawback to exposure assessment in this study was that occupational risk factors were assessed through a self-administered questionnaire (35). Nevertheless, even if this led to a lack of precision in estimating the absolute levels of exposure, self assessments are probably accurate to assess relative differences in exposure of this heterogeneous population (36). 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, but under-rating was also possible, especially for workers who moved to lighter work because of recurrent symptoms (37).

In conclusion, the study showed that personal and work-related physical and psychosocial factors were associated with clinically diagnosed RCS. The relative importance of the ageing process was higher than that of work-related factors in this large working population, and arm abduction was the major work-related risk factor. Since, as for most personal factors and in contrast to work-related factors, age is not modifiable, mechanical exposure should therefore be an important target for strategies on the prevention of RCS in the working population.

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