Risk factors for upper-extremity musculoskeletal disorders in the working population

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Abstract

SUMMARY

Objective

The study aimed to assess the relative importance of personal and occupational risk factors for upper-extremity musculoskeletal disorders (UEMSDs) in the working population.

Methods

A total of 3,710 workers (58% of men) participating in a surveillance program of MSDs in a French region in 2002–2005 were included. UEMSDs were diagnosed by 83 trained occupational physicians performing a standardized physical examination. Personal factors and work exposure were assessed by a self-administered questionnaire. Statistical associations between MSDs, personal and occupational factors were analyzed using logistic regression modeling.

Results

A total of 472 workers suffered from at least one UEMSD. The risk of UEMSDs increased with age for both genders (P<0.001) (O.R. up to 4.9 in men and 5.0 and in women) and in cases of prior history of UEMSDs (OR 3.1 and 5.0, P<0.001). In men, UEMSDs were associated with obesity (OR 2.2, P=0.014), high level of physical demand (OR 2.0, P<0.001), high repetitiveness of the task (OR 1.5, P= 0.027), postures with the arms at or above shoulder level (OR 1.7, P=0.009) or with full elbow flexion (OR 1.6, P=0.006), and high psychological demand (O.R. 1.5, P=0.005). In women, UEMSDs were associated with diabetes mellitus (O.R. 4.9, P=0.001), postures with extreme wrist bending (OR 2.0, P<0.001), use of vibrating hand tools (O.R. 2.2, P=0.025) and low level of decision authority (OR 1.4, P=0.042).

Conclusion

The study showed that personal and work-related physical and psychosocial factors were strongly associated with clinically-diagnosed UEMSDs.

Author Keywords Musculoskeletal disorders ; upper extremity ; risk factors ; personal factors ; physical exposure ; psychosocial factors ; work

MESH Keywords Adult ; Employment ; Female ; Humans ; Male ; Middle Aged ; Musculoskeletal Diseases ; diagnosis ; epidemiology ; etiology ; Occupational Diseases ; diagnosis ; epidemiology ; etiology ; Risk Factors ; Safety Management ; Upper Extremity ; pathology ; physiopathology

INTRODUCTION

Upper Extremity Musculoskeletal Disorders (UEMSDs), which include peripheral nerve entrapments and tendon disorders, as well as non-specific musculoskeletal regional pain disorders (1 ,2), have become one of the most significant and costly health problems in the working population (2 ,3). Epidemiological studies have identified several combinations of personal factors, work factors and psychosocial factors related to UEMSDs (1 –6). The main work-related factors of UEMSDs are rapid work pace and repetitive motion patterns, insufficient recovery time, heavy lifting and forceful manual exertion, sustained awkward posture of the wrists, elbows or shoulders, mechanical pressure concentration, use of vibrating hand tools (1 –4), and psychosocial factors, such as job stress (5 –6). A scientific consensus has been progressively developed on the multifactorial risk model of UEMSDs (1 –6), but the relative importance of the personal factors and work-related factors remains to be agreed (3).

The information on UEMSDs available in the literature may suffer from lack of comparability because of the variability of the definitions of both disorders and work exposure (7). Moreover, many studies have focused on selected occupational populations recruited from companies characterized by high levels of exposure to risk factors for UEMSDs (8 –9) whereas the working population includes workers exposed to various levels of risk of UEMSDs. Since the relative importance of each risk factor for UEMSDs varies between work environments (2), these studies should not be extrapolated to the whole working population without caution (7). Several studies have involved subjective complaints without clinical findings whose determinants may differ from those of specific UEMSDs (7). Population-based studies on specific disorders using defined objective criteria are therefore needed to assess the prevalence of UEMSDs and the relative importance of their determinants.

We have recently reported the results of the first two years of the surveillance of UEMSDs implemented by the French Institute for Public Health Surveillance (InVS) in the working population of a French region (10). This survey was conducted in a large sample of workers representative of the regional working population and used the recommendations of a European consensus to standardize the diagnoses of specific UEMSDs and the definition of their risk factors (11). Previous preliminary results showed that the prevalence of such disorders and the main risk factors varied widely across economic sectors and occupations (10). Overall, 11% of working men and 15% of working women suffered from at least one of the main clinically-diagnosed specific UEMSDs (10).

Using the results of the epidemiological surveillance over a three-year period, our aim in this study was to assess the occupational and non-occupational risk factors for UEMSDs and their relative importance in a large sample of workers representative of the regional working population.

METHODS

Study population and design

Population

This cross-sectional study was conducted in the Loire Valley district of West-Central France. The economic structure of the region, which represents 5% of the French working population, is diversified and similar to that of most French regions (10).

In France, all salaried workers, including temporary and part-time workers, undergo a mandatory annual health examination by a qualified occupational physician (OP) in charge of the medical surveillance of a group of companies. A total of 83 OPs, representative of the region's OPs, participated in the study. Subjects were randomly selected from workers undergoing a mandatory regularly-scheduled annual health examination between April, 2002 and April, 2005. All OPs were trained by the investigators to randomly include workers and perform a standardized physical examination (11). See reference (10) for more details.

Outcomes

Outcomes were assessed by the OPs performing a standardized physical examination which strictly applied the methodology and clinical tests of the European consensus (11) for rotator cuff syndrome (ICD10-M75.1), lateral epicondylitis (ICD10-M77.1), ulnar tunnel syndrome (ICD10-G56.2), carpal tunnel syndrome (ICD10-G56.0), De Quervain's disease (ICD10-M65.4) and flexor-extensor peritendinitis or tenosynovitis of the forearm-wrist region (ICD10-M65.8). These disorders are referred to as 'UEMSDs" in the remainder of the text. See reference (10) for details.

Potential risk factors

The potential risk factors included personal factors and medical history, work history and exposure to physical, psychosocial and organizational work factors (Table 1).

Personal factors and medical history

Details of age, weight, height, prior history of at least one of the major MSDs under study, inflammatory arthritis, diabetes mellitus, and thyroid disorders were collected during the physical examination.

Work status and occupational risk factors

Exposure was assessed with a self-administered questionnaire including information on the characteristics of the job and tasks, work organization and the main potential risk factors for UEMSDs. Most risk factors for UEMSDs were defined and quantified according to the European consensus (11). Stress at work was assessed according to the 'Demand-Control-Support model' using the validated French version of the 'Job Content Questionnaire' (12 –13). See reference (10) for more details.

Statistical methods

The outcome defined for this study was the presence of at least one of the six main clinically diagnosed UEMSDs. Cases were assessed by subject, and thus bilateral cases of UEMSDs counted as one disorder, not two.

The list of independent variables (Table 1) considered in the analyses comprised variables known or suspected to be potential risk factors for at least one of the disorders under study on the basis of epidemiological and ergonomic studies (1 , 2 , 4 , 5 , 6 , 10 , 14). Analyses were first performed for men and women separately to take into account possible differences in exposure to work constraints between genders (1 –2) and subsequently for the whole sample of workers. For this, we used logistic regression modeling, which followed a three-level process consisting of univariate models (Stage 1), group multivariate models in order to avoid collinearity between exposure variables in the final model (Stage 2) and the final multivariate model (Stage 3).

- Stage 1: Univariate analyses were performed with each of the potential explanatory variables as independent variables and having at least one UEMSD as dependent variable. Non-significant variables (P > 0.20) were excluded from further analyses, with the exception of age for all three samples, and gender for the entire sample, which were retained regardless of statistical significance.

- Stage 2: The independent variables not excluded in stage 1 were grouped into the five groups of potential determinants, i.e. personal factors and medical history (Group 1), current occupational category and length of service in the current job (Group 2), factors related to work organization (Group 3), postural and biomechanical constraints (Group 4) and psychosocial factors at work (Group 5). Backward multivariate logistic regression models were then performed for each of the five groups of variables, with age (and gender) forced into the models. Non-significant variables (P > 0.10) after this stage were excluded from further analyses.

- Stage 3. Final multivariate logistic regression analyses were performed using all remaining variables. Multiplicative interactions for the risk of UEMSDs were assessed for the following combinations: age x biomechanical variables, age x psychosocial variables, gender x biomechanical variables, gender x psychosocial variables and repetitiveness x physical demand. Only interaction terms contributing to the final model with a P value of less than 0.05 were retained in the model. Each model was tested with the Hosmer-Lemeshow goodness-of-fit test and ROC curves were computed.

All analyses were performed with the SAS statistical software packages (version 9.1: SAS Institute, Inc., Cary, NC, US).

RESULTS

The study population (Table 2) comprised 3,710 workers (2,162 men (58%), 1,548 women (42%), mean age = 38.4, SD = 10.4 years) representing about 3.4‰ of the regional workforce. 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 in the study sample was close to that of the regional workforce, except for the occupations not surveyed by OPs (e.g., shopkeepers and independent workers). Length of service in the current job was high for the majority of workers. In particular, it was more than ten years in 55% of cases, more than two years in 82% and more than one year in 92%.

A total of 581 cases of uni- or bilateral cases of UEMSDs (Table 3) were diagnosed (292 in men and 289 in women), representing 472 subjects (243 men and 229 women) suffering from at least one disorder. Rotator cuff syndrome accounted for 49% of cases in men and 46 % in women, carpal tunnel syndrome for 18% in men and 22% in women and lateral epicondylitis for 18% in men and 14% in women. The prevalence rates of the UEMSDs were 11.2% [95% CI 9.9 to 12.6] for males and 14.8% [95% CI 13.0 to 16.6] for females.

Univariate analyses (Table 1) showed a strong association between age and UEMSDs for both genders (P < 0.001). Length of service in the current job was also associated with UEMSDs for both genders (P < 0.001). Since age and length of service in the current job were strongly associated, the specific role of these two variables for UEMSDs was examined. The increased risk of UEMSDs with age remained statistically (P < 0.001) significant after adjustment for length of service, contrary to the increased risk related to length of service after adjusting for age (P = 0.08). In the latter case, the age-adjusted ORs (for the whole population) were 0.9 [95% CI 0.6 to 1.5], 1.0 [95% CI 0.7 to 1.6] and 1.3 [95% CI 0.9 to 2.0] for length of service of 1–2, 3–10 and over 10 years, respectively. Similar findings were observed for men (P = 0.16) and women (P = 0.14).

As shown in Table 4 , the final multivariate models of UEMSDs differed between genders. A total of twelve risk factors for MSDs were highlighted: eight in men and six in women. A strong relationship was observed between age and UEMSDs for both genders after adjustment for potential confounders. The risk of UEMSDs for individuals aged 30 years or over in 5-year increments was significantly (P < 0.001) higher than for those under 30, with ORs ranging from 1.8 to 4.9 in men and from 1.8 to 5.0 in women. Individuals aged 50–54 years had a significantly higher risk than all other age groups for both genders. Except for age, the main personal factor associated with UEMSDs (P < 0.001) was a prior history of UEMSDs during the preceding 12 months (OR 3.1 to 5.0 in men and women, respectively). Diabetes mellitus in women (OR 4.9, P = 0.001) and obesity (OR 2.2, P = 0.013)] were associated with UEMSDs, but not thyroid disorders and prior history or co-existing inflammatory arthritis.

No factor related to the work organization remained in the final models for men and women. Two biomechanical factors at work were highlighted: a high level of physical demand (OR 2.0, $P < 0.001$) and high repetitiveness of the task in men (OR 1.5, $P < 0.027$). The risk of UEMSDs associated with high repetitiveness in women was close to statistical significance (OR 1.4, $P < 0,10$). In terms of working postures, work with the arms at or above shoulder level in men (OR 1.7, $P = 0.009$), with full elbow flexion/extension movements in men (OR 1.6, $P = 0.006$) and with wrist bending in extreme postures in women (OR 2.0, $P < 0.001$) were associated with UEMSDs. No significant relationships were observed for moderate arm abduction or extension, full pronosupination and screwing movements, pinching and pressing with the base of the palm, and wearing gloves. Use of vibrating hand tools was associated with an increased risk of UEMSD in women (OR 2.2, $P = 0.025$), contrary to the exposure to cold. No significant association was found for keying and computer work, whatever the gender.

Associations with psychosocial risk factors at work were relatively modest, apart from an association between UEMSDs and high psychological demand in men (OR 1.5, $P = 0.005$) and low decision authority in women (Or 1.4, $P = 0.042$). Neither low social support from supervisors nor job strain (combination of high psychological demand and low control over the work) were associated with UEMSDs. No significant interaction between the risk factors was found in the separate multivariate models for men and women.

The multivariate model for the whole sample of workers (Table 5) slightly differed from the models computed separately for men and women. Most of the personal and biomechanical risk factors remained in the final model (age, prior history of UEMSDs, obesity, work with arm at or above shoulder level and/or with extreme wrist bending). Pressing with the base of the palm (OR 1.5) and the occurrence of frequent job rotations during the week (OR 1.2) were related to UEMSDs with a P-value at the limit of the statistical level of signification. The only psychosocial risk factors associated with UEMSDs was a low level of social support from supervisors (OR 1.3, $P = 0.015$). We found that there was an interaction ($P = 0.037$) between gender and the level of physical demand of the job. Female gender was associated with a higher risk of UEMSDs, but the difference was statistically significant only when the physical demand was low (OR 1.9 [95 % CI 1.3 to 2.8]). High physical demand was significantly associated with UEMSDs in men (OR 1.8 [95% CI 1.3 to 2.6]), but not in women (OR 1.1 [95 % CI. 0.9 to 1.4]). We have have re-run the final multivariate model as represented in Table 5 excluding prior history of UEMSDs to test the possibility of over adjustment. The other risk estimates were mostly unchanged.

The final multivariate model considering only rotator cuff syndrome for the whole sample of workers emphasized almost the same risk factors as the model for the six UEMSDs: age, prior history of UEMSDs, high physical demand, high repetitiveness, and working postures with the arms at or above shoulder level or with full elbow flexion. Considering the five other UEMSDs only, the model highlighted the same risk factors (age, prior history of UEMSDs, high physical demand and working postures with full elbow flexion), diabetes mellitus and working postures with extreme wrist bending and screwing.

DISCUSSION

The prevalence of clinically-diagnosed MSDs over the three-year period was high in this study conducted in a large representative sample of salaried workers: about 13% of workers suffered from at least one of the MSDs. The most frequent disorder was rotator cuff syndrome, followed by carpal tunnel syndrome and lateral epicondylitis, as previously observed during the first two years of the surveillance program (10). The study confirms the multifactorial origin of clinically-diagnosed UEMSDs (1 –4 , 7 –9) and highlights a limited number of personal and work-related physical and psychosocial factors.

The relative importance of personal factors was high and advancing age represented the main factor associated with UEMSDs. Normal age degeneration of tissue is a predisposing factor for numerous UEMSDs (1) and our findings are consistent with the epidemiologic literature (1 , 2 , 4 , 14 –21). Length of service was a significant univariate predictor of UEMSDs, but no significant association was observed after adjusting for age. Advancing age and length of service in the last job were highly correlated, so that it is difficult to disentangle the role of age from the effects of cumulative exposure to occupational hazards in the interpretation of our results (22).

As reported in some studies undertaken in working populations (1 , 2 , 14 , 16 , 23 –24), women have a higher risk of UEMSDs than men, but the study failed to quantify this association because of the occurrence of an interaction between gender and physical demand of the task in the final multivariate model. Except for age and prior history of UEMSDs, the risk factors for UEMSDs differed between men and women. The gender difference could be due to physiological differences (e.g., body size and hormonal conditions), differences in exposure to constraints at work (1 –2) or at home and, less probably, in reporting work exposure (16 ,23). It could also reflect differences in the relative weights of the disorders under study - since more women suffered from carpal tunnel syndrome than men while more men suffered from lateral epicondylitis.

Prior history of UEMSDs drastically increased the risk of UEMSDs in our study, whatever the gender. The occurrence of previous MSDs was assessed by OPs during the physical examination, both by interview and the use of the medical files completed each year. Previous UEMSDs are known to increase the risk of UEMSDs (1 ,15 ,25 –26), but the relationship observed may be overestimated by a recall bias, since the recall of previous UEMSDs is strongly influenced by current symptoms of UEMSDs (27). Because of the cross-sectional design of the study, we cannot exclude the possibility that prior UEMSD injuries were in fact the same persistent disorders for some workers. This could lead to overestimation of the relationship between UEMSDs and prior history of such disorders. The study confirms the association of UEMSDs with diabetes mellitus (28 –29) and obesity (1 –2 ,7 ,17 ,19 ,30), which may have a profound effect on soft-tissue structures (31).

The study highlights four work-related physical factors. In accordance with the epidemiological literature (1 , 2 , 4), performing highly repetitive or physically demanding tasks was associated with specific UEMSDs. A sustained or repetitive working posture with arms at or above shoulder level was clearly associated with UEMSDs. This posture may be related to rotator cuff syndrome and several pathophysiological mechanisms may be involved (e.g. compression and ischemia of the tendons due to impingement, increased intramuscular pressure)(1 , 18). Sustained or repetitive bending of the wrist and, to a lesser extent, pressing with the base of the palm increased the risk of UEMSDs, in accordance with epidemiological (1 , 2 , 8 , 32) and biomechanical (1 , 2 , 32) literature on carpal tunnel syndrome. No elbow posture was clearly associated with UEMSDs, except for full elbow flexion/extension movements in men, considered to be important factor for wrist/forearm/elbow disorders (11). The lack of association between shoulder and elbow posture and UEMSDs in women more probably reflects the relative weights of the disorders between genders rather than a gender effect. None of the physical factors seems to have a higher role than any other, which confirms epidemiological studies showing stronger associations between specific UEMSDs and combinations of risk factors (e.g., force and repetition, force and posture)(4).

This study failed to show an association between UEMSDs and any organizational factors studied, except for job/task changes during the week. We found a moderate association between UEMSDs and all the dimensions of the Demand-Control-Support model of stress at work independently of physical exposure, as previously reported in mixed populations (6 ,33). However, the results were inconsistent across the samples studied and no one dimension of the model of stress at work seemed to be more important than the others (34). The modest contribution of the psychosocial risk factors observed in our study could be explained by the specific nature of the disorders, since non-specific disorders seem to be more highly related to psychosocial factors than specific disorders (7).

The study covered several activity sectors and occupations representing a broad range of physical and mental occupational tasks (10). Its good representativeness of the regional workforce allows greater generalization of the results than epidemiological studies conducted in selected occupational populations (7). Few workers failed to participate but, due to the cross-sectional design of the study, some workers suffering from UEMSDs may have left the labor market or changed to less exposed work. Such a "healthy worker effect" could have occurred and may have caused an underestimation of the estimates of risk. This may explain the decrease in the risk of UEMSDs observed after age 55. However, the selection phenomenon was probably low because the prevalence rates we report are in line with the estimate that 5 to 20% of people of working age are affected by upper extremity disorders (1 –2). Due to its cross sectional design, no causal relationships could be demonstrated by our study. Including previous injury in the model may be over adjusting insofar as selected risk factors are concerned. However, very few changes of risk estimates were observed in the final multivariate model excluding this factor.

In contrast to several studies on UEMSDs (2), our survey allowed assessment of the risk factors for specific UEMSDs defined by objective criteria in a diversified working population. Outcomes were clinically assessed by trained physicians using a rigorous procedure and standardized provocation tests (10 –11). The main occupational and non-occupational potential risk factors for MSDs described in the literature on UEMSDs (1 , 2 , 3 ,4 , 11 , 14 , 35) were taken into account. While the potential determinants of UEMSDs are numerous, few studies conducted in workers have taken personal, physical and psychosocial factors into account together. However, we did not collect information on perceived stress and psychological distress, despite their possible association with UEMSDs (2 , 5 , 6 , 14). No specific information was available on education or income levels, but the current occupational category (allowing a rough estimation of the socioeconomic level) was taken into account in our analyses. Non-occupational activity, such as housework, leisure and sports, were not assessed. They may increase the risk of UEMSDs but seem unlikely to play a major role as confounding factors (1 , 2 , 8 , 14). Although residual confounding is always possible, we believe that we had information on the most important confounders. The use of standardized and validated questions and recall period of 12 months limited recall errors of self-reported exposure (36). One serious drawback was the self assessment of occupational exposure which may have biased risk estimates since workers in pain may overrate their exposure levels (10 , 37). However, under-rating was also possible, especially for workers who moved to lighter work because of recurrent symptoms (3).

In conclusion, the study showed that personal and work-related physical and psychosocial factors were strongly associated with clinically-diagnosed UEMSDs. The relative importance of personal factors was higher than that of work-related risk factors. Because of the multifactorial nature of the disorders, the importance of work exposure to physical and psychosocial factors contributing to UEMSDs is not diminished by the relative impact of personal factors. Depending on the intensity, frequency and duration of workplace exposure, personal factors may have a greater or less important role (1). Moreover, most personal factors are less modifiable or preventable than workplace psychosocial factors, and they should therefore provide an important target for strategies for the prevention of UEMSDs in the working population.

Ackowledgements:

We are grateful to the occupational physicians involved in the sentinel network: Doctors Abonnat, Banon, Bardet, Benetti, Becquemie, Bertin, Bertrand, Bidron, Biton, Bizouarne, Boisse, Bonamy, Bonneau, Bouguer, Bouguer-Diquelou, Bourut-Lacouture, Breton, Caillon, Cesbron, Chisacoff, Chotard, Compain, Coquin-Geogeac, Cordes, Couet, Coutand, Daniellou, Darcy, Davenas, De Lescure, Delansalut, Dupas, Evano, Fache, Fontaine, Frampas-Chotard, Guiller, Guillimin, Harinte, Harrigan, Hervio, Hirigoyen, Jahan, Joliveau, Jube, Kalfon, Laine-Colin, Laventure, Le Dizet, Lechevalier, Leclerc, Ledenvic, Leroux, Leroy-Maguer, Levrard, Levy, Logeay, Lucas, Mallet, Martin, Mazoyer, Meritet, Michel, Migne-Cousseau, Moisan, Page, Patillot, Pinaud, Pineau, Pizzala, Plessis, Plouhinec, Raffray, Roussel, Russu, Saboureault, Schlindwein, Soulard, Thomson, Treillard, Tripodi. We thank Julie Bodin for her help in preparing the manuscript.

Supported by the French Institute for Public Health Surveillance, Saint-Maurice, France (grant 9/25/2002-5 "réseau expérimental de surveillance des troubles musculo-squelettiques") and the French National Research Agency (ANR-grant SEST-06-36).

Footnotes:

The Pays de la Loire study received the approval of France's National Committee for Data Protection (CNIL: Commission Nationale Informatique et Liberté).

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Table 1

Potential risk factors for UEMSDs considered in the study and univariate analyses

		Altogether (n = 3,710)					Men (n = 2,162)			Women (n = 1,548)		
		N_{sample}	n_{MSD}	OR	[95%CI]	p^{γ}	OR	[95%CI]	p^{γ}	OR	[95%CI]	p^{γ}
PERSONAL FACTORS												
1. Personal factors and medical history												
Age	< 30 (ref)	875	39	1			1			1		
	30–34;	572	44	1.8	[1.1–2.8]		1.8	[1.0–3.3]		1.7	[0.9– 3.4]	
	35–39;	508	61	2.9	[1.9–4.4]		2.5	[1.4–4.4]		3.6	[1.9–6.6]	
	40–44;	561	73	3.2	[2.1–4.8]	**<0.001**	2.9	[1.7–5.1]	**<0.001**	3.5	[1.9– 6.4]	**<0.001**
	45–49;	538	109	5.4	[3.7–8.0]		4.9	[2.9–8.2]		6.1	[3.4 –10.8]	
	50–54;	451	103	6.3	[4.3–9.4]		5.5	[3.2–9.2]		7.6	[4.3 –13.7]	
	55 yrs	198	42	5.8	[3.6–9.2]		5.1	[2.7–9.6]		6.7	[3.4 –13.5]	
Gender	Female vs male	1,548	229	1.4	[1.1–1.7]	**0.001**						
Body mass index (Kg/m^2)	Normal (BMI=18.5–24.9)	2,157	230	1			1			1		
	Underweight (BMI<18.5)	124	8	0.6	[0.3–1.2]	**<0.001**	-	-	**<0.001**	0.7	[0.3– 1.4]	**0.006**
	Overweight (BMI=25–29.9)	1,078	160	1.5	[1.2–1.8]		1.6	[1.2–2.1]		1.6	[1.1– 2.2]	
	Obesity (BMI≥30)	300	59	2.1	[1.5–2.8]		2.5	[1.7–3.9]		1.7	[1.0– 2.7]	
Prior history of at least one of the UEMSDs	yes vs no	713	226	5.3	[4.3 – 6.5]	**<0.001**	4.3	[3.2 – 5.8]	**<0.001**	6.4	[4.7 – 8.6]	**<0.001**
Diabetes mellitus	yes vs no	61	17	2.7	[1.5 – 4.8]	**<0.001**	2.0	[0.9 – 4.4]	**0.083**	4.5	[1.9– 10.8]	**<0.001**
Thyroid disorders	yes vs no	135	24	1.5	[1.0 – 2.4]	**0.073**	0.8	[0.2 – 2.6]	0.693	1.6	[0.9 – 2.6]	**0.086**
Upper limb inflammatory arthritis	yes vs no	78	20	2.4	[1.5 – 4.1]	**<0.001**	1.7	[0.8 – 4.0]	**0.187**	3.0	[1.5 – 6.0]	**0.001**
OCCUPATIONAL FACTORS												
2. Current occupational category and length of service												
Current occupational category	Managers, professionals, technicians (ref	1,113	116	1			1			1		
	Low-grade white-collar	986	114	1.1	[0.9–1.5]	**<0.001**	0.9	[0.5–1.7]	**0.026**	1.0	[0.7– 1.4]	**<0.001**
	Skilled blue-collar	943	135	1.5	[1.1–1.9]		1.5	[1.1–2.1]		1.9	[1.1– 3.3]	
	Unskilled blue-collar	643	107	1.8	[1.3–2.3]		1.4	[1.0–2.1]		2.0	[1.3– 3.0]	
Length of service in the current job (year)	<1(ref)	455	36	1			1			1		
	1–2	591	48	1.0	[0.7–1.6]		1.7	[0.9–3.2]		0.6	[0.3– 1.2]	

	3–10	1,238	127	1.3	[0.9–2.0]	**<0.001**	1.9	[1.0–3.4]	**<0.001**	1.0	[0.6– 1.7]	**<0.001**
	> 10	1,389	257	2.6	[1.8 – 3.8]		3.6	[2.0 –6.3]		2.0	[1.3 – 3.3]	
3. Factors related to the work organization												
Paced work	yes vs no	383	59	1.3	[1.0–1.8]	**0.078**	1.3	[0.8–1.9]	0.242	1.4	[0.9– 2.1]	**0.147**
Work pace dependent on automatic rate	yes vs no	400	70	1.5	[1.2–2.0]	**0.002**	1.5	[1.0–2.1]	**0.043**	1.8	[1.2– 2.7]	**0.009**
Work pace dependent on other technical organization	yes vs no	742	100	1.1	[0.9–1.4]	0.405	1.1	[0.8–1.5]	0.511	1.4	[0.9– 2.1]	**0.113**
Work pace dependent on customers' demand	yes vs no	1,643	184	0.8	[0.7–1.0]	**0.025**	0.9	[0.7–1.1]	0.299	0.7	[0.5– 0.9]	**0.021**
Work pace dependent on the colleagues' work	yes vs no	1,109	146	1.1	[0.9–1.4]	0.399	1.4	[1.1–1.8]	**0.022**	0.9	[0.6– 1.2]	0.353
Work pace dependent on quantified targets	yes vs no	1,729	241	1.2	[1.0–1.5]	**0.030**	1.1	[0.8–1.4]	0.506	1.6	[1.2– 2.1]	**0.002**
Job/task rotation (≥ 1 job rotation per week)	yes vs no	1,350	199	1.3	[1.1–1.6]	**0.004**	1.4	[1.1–1.9]	**0.013**	1.3	[1.0– 1.7]	**0.086**
Work with temporary workers	yes vs no	1,106	165	1.3	[1.1–1.6]	**0.010**	1.3	[1.0–1.7]	**0.105**	1.4	[1.0– 1.8]	**0.042**
High visual demand	yes vs no	2,380	331	1.4	[1.1–1.7]	**0.005**	1.2	[0.9–1.6]	0.201	1.5	[1.1– 2.1]	**0.008**
Overtime hours	yes vs no	2,186	260	0.8	[0.7–1.0]	**0.055**	0.9	[0.7–1.2]	0.647	0.8	[0.6– 1.0]	**0.075**
Prior knowledge of the workload	yes vs no	366	43	0.9	[0.6–1.3]	0.546	1.2	[0.8–1.7]	0.469	0.6	[0.3– 1.2]	**0.140**
4. Working postures and biomechanical constraints												
High repetitiveness (≥ 4 h per day) #	yes vs no	958	183	2.0	[1.6–2.5]	**<0.001**	1.8	[1.4–2.5]	**<0.001**	2.1	[1.6– 2.8]	**<0.001**
Too little recovery time (< 10-min. break possible)#	yes vs no	205	50	2.4	[1.7–3.3]	**<0.001**	1.9	[1.1–3.3]	**0.020**	2.5	[1.6– 3.9]	**<0.001**
High physical demand (RPE Borg scale ≥ 13)	yes vs no	1,856	309	2.1	[1.7–2.6]	**<0.001**	2.5	[1.8–3.3]	**<0.001**	1.9	[1.5– 2.6]	**<0.001**
Arms at or above shoulder level (≥ 2 h/day)#	yes vs no	487	104	2.1	[1.7–2.7]	**<0.001**	2.6	[1.9–3.6]	**<0.001**	1.6	[1.1– 2.4]	**0.013**
Arms abducted (≥ 2 h/day)#	yes vs no	572	108	1.8	[1.4–2.2]	**<0.001**	1.8	[1.3–2.4]	**<0.001**	1.9	[1.3– 2.7]	**<0.001**
Holding the hand behind the trunk (≥ 2 h/day)	yes vs no	187	29	1.3	[0.8–1.9]	0.242	1.6	[0.9–2.7]	**0.084**	1.0	[0.5– 1.8]	0.902
Full elbow flexion/extension movements (≥ 2 h/day)#	yes vs no	1,214	221	2.0	[1.6–2.4]	**<0.001**	2.4	[1.8–3.1]	**<0.001**	1.7	[1.2– 2.2]	**<0.001**
Working with full pronosupination movements(≥ 2 h/day)#	yes vs no	534	86	1.4	[1.1–1.8]	**0.011**	1.4	[1.0–1.9]	**0.027**	2.1	[1.3– 3.4]	**0.004**
Wrist bending in extreme postures (≥ 2 h/day)#	yes vs no	1,236	222	2.0	[1.6–2.4]	**<0.001**	1.8	[1.4–2.4]	**<0.001**	2.2	[1.6– 2.9]	**<0.001**
Use of handtools (≥ 2 h/day)	yes vs no	1,711	251	1.4	[1.2–1.7]	**<0.001**	1.3	[1.0–1.7]	**0.074**	1.8	[1.4– 2.4]	**<0.001**
Holding tools or objects in a pinch grip(≥ 4 h/day)#	yes vs no	297	66	2.1	[1.6–2.8]	**<0.001**	2.1	[1.4–3.1]	**<0.001**	2.1	[1.4– 3.2]	**<0.001**
Precise finger movements (≥ 2 h/day)	yes vs no	1,665	263	1.6	[1.4–2.0]	**<0.001**	1.5	[1.1–1.9]	**0.004**	1.9	[1.4– 2.5]	**<0.001**
Pressing with the base of the palm (≥ 2 h/day) #	yes vs no	294	59	1.8	[1.4–2.5]	**<0.001**	1.9	[1.3–2.7]	**<0.001**	2.4	[1.3– 4.4]	**0.004**
Use of vibrating handtools (≥ 2 h/day)#	yes vs no	469	73	1.3	[1.0–1.7]	**0.046**	1.3	[1.0–1.8]	**0.098**	2.5	[1.4– 4.4]	**0.002**
Exposure to cold temperature (≥ 4 h/day)#	yes vs no	220	34	1.3	[0.9–1.9]	0.205	1.2	[0.7–1.9]	0.529	1.6	[0.9– 2.8]	**0.127**
Keying and computer work (≥ 4 h/day)#	yes vs no	1,024	96	0.6	[0.5–0.8]	**<0.001**	0.6	[0.4–0.9]	**0.022**	0.5	[0.4– 0.7]	**<0.001**
Wearing gloves (≥ 4 h/day)	yes vs no	584	95	1.4	[1.1 – 1.8]	**0.005**	1.3	[1.0 – 1.8]	**0.089**	1.7	[1.2 – 2.5]	**0.006**
5. Psychosocial factors at work												

High psychological demand (score ≥ 22)#	yes vs no	1,814	250	1.2	[1.0–1.5]	**0.050**	1.4	[1.1–1.9]	**0.009**	1.0	[0.8– 1.3]	0.968
Low skill discretion (score ≤ 34)	yes vs no	2,016	297	1.5	[1.2–1.8]	**<0.001**	1.4	[1.1–1.8]	**0.013**	1.5	[1.1– 2.1]	**0.006**
Low decision authority (score ≤ 32)#	yes vs no	1,276	185	1.3	[1.1–1.6]	**0.014**	0.9	[0.7–1.3]	0.711	1.6	[1.2– 2.2]	**<0.001**
Low supervisor support (score ≤ 11)	yes vs no	1,427	216	1.4	[1.21.8]	**<0.001**	1.4	[1.1–1.9]	**0.009**	1.5	[1.1– 2.0]	**0.007**
Low coworker support (score ≤ 11)	yes vs no	708	111	1.4	[1.1 – 1.7]	**0.007**	1.4	[1.0 – 1.9]	**0.039**	1.3	[1.0 – 1.9]	**0.088**

See references [10,13] for details;

γ In bold, p-value<0.20.

Risk factors taken into account by the European consensus.

Table 2

Characteristics of workers participating in the French Pays de la Loire study

	MEN		**WOMEN**		**ALTOGETHER**	
	N	**(%)**	**N**	**(%)**	**N**	**(%)**
Study population	**2,162**	**(58.3)**	**1,548**	**(41.7)**	**3,710**	**(100)**
Age (years) (n = 3,703)						
• < 30	514	(23.8)	361	(23.3)	875	(23.6)
• 30–35	344	(16.0)	228	(14.8)	572	(15.5)
• 35–39	307	(14.2)	201	(13.0)	508	(13.7)
• 40–44	311	(14.4)	250	(16.2)	561	(15.2)
• 45–49	301	(14.0)	237	(15.3)	538	(14.5)
• 50–54	265	(12.3)	186	(12.0)	451	(12.2)
• ≥ 55	114	(5.3)	84	(5.4)	198	(5.3)
Economic sector (n = 3,701)						
• Agriculture	31	(1.4)	25	(1.6)	56	(1.5)
• Industry	859	(39.8)	401	(26.0)	1,260	(34.0)
• Construction	189	(8.8)	25	(1.6)	214	(5.8)
• Services	1,078	(50.0)	1,093	(70.8)	2,171	(58.7)
Occupation (n = 3,705)						
• Farmers (1)	0	(0.0)	0	(0.0)	0	(0.0)
• Craftsmen (1)	13	(0.6)	3	(0.2)	16	(0.4)
• Managers and professionals	210	(9.7)	78	(5.0)	288	(7.8)
• Associate professionals and technicians	540	(25.0)	289	(18.7)	829	(22.4)
• Low-grade white-collar workers	188	(8.7)	798	(51.7)	986	(26.6)
• Skilled and unskilled blue-collar workers	1,209	(56.0)	377	(24.4)	1,586	(42.8)

(1) Farmers and most craftsmen are not surveyed by the occupational physicians in France.

Table 3

Prevalence rates of clinically-diagnosed UE-MSDs of the upper extremities

	MEN			WOMEN			ALTOGETHER		
	N	%	**95%CI**	**N**	%	**95%CI**	**N**	%	**95%CI**
Rotator cuff syndrome	142	6.6	[5.5 – 7.6]	132	8.5	[7.1 – 9.9]	274	7.4	[6.5 – 8.2]
Lateral epicondylitis	51	2.5	[1.8 – 3.1]	39	2.7	[1.9 – 3.5]	90	2.6	[2.0 – 3.1]
Ulnar tunnel syndrome	16	0.7	[0.4 – 1.1]	14	0.9	[0.4 – 1.4]	30	0.8	[0.5 – 1.1]
Carpal tunnel syndrome	51	2.4	[1.7 – 3.0]	62	4.0	[3.0 – 5.0]	113	3.1	[2.5 – 3.6]
Wrist tendinitis	19	0.9	[0.5 – 1.3]	10	0.7	[0.3 – 1.1]	29	0.8	[0.5 – 1.1]
De Quervain's Disease	13	0.6	[0.3 – 0.9]	32	2.1	[1.4 – 2.8]	45	1.2	[0.9 – 1.6]
At least one UEMSD	243	11.2	[9.9 –12.6]	229	14.8	[13.0 – 16.6]	472	12.7	[11.7 – 13.8]
At least two UEMSDs	42	1.9	[1.4 – 2.5]	44	2.8	[2.0 – 3.7]	86	2.3	[1.8 – 2.8]

Table 4

Multivariate models for risk factors of UE-MSDs in the male and female working populations

	Men (n = 2,058)					Women (n = 1,481)				
	N_{sample} *	n_{MSD} *	OR	[95%CI]	p	N_{sample} *	n_{MSD} *	OR	[95%CI]	p
PERSONAL FACTORS										
Age (years)					<0.001					<0.001
< 30	499	22	1			349	17	1		
30–34	333	26	1.8	[1.0 – 3.3]		221	18	1.8	[0.9 – 3.6]	
35–39	291	28	2.4	[1.3 – 4.4]		189	26	2.8	[1.4 – 5.5]	
40–44	296	32	2.4	[1.3 – 4.4]		242	37	3.0	[1.6 – 5.7]	
45–49	284	50	4.5	[2.6 – 7.9]		224	51	4.5	[2.4 – 8.2]	
50–54	250	49	4.9	[2.7 – 8.6]		177	48	5.0	[2.7 – 9.3]	
≥ 55	105	20	4.0	[2.0 – 8.1]		79	20	4.4	[2.1 – 9.4]	
Prior history of UE-MSDs	357	93	3.1	[2.3 – 4.2]	<0.001	321	120	5.0	[3.6 – 7.0]	<0.001
BMI (Kg/m^2)					0.014					
Normal (BMI = 18.5 – 24.9)	1,130	98	1							
Underweight (BMI <18.5)	33	0	-	-						
Overweight (BMI = 25 – 29.9)	731	97	1.2	[0.9 – 1.7]						
Obesity (BMI ≥ 30)	164	32	2.2	[1.4 – 3.6]						
Diabetes mellitus						20	9	4.9	[1.8 – 12.9]	0.001
OCCUPATIONAL FACTORS										
High physical demand (RPE-Borg scale ≥ 13)	1,106	166	2.0	[1.4 – 2.8]	<0.001					
High repetitiveness	446	74	1.5	[1.0 – 2.1]	0.027					
Arms at or above shoulder level	283	61	1.7	[1.1 – 2.4]	0.009					
Full elbow flexion/extension movements	690	115	1.6	[1.1 – 2.2]	0.006					
Wrist bending in extreme postures						466	104	2.0	[1.4 – 2.8]	<0.001
Use of vibrating handtools						61	17	2.2	[1.1 – 4.2]	0.025
High psychological demand	1,006	129	1.5	[1.1 – 2.1]	0.005					
Low level of decision authority						600	112	1.4	[1.0 – 1.9]	0.042

Note.

* Subjects with no missing value for the risk factors in the multivariate model; Number of subjects excluded from analyses because of missing values: 129 men and 112 women; OR, odds ratio; CI, confidence interval; Variables excluded from the model for men (in order of exclusion): current occupational category, work with temporary workers, work pace dependent on the colleagues' work, frequent job/task rotation, low level of skill discretion, low supervisor support; Variables excluded from the model for women: work pace dependent on demand of customers, arms abducted, high visual demand, frequent job/task rotation, current occupational category, work pace dependent on quantified targets, work with temporary workers, length of service in the current job, keying and computer work, low supervisor support, knowledge of the workload, high repetitiveness; Hosmer Lemeshow goodness-of-fit test: P = 0.016 for the model for men and P = 0.319 for the model for women; area under ROC curve = 0.78 (men) and 0.78 (women).

Table 5

Multivariate model for risk factors of UE-MSDs in the total working population

	Men and women altogether (n = 3,275)				
	N_{sample}*	n_{MSD}*	OR	[95%CI]	p
PERSONAL FACTORS					
Age (years)					**<0.001**
<30	792	36	1		
30–34	520	41	1.8	[1.1 – 3.0]	
35–39	439	47	2.6	[1.6 – 4.2]	
40–44	496	63	2.9	[1.9 – 4.5]	
45–49	459	92	4.9	[3.2 – 7.5]	
50–54	401	92	5.6	[3.6 – 8.6]	
≥55	168	36	4.5	[2.6 – 7.7]	
Prior history of MSDs	621	188	3.3	[2.6 – 4.2]	**<0.001**
BMI (Kg/m^2)					0.056
Normal (BMI = [18.5 – 25[)	1,926	205	1		
Underweight (BMI <18.5)	109	7	0.9	[0.4 – 2.0]	
Overweight (BMI = [25 – 30[)	975	143	1.2	[0.9 – 1.5]	
Obesity (BMI ≥ 30)	265	52	1.6	[1.1 – 2.4]	
OCCUPATIONAL FACTORS					
High repetitiveness	858	165	1.6	[1.2 – 2.0]	**<0.001**
Arms at or above shoulder level	430	93	1.5	[1.1 – 2.0]	**0.016**
Wrist bending in extreme postures	1,107	198	1.5	[1.2 – 2.0]	**0.002**
Pressing with the base of the palm	260	52	1.5	[1.0 – 2.1]	0.058 δ
Frequent job rotation	1,265	180	1.2	[1.0 – 1.5]	0.079 δ
Low supervisor support	1,312	198	1.3	[1.1 – 1.7]	**0.015**
Interaction terms: Gender x Physical demand					0.037#
Women vs men in low physical demand			1.9	[1.3 – 2.8]	
Women vs men in high physical demand			1.2	[0.9 – 1.6]	
High vs low physical demand in males			1.8	[1.3 – 2.6]	
High vs low physical demand in females			1.1	[0.8 – 1.6]	

Note.

* subjects with no missing value for the risk factors in the multivariate model; Number of subjects excluded from analyses because of missing values: 435; OR., odds ratio; CI., confidence interval; Variables excluded from the model (in order of elimination): high visual demand, work pace dependent on quantified targets, work pace dependent on customers' demand, current occupational category, full elbow flexion, high psychological demand, work with temporary workers, diabetes mellitus, low level of skill discretion; Hosmer Lemeshow goodness-of-fit test: P = 0.243; area under ROC curve = 0.78;

δ P> 0.05;

P-value for multiplicative interaction.