Arthritis Care & Research
Vol. 64, No. 6, June 2012, pp 898–904
DOI 10.1002/acr.21615

ORIGINAL ARTICLE

Risk Factors for Raynaud's Phenomenon in the Workforce

YVES ROQUELAURE,[1] CATHERINE HA,[2] AUDREY PETIT LE MANAC'H,[1] JULIE BODIN,[1] ANAÏS BODERE,[1] CHRISTIAN BOSSEAU,[1] ALEXIS DESCATHA,[3] ANNETTE LECLERC,[3] MARCEL GOLDBERG,[3] AND ELLEN IMBERNON[2]

Objective. **To assess the prevalence of and risk factors for Raynaud's phenomenon (RP) in a French working population characterized by various levels of exposure to work-related constraints.**

Methods. **The study population comprised 3,710 workers (2,161 men and 1,549 women) who were followed up by 83 occupational physicians and were representative of the region's workforce. RP, as diagnosed by a questionnaire and a standardized interview, was defined as the occurrence of at least occasional attacks of finger blanching triggered by exposure to environmental cold during the previous 12 months. Personal factors and work exposure were assessed by self-administered questionnaires. The associations between RP and personal and occupational factors were analyzed using logistic regression modeling.**

Results. **A total of 87 cases of RP (56 women and 31 men) were diagnosed. The population-based annual prevalence rates of RP were 3.6% (95% confidence interval [95% CI] 2.7–4.5%) for women and 1.4% (95% CI 0.9–1.9%) for men. Women had a higher risk of RP (odds ratio [OR] 2.1 [95% CI 1.3–3.4]) and the risk decreased continuously with body mass index (OR for 1-kg/m^2 increment 0.87 [95% CI 0.81–0.94]). The risk of RP increased consistently but moderately with age after 35 years (ORs ranging from 2.0 [95% CI 1.1–3.8] to 2.9 [95% CI 1.6–5.2]). Among the work-related factors studied, RP was associated with an exposure to a cold environment or objects (OR 2.2 [95% CI 1.0–4.6]), a high repetitiveness of a task (OR 1.7 [95% CI 1.0–2.7]), a high psychological demand at work (OR 1.7 [95% CI 1.0–2.7]), and low support from supervisors (OR 2.4 [95% CI 1.5–3.8]).**

Conclusion. **Personal and work-related factors were associated with RP, with a clear difference between the sexes. Work-related psychosocial stressors played a significant role independently of biomechanical and environmental exposure.**

INTRODUCTION

Raynaud's phenomenon (RP) is characterized by episodic vasospasm of the extremities, frequently induced by exposure to cold temperatures and emotional stress. Cases of RP are mostly idiopathic and sometimes induced by several medical conditions (e.g., systemic sclerosis and rheumatoid arthritis) and medications (e.g., beta-blockers) (1). Several personal factors (e.g., age, sex, genetic factors, smoking status, alcohol consumption, anxiety, and stress) increase the risk of RP (2–9). RP has been related to occupational exposure to cold temperatures and hand- and arm-transmitted vibrations (often called vibration-induced white finger syndrome) and especially exposure to chemicals (e.g., vinyl chloride monomer) (10–14).

RP that is not associated with an underlying connective tissue disease is a common disorder (1), but wide varia-

The Pays de la Loire study received approval from the French National Committee for Data Protection and was supported by the French Institute for Public Health Surveillance, Saint-Maurice, France (grant 9/25/2002-5 "réseau expérimental de surveillance des troubles musculo-squeletiques"), and the French National Research Agency (ANR grant SEST-06-36).

[1]Yves Roquelaure, MD, PhD, Audrey Petit Le Manac'h, MD, Julie Bodin, MSc, Anaïs Bodere, MSc, Christian Bosseau, MSc: L'Université Nantes Angers Le Mans, Université d'Angers, Centre Hospitalier Universitaire d'Angers, Laboratoire d'Ergonomie et d'épidémiologie en santé au travail, Angers, France; [2]Catherine Ha, MD, PhD, Ellen Imbernon, MD: French Institute for Public Health Surveillance, Saint-Maurice, France; [3]Alexis Descatha, MD, PhD, Annette Leclerc, PhD, Marcel Goldberg, MD, PhD: INSERM U1018, Université de Versailles St-Quentin, Centre for Research in Epidemiology and Population Health, Epidemiology of Occupational and Social Determinants of Health, Villejuif, France.

Address correspondence to Yves Roquelaure, MD, PhD, Laboratoire d'Ergonomie et d'épidémiologie en santé au travail, CHU, F-49933 Angers Cedex, France. E-mail: yvroquelaure@chu-angers.fr.

Submitted for publication August 11, 2011; accepted in revised form January 10, 2012.

tions in prevalence have been reported (between 0.5% and 20% depending on the population studied, the study region's climate, and the outcome definition) (8,14–22). Several studies of workers highly exposed to hand-transmitted vibration in cold environments reported high levels of prevalence, but it is still difficult to compare the prevalence of RP among occupations and economic sectors. The French Institute for Public Health Surveillance therefore implemented an epidemiologic surveillance system for musculoskeletal disorders (MSDs) in the Pays de la Loire region of France in 2002 (23). The surveillance system relies on a regional network of occupational physicians (OPs) and was designed to assess prevalence rates of MSDs of the upper extremities, back pain, and RP and their risk factors in the regional working population (24). To offer data comparable with other European countries, the surveillance protocol uses the recommendations of the criteria document for evaluating the work relatedness of upper extremity MSDs published by European experts (25). The aim of this study was to assess the prevalence of RP and its risk factors in the general working population characterized by various levels of exposure to work-related constraints.

PATIENTS AND METHODS

Population. This cross-sectional study was undertaken in the Loire Valley area of West-Central France between April 2002 and April 2005. The economic structure of the region, which represents 5% of the French working population, is similar to that of most French regions in terms of age, sex, and occupation, except for the Paris region. The region's climate is mild, with normal daily temperatures ranging from 6–8°C (43–46°F) in the winter and 18–20°C (64–68°F) in the summer.

All French workers, 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 OPs participating in this study were representative of the 460 OPs of the Pays de la Loire region in terms of medical practice, working time, geography, and economic sectors covered. The participation rate of the OPs ranged between 14% and 18% depending on the type of company surveyed (private company 18%, public services 17%, hospitals 15%, and the agriculture sector 14%). Each physician working full time was asked to recruit 30–45 workers; those working part time were asked to recruit 15–20 workers to limit their additional workload generated by the surveillance program. Subjects were selected at random, following a 2-stage sampling procedure: first, 15–45 half days of scheduled examinations for each physician were chosen for sampling by the investigators. Next, using random sampling tables, each physician included 1 of 10 workers from the schedule on the half days of worker examinations under consideration. Less than 2% of workers refused inclusion in the study. Less than 5% were not shown or were not included because of duplication. The Pays de la Loire study received ethical approval from the French National Committee for Data Protection (Commission Nationale Informatique et Liberté) prior to the start of the study, and all workers gave consent.

The study population comprised 3,710 workers (2,161 men [58%] and 1,549 women [42%], mean ± SD age 38.7 ± 10.3 years) that were randomly included from 184,600 workers (sampling rate 2%) under surveillance by the 83 OPs. Comparison of the study population's socioeconomic status with the last available French census from 1999 (http://www.insee.fr) showed no major differences for either sex; however, women were slightly underrepresented in the sample (42% versus 47%). The distribution of occupations in the study sample was overall relatively close to that of the region's workforce. Participants worked mainly in the private sector (78%) and only rarely in the public sector (20%), which was similar to the region's working population. Almost all occupations were represented in the sample, except for the few occupations not monitored by the OPs, including farmers, craftsmen, shopkeepers, and independent workers. Approximately 60% of men and 45% of women had a job that included manual labor. The length of service in their current job was >1 year for most workers, whether they had RP (98%) or not (87%). Approximately 11% of men and 32% of women worked part time.

Outcomes. Musculoskeletal symptoms (pain, discomfort, tenderness, and numbness) of the upper extremities occurring during the preceding 12 months were assessed for each worker using the Nordic Musculoskeletal Questionnaire, which included a mannequin denoting the finger regions (13). When finger symptoms occurred during the past 12 months, the OPs systematically asked workers whether they had experienced episodes of sudden well-demarcated blanching of ≥1 finger(s) during the 12-month period and whether these episodes were precipitated by cold temperatures. RP was defined according to the European consensus criteria document for the evaluation of upper extremity MSDs (25) as the occurrence of at least occasional attacks of finger blanching triggered by exposure to environmental cold. The presence of only cyanosis or rubeosis was not accepted as RP if not preceded by characteristic pallor.

Potential risk factors. Personal factors (age, sex, weight, and height), medical history (thyroid disorders, arthritis, and diabetes mellitus), and carpal tunnel syndrome (CTS) (25) were assessed during the physical examination and with a self-administered questionnaire. No biologic test was performed. Information on work history and exposure to the main work-related physical, psychosocial, and organizational factors was collected using a self-administered questionnaire and quantified according to the European consensus criteria document (25). The physical workload was assessed by a psychophysical rating of perceived exertion (RPE) scale scored from 6 (no effort at all) to 20 (exhausting; the 20-RPE Borg scale) (13). Psychosocial factors were appraised according to the demand–autonomy model of stress at work using the validated French version of Karasek's Job Content Questionnaire, including the full recommended scales of decision latitude (9 items), the skill discretion and decision authority scales, psychological demands (9 items), and social support from

supervisors and colleagues (8 items). Scores were dichotomized using the median scores of the large national French Medical Surveillance of Occupational Risk Exposures (SUMER) study (26).

Statistical analysis. Information on sex, age, occupation, and occupational risk factors was available for all participants. The prevalence of RP was computed by subject and not by hand, and therefore bilateral cases of RP counted as 1 disorder, not 2. The list of independent variables considered in the analyses comprised variables known or suspected to be potential risk factors for RP on the basis of epidemiologic and ergonomic studies (5–8,11–14).

Because of the small number of cases of RP, analyses were performed first for the whole sample of workers and for all RP cases using binary logistic regression modeling, and subsequently for men and women to take into account any possible differences in exposure to work constraints between the sexes (8,14). Univariate analyses were performed with each of the potential explanatory variables, and nonsignificant variables (P values greater than 0.20) were excluded from further analyses. Backward multivariate logistic regression models were then performed using all remaining variables. Age and sex (in the model for the whole population) were forced into the models. Nonsignificant variables (P values greater than 0.05) were excluded.

RESULTS

Prevalence of RP. A total of 87 cases of RP, mostly bilateral, were diagnosed in 56 women and 31 men (male: female ratio 1:1.8). Finger symptoms had been present during the past 7 days in 28% of the cases and RP had been recurrent for many years in 61%. The duration of recurrent symptoms was <1 year in 5%, between 1 and 5 years in 30%, and >5 years in 65% of the cases. Workers who had RP were significantly older than those who did not (mean ± SD age 42.4 ± 9.8 years versus 38.6 ± 10.3 years; $P < 0.001$). In a few cases (3.4% [3 of 87], all with both hands affected), RP coexisted with a declared prior history of inflammatory arthritis requiring treatment, the latter disorder being declared by 75 workers (2.1%) without RP. The population-based annual prevalence rates of RP were 3.6% (95% confidence interval [95% CI] 2.7–4.5%) for women and 1.4% (95% CI 0.9–1.9%) for men.

Risk factors for RP. The univariate analyses (Table 1) showed an association between RP and several personal, occupational, and psychosocial factors at work. As shown in Table 2, multivariate analyses showed that RP was strongly associated (odds ratio [OR] >2) with female sex (OR 2.1 [95% CI 1.3–3.4]). The risk of RP increased consistently but moderately with age (ORs ranging from 2.0 [95% CI 1.1–3.8] to 2.9 [95% CI 1.6–5.2]). The risk of RP decreased continuously with body mass index (BMI; OR for 1-kg/m^2 increment of BMI 0.87 [95% CI 0.81–0.94]). The association between RP and coexisting CTS did not remain in the final model after adjustment for other potential confounding factors. No relationship was observed with arthritis or the other personal factors studied. RP was associated with exposure to a cold environment or objects (defined as temperature below 15°C [59°F]) for >4 hours per day (OR 2.2 [95% CI 1.0–4.6]) and, to a lesser extent, with the high repetitiveness of the task (OR 1.7 [95% CI 1.0–2.7]). No association was found with the use of vibrating hand tools or machines that made the hand vibrate (OR 1.3 [95% CI 0.6–2.6]). Of the psychosocial factors at work, high psychological demand at work (OR 1.7 [95% CI 1.0–2.7]) and low support from supervisors (OR 2.4 [95% CI 1.5–3.8]) were highlighted in the final logistic model. Logistic modeling for men and women separately showed that the risk factors differed considerably between the sexes, except for age (ORs ranging from 2.2 to 2.3 for men and from 1.8 to 2.8 for women). Therefore, only exposure to a cold environment or objects (OR 4.5 [95% CI 1.9–10.7]) remained in the model for men, and high repetitiveness of the task (OR 1.8 [95% CI 1.0–3.2]), high psychological demands of the job (OR 2.7 [95% CI 1.4–5.2]), and low supervisor support (OR 2.6 [95% CI 1.4–4.7]) remained in the model for women.

DISCUSSION

This study showed a relatively low prevalence of RP in this regional working population and highlighted a limited number of personal and work-related risk factors for RP that differed between the sexes.

The prevalence in this working population ranged over the same orders of magnitude as observed in Spanish and Italian general populations (15,20); however, higher prevalence has been reported (above all for men) in the several surveys conducted in the US (5,17,19), UK, Japan (14,16), and French Alps (27). This discrepancy might reflect not only differences between the populations studied and the definitions used, but also lower exposure to a cold climate due to the mild climate of the region studied.

RP was associated with a limited number of risk factors in this working population. The higher risk of RP among women agrees with the findings from most epidemiologic studies in the general population (5,6,8,17,19,20). Our results cannot be compared to most studies undertaken in selected working populations since the sex ratio in our sample differed considerably from that of highly exposed workers (mostly men) performing strenuous tasks (13). The higher risk of RP in women might reflect both physiologic predisposition (sex effect) such as hormonal factors (6), and overexposure to work-related constraints (sex effect). The increase in risk of RP with age is consistent with results from some studies in the general population (6,14), but contradictory results have also been reported (18). Moreover, this finding must be interpreted with caution since the role of age cannot easily be deciphered from the effects of cumulative exposure to occupational hazards because of the high correlation between age and length of service. The lower risk of RP in cases of high BMI agrees with the findings from some studies (4,27) and could be explained by a lower exposure of the digital arteries to cold in obese people (27). The association of RP with CTS has been reported previously (20,28), but the relationship

Table 1. Univariate analyses for risk factors for RP*

	Whole sample (n = 3,710)				Men (n = 2,161)				Women (n = 1,549)			
	N_{sample}	No. (%)	OR (95% CI)	*P*	N_{sample}	No. (%)	OR (95% CI)	*P*	N_{sample}	No. (%)	OR (95% CI)	*P*
Personal factors and medical history												
Sex, female vs. male	1,549	56 (3.6)	2.6 (1.7–4.0)	< 0.001†								
Age												
<35 years (ref.)	1,425	19 (1.3)	1	0.007†	847	7 (0.8)	1	0.176†	578	12 (2.1)	1	0.046†
35–44 years	1,060	30 (2.8)	2.2 (1.2–3.9)		612	11 (1.8)	2.2 (0.8–5.7)		448	19 (4.2)	2.1 (1.0–4.4)	
≥45 years	1,224	38 (3.1)	2.4 (1.4–4.1)		701	13 (1.9)	2.3 (0.9–5.7)		523	25 (4.8)	2.4 (1.2–4.8)	
BMI (1-kg/m^2 increment)			0.88 (0.83–0.94)	< 0.001†			0.93 (0.84–1.04)	0.203†			0.89 (0.82–0.97)	0.007†
Coexisting carpal tunnel syndrome, yes vs. no	113	7 (6.2)	2.9 (1.3–6.4)	0.009†	51	2 (3.9)	2.9 (0.7–12.6)	0.149†	62	5 (8.1)	2.5 (1.0–6.4)	0.064†
Diabetes mellitus, yes vs. no	61	2 (3.3)	1.4 (0.3–5.9)	0.634	40	1 (2.5)	1.8 (0.2–13.4)	0.576	21	1 (4.8)	1.3 (0.2–10.1)	0.782
Thyroid disorders, yes vs. no	135	3 (2.2)	0.9 (0.3–3.0)	0.916	33	0 (0.0)	nc	0.984	102	3 (2.9)	0.8 (0.2–2.6)	0.701
Occupational factors												
Working postures and biomechanical constraints												
High repetitiveness (≥4 hours/day), yes vs. no	958	37 (3.9)	2.1 (1.4–3.3)	0.001†	477	10 (2.1)	1.7 (0.8–3.6)	0.180†	481	27 (5.6)	2.1 (1.2–3.6)	0.007†
Too little recovery time (<10 minutes, break possible), yes vs. no	205	12 (5.9)	2.9 (1.5–5.3)	0.001†	90	2 (2.2)	1.6 (0.4–6.8)	0.531†	115	10 (8.7)	2.9 (1.4–5.9)	0.004†
High physical demand (RPE Borg scale ≥13), yes vs. no	1,856	49 (2.6)	1.3 (0.8–2.0)	0.258	1,168	22 (1.9)	2.1 (1.0–4.5)	0.066	688	27 (3.9)	1.2 (0.7–2.0)	0.594
Use of hand tools (≥2 hours/day), yes vs. no	1,711	37 (2.2)	0.9 (0.6–1.4)	0.656	1,159	21 (1.8)	2.0 (0.9–4.4)	0.081	552	16 (2.9)	0.7 (0.4–1.3)	0.324
Use of vibrating hand tools (≥2 hours/day), yes vs. no	469	9 (1.9)	0.8 (0.4–1.7)	0.582	407	7 (1.7)	1.3 (0.6–3.1)	0.533	62	2 (3.2)	0.9 (0.2–3.8)	0.902
Exposure to cold temperatures (≥4 hours/day), yes vs. no	220	9 (4.1)	1.9 (1.0–3.9)	0.067†	149	7 (4.7)	4.3 (1.8–10.1)	0.001†	71	2 (2.8)	0.8 (0.2–3.3)	0.749†
Keying and computer work (≥4 hours/day), yes vs. no	1,024	25 (2.4)	1.1 (0.7–1.8)	0.670	432	3 (0.7)	0.4 (0.1–1.5)	0.178	592	22 (3.7)	1.1 (0.6–1.9)	0.718
Psychosocial factors at work												
High psychological demand, yes vs. no	1,815	56 (3.1)	1.9 (1.2–3.0)	0.004†	1,050	13 (1.2)	0.8 (0.4–1.6)	0.525†	765	43 (5.6)	3.4 (1.8–6.5)	< 0.001†
Low skill discretion, yes vs. no	2,016	55 (2.7)	1.6 (1.0–2.5)	0.050†	1,060	19 (1.8)	2.0 (0.9–4.2)	0.087†	956	36 (3.8)	1.1 (0.6–2.0)	0.648†
Low decision authority, yes vs. no	1,276	38 (3.0)	1.5 (1.0–2.3)	0.061†	652	12 (1.8)	1.5 (0.7–3.2)	0.250†	624	26 (4.2)	1.3 (0.7–2.2)	0.369†
Low supervisor support, yes vs. no	1,427	50 (3.5)	2.4 (1.5–3.7)	< 0.001†	850	16 (1.9)	1.7 (0.8–3.6)	0.137†	577	34 (5.9)	3.0 (1.7–5.3)	< 0.001†
Low colleague support, yes vs. no	708	17 (2.4)	1.0 (0.6–1.7)	0.941	406	4 (1.0)	0.6 (0.2–1.9)	0.423	302	13 (4.3)	1.2 (0.6–2.3)	0.539

* RP = Raynaud's phenomenon; OR = odds ratio; 95% CI = 95% confidence interval; BMI = body mass index; nc = not calculated; RPE = rating of perceived exertion.
† Significant finding.

Table 2. Multivariate model for risk factors for RP*

	Whole sample (n = 3,528)				Men (n = 2,153)				Women (n = 1,458)			
	N_{sample}	No. (%)	OR (95% CI)	*P*	N_{sample}	No. (%)	OR (95% CI)	*P*	N_{sample}	No. (%)	OR (95% CI)	*P*
Sex				0.003								
Men	2,074	28 (1.4)	1									
Women	1,454	51 (3.5)	2.1 (1.3–3.4)									
Age				0.002				0.177				0.022
<35 years (ref.)	1,377	19 (1.4)	1		844	7 (0.8)	1		555	12 (2.2)	1	
35–44 years	996	25 (2.5)	2.0 (1.1–3.8)		612	11 (1.8)	2.2 (0.8–5.7)		415	15 (3.6)	1.8 (0.8–3.9)	
≥45 years	1,155	35 (3.0)	2.9 (1.6–5.2)		697	12 (1.7)	2.3 (0.9–5.9)		488	24 (4.9)	2.8 (1.3–5.8)	
BMI (1-kg/m^2 increment)			0.87 (0.81–0.94)	< 0.001							0.87 (0.79–0.95)	0.003
High repetitiveness (≥4 hours/day)				0.034								0.047
No	2,624	46 (1.8)	1						1,005	27 (2.7)	1	
Yes	904	33 (3.7)	1.7 (1.0–2.7)						453	24 (5.3)	1.8 (1.0–3.2)	
Exposure to cold temperatures (≥4 hours/day)				0.039				0.001				
No	3,317	70 (2.1)	1		2,004	23 (1.2)	1					
Yes	211	9 (4.3)	2.2 (1.0–4.6)		149	7 (4.7)	4.5 (1.9–10.7)					
High psychological demand				0.033								0.004
No	1,774	27 (1.5)	1						724	12 (1.7)	1	
Yes	1,754	52 (3.0)	1.7 (1.0–2.7)						734	39 (5.3)	2.7 (1.4–5.2)	
Low supervisor support				< 0.001								0.002
No	2,138	30 (1.4)	1						902	18 (2.0)	1	
Yes	1,390	49 (3.5)	2.4 (1.5–3.8)						556	33 (5.9)	2.6 (1.4–4.7)	

* RP = Raynaud's phenomenon; OR = odds ratio; 95% CI = 95% confidence interval; BMI = body mass index.

we observed was not confirmed by multivariate analyses. Most cases were bilateral and no association was observed with arthritis or connective tissue diseases, suggesting that most cases of RP were idiopathic; however, due to the sample size, very few workers had such disorders in our study, in contrast with patients consulting rheumatology clinics for treatment of RP (1). This result agrees with the results from surveys in the general population (18,20) and may be explained by a healthy worker effect, leading severely injured workers to cease working.

The main biomechanical work-related factor was the high repetitiveness of the task requiring repetitive hand movements (in men), which is in accordance with the findings of studies examining selected working populations performing repetitive movements in the manufacturing industry, forestry industry, and food industry (10–13,29). Most of these workers were exposed to both repetitive movements and either hand-transmitted vibrations or cold environments, but our results suggest that repetitive movement could act as an independent factor.

Working in a cold environment (ambient temperature below 15°C [59°F]) and handling cold objects and hand tools were strongly associated with RP in our study. This might be explained by the definition of the disorders used, but agrees with findings from previous epidemiologic studies and the physiopathology of RP (1,13).

In contrast to the large study by Palmer et al in the general population of the UK and several studies in more selected working populations (11,12,14), no statistically significant association was found between RP and exposure to hand-transmitted vibrations by vibrating tools or machines after adjustment for potential confounders. This could be explained by the lack of statistical power of the study since few workers (only 13%) were exposed (for >2 hours/day) to vibrating tools or machines in our working population compared to studies involving highly exposed workers (10,11,30).

In our study, psychosocial work characteristics were appraised with reference to the demand–control–support model (31), which hypothesizes that the combination of high job demands and low possibilities of control of the job (called job strain) leads to stress and stress-related health outcomes (13,31,32). A low level of social support enhances the adverse effects of this combination, which is then called a job isostrain situation (31,32). Our results show that performing a job requiring high psychological demand and offering low support from supervisors increased the risk of RP. Consequently, the risk of RP seemed to be influenced by 2 major work-related psychosocial stressors, independently of biomechanical and environmental exposure, and the amplitude of the effect seemed to be in the same order of magnitude as for work-related biomechanical and environmental factors. As far as we are aware, few studies have reported relationships between RP and occupational psychosocial stressors, despite the information accumulated regarding their impact on cardiovascular health and MSDs (31,32). The higher risk of RP in workers exposed to occupational psychosocial stressors in this study is supported by clinical experience and the provocation effect of emotional stress among many patients (1,2,7,33); however, although our results are biologically plausible, no causal conclusion could be drawn due to the cross-sectional design of the study.

It has been shown that personal risk factors for RP differed between the sexes in the general population (5). Our study in a working population showed that the work-related risk factors for RP differed between men and women, with a greater influence of environmental and biomechanical constraints in men and of psychosocial work environment in women. Although the lack of statistical power of our study could partly explain these results, they might also reflect the different mechanisms influencing the expression of RP in men and women (5) and variations in the exposure to biomechanical and psychosocial constraints at work.

The surveillance method was based on a large regional sentinel network of OPs that allowed the random inclusion of a large sample of workers during their compulsory annual occupational health examination to ensure a representative sample of the region's workforce. Although few workers failed to participate, a healthy worker effect could have occurred due to the cross-sectional design of the study and, since patients unable to work because of RP or associated diseases were not analyzed, this may have caused an underestimation of the estimates of risk. The surveillance program involved upper extremity MSDs as a whole and did not focus on RP. The physicians therefore had no particular interest in RP that could have led to a diagnostic bias and an overestimation of the prevalence of RP.

RP was assessed by a self-administered questionnaire to evaluate the occurrence of symptoms in the fingers during the previous 12 months and then by a personal interview asking about changes in finger color. Symptoms in the toes or nose and the occurrence of headaches were not checked and we could not assess the occurrence of symptoms in both the upper and lower extremities. Information on sclerodactyly and digital pitting scars (if collected) was not available. There was no color chart showing well-demarcated local blanching of the fingers used to assist the diagnosis (34), and therefore our definition of RP may lack specificity. Few connective tissue diseases occurred in this sample of workers, but their assessment was based only on the medical files and without specific clinical examination or biologic analyses. Despite their potential association with RP, no information was available on any possible family history of RP, smoking status, caffeine consumption, or treatment with antihypertensive medication (10); however, contradictory results have been reported in the general population (5,18) and, although these factors may represent important confounders, their influence is probably not sufficient to diminish the value of the study.

While the potential determinants of RP are numerous, few studies examining workers have simultaneously taken into account the main personal and occupational risk factors for RP described in the literature. For most workers, the 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 most serious drawback to exposure assessment in this study was that occupational risk factors were assessed through a self-administered questionnaire, meaning that we cannot

exclude the possibility that self-reported exposure may have biased risk estimates.

In conclusion, this study showed that personal and work-related factors were associated with RP. Since most individual factors are less modifiable than work-related factors, exposure to cold, repetitive movements, and psychosocial stressors should be an important target of strategies for the prevention of RP in the working population.

AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be published. Dr. Roquelaure had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. Roquelaure, Ha, Goldberg, Imbernon.

Acquisition of data. Roquelaure, Bodere, Bosseau, Goldberg.

Analysis and interpretation of data. Roquelaure, Ha, Petit Le Manac'h, Bodin, Descatha, Leclerc, Goldberg, Imbernon.

REFERENCES

1. Gayraud M. Raynaud's phenomenon. Joint Bone Spine 2007; 74:e1–8.
2. Freedman RR, Ianni P. Role of cold and emotional stress in Raynaud's disease and scleroderma. Br Med J 1983;287:1499–502.
3. Freedman RR, Mayes MD. Familial aggregation of primary Raynaud's disease. Arthritis Rheum 1996;39:1189–91.
4. Keil JE, Maricq HR, Weinrich MC, McGregor AR, Diat F. Demographic, social and clinical correlates of Raynaud's phenomenon. Int J Epidemiol 1991;20:221–4.
5. Fraenkel L, Zang Y, Chaisson CE, Maricq HR, Evans SR, Brand F, et al. Different factors influencing the expression of Raynaud's phenomenon in men and women. Arthritis Rheum 1999;42:306–10.
6. Fraenkel L. Raynaud's phenomenon: epidemiology and risk factors. Curr Rheumatol Rep 2002;4:123–8.
7. Brown KM, Middaugh SJ, Haythornthwaite JA, Bielory L. The effects of stress, anxiety, and outdoor temperature on the frequency and severity of Raynaud's attacks: the Raynaud's Treatment Study. J Behav Med 2001;24:137–53.
8. Suter LG, Murabito JM, Felson DT, Fraenkel L. The incidence and natural history of Raynaud's phenomenon in the community. Arthritis Rheum 2005;4:1259–63.
9. Suter LG, Murabito JM, Felson DT, Fraenkel L. Smoking, alcohol consumption and Raynaud's phenomenon in middle age. Am J Med 2007;120:264–71.
10. Bovenzi M, Franzinelli A, Manchini R, Cannava MG, Maiorano M, Ceccarelli F. Dose-response relation for vascular disorders induced by vibration in the fingers of forestry workers. Occup Environ Med 1995;52:722–30.
11. Bovenzi M, Della Vedova A, Nataletti P, Alessandrini B, Poian T. Work-related disorders in the upper limb in female workers using orbital sanders. Int Arch Occup Environ Health 2005; 78:303–10.
12. Burstrom L, Jarvholm B, Nilsson T, Wahlstrom J. White fingers, cold environment and vibration-exposure among Swedish construction workers. Scand J Work Environ Health 2010; 36:509–13.
13. Hagberg M, Silverstein B, Wells R, Smith MJ, Hendrick HW, Carayon P, et al. Work related musculoskeletal disorders (WMSDs): a reference book for prevention. London: Taylor & Francis; 1995.
14. Palmer KT, Griffin MJ, Sydall H, Pannett B, Cooper C, Coggon D. Prevalence of Raynaud's phenomenon in Great Britain and its relation to hand transmitted vibration: a national postal survey. Occup Environ Med 2000;57:448–52.
15. Riera G, Vilardell M, Vaque J, Fonollosa V, Bermejo B. Prevalence of Raynaud's phenomenon in a healthy Spanish population. J Rheumatol 1993;20:66–9.
16. Harada N, Ueda A, Takegata S. Prevalence of Raynaud's phenomenon in Japanese males and females. J Clin Epidemiol 1991;44:649–55.
17. Gelber AC, Wigley FM, Stallings RY, Bone LR, Barker AV, Baylor I, et al. Symptoms of Raynaud's phenomenon in an inner-city African-American community: prevalence and self-reported cardiovascular comorbidity. J Clin Epidemiol 1999; 52:441–6.
18. Voulgari PV, Alamanos Y, Papazisi D, Christou K, Papanikolaou C, Drosos AA. Prevalence of Raynaud's phenomenon in a healthy Greek population. Ann Rheum Dis 2000;59:206–10.
19. Weinrich MC, Maricq HR, Keil JE, McGregor AR, Diat F. Prevalence of Raynaud's phenomenon in the adult population of South Carolina. J Clin Epidemiol 1990;43:1343–9.
20. De Angelis R, Salaffi F, Grassi W. Raynaud's phenomenon: prevalence in an Italian population sample. Clin Rheumatol 2006;25:506–10.
21. Onbasi K, Sahin I, Onbasi O, Ustun Y, Koca D. Raynaud's phenomenon in a healthy Turkish population. Clin Rheumatol 2005;24:365–9.
22. Czirjak L, Kiss CG, Lovei C, Suto G, Varju C, Fuzesi Z, et al. Survey of Raynaud's phenomenon and systemic sclerosis based on a representative study of 10,000 South-Transdanubian Hungarian inhabitants. Clin Exp Rheumatol 2005;23: 801–8.
23. Ha C, Roquelaure Y, Leclerc A, Touranchet A, Goldberg M, Imbernon E. The French Musculoskeletal Disorders Surveillance Program: Pays de la Loire network. Occup Environ Med 2009;66:471–9.
24. Roquelaure Y, Ha C, Leclerc A, Touranchet A, Sauteron M, Melchoir M, et al. Epidemiologic surveillance of upper-extremity musculoskeletal disorders in the working population. Arthritis Rheum 2006;55:765–78.
25. Sluiter JK, Rest KM, Frings-Dresen MH. Criteria document for evaluation of the work-relatedness of upper extremity musculoskeletal disorders. Scand J Work Environ Health 2001;27 Suppl 1:1–102.
26. Niedhammer I, Chastang JF, Gendrey L, David S, Degioanni S. Psychometric properties of the French version of Karasek's Job Content Questionnaire and its scales measuring psychological pressures, decisional latitude and social support: the results of the SUMER. Sante Publique 2006;18:413–27. In French.
27. Maricq HR, Carpentier PH, Weinrich MC, Keil JE, Palesh Y, Biro C, et al. Geographic variation in the prevalence of Raynaud's phenomenon: a 5 region comparison. J Rheumatol 1997;24:879–89.
28. Pal B, Keenan J, Misra HN, Moussa K, Morris J. Raynaud's phenomenon in idiopathic carpal tunnel syndrome. Scand J Rheumatol 1996;25:143–5.
29. Kaminski M, Bourgine M, Zins M, Touranchet A, Verger C. Risk factors for Raynaud's phenomenon among workers in poultry slaughterhouse and canning factories. Int J Epidemiol 1997;26:371–80.
30. Barregard L, Ehrenstrom L, Marcus K. Hand-arm vibration syndrome in Swedish car mechanics. Occup Environ Med 2003;60:287–94.
31. Karasek R, Theorell T. Healthy work: stress, productivity and the reconstruction of the working life. New York: Basic Books; 1990.
32. Bongers PM, Ijmker S, van den Heuvel S, Blatter BM. Epidemiology of work related neck and upper limb problems: psychosocial and personal risk factors (part I) and effective intervention from a bio behavioural perspective. J Occup Rehabil 2006;16:279–302.
33. Edwards CM, Marshall JM, Pugh M. Lack of habituation of the pattern of cardiovascular response evoked by sound in subjects with primary Raynaud's disease. Clin Sci 1998;95:249–60.
34. O'Keeffe ST, Tsapatsaris NP, Beetham WP. Color chart assisted diagnosis of Raynaud's phenomenon in an unselected hospital employee population. J Rheumatol 1992;52:441–6.