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Personal, Biomechanical, Organizational and Psychosocial Risk Factors for Neck Disorders in a Working Population

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Abstract: Personal, Biomechanical, Organizational and Psychosocial Risk Factors for Neck Disorders in a Working Population: Audrey PETIT, *et al*. LUNAM University, Laboratory of Ergonomics and Epidemiology in Occupational health, (LEEST), University of Angers, Faculty of Medicine, France—Objectives: The aim of the study was to assess both personal and occupational risk factors for non-specific neck disorder (ND) in a representative working population characterized by various levels of exposure to work-related constraints. ND during the preceding 7 days was assessed in 3,710 workers surveyed by 83 occupational physicians between 2002 and 2005. Personal risk factors and work exposure were assessed by a standardized examination and a self-administered questionnaire. Associations between ND and personal and occupational factors were analyzed using logistic regression modeling separately in men and in women. **Results:** The personal risk factors for ND were age (OR for 1-year increment 1.02, 95% CI 1.01 to 1.03 in men and 1.03 [1.01−1.04] in women) and previous history of arthritis disease (OR 2.39 [1.17−4.91] in men and 3.95 [1.92−8.12] in women). The risk of ND increased with previous history or upper limb musculoskeletal disorders in men (OR 1.58 [1.17−2.13]) and decreased with BMI in women (OR for 1-kg/m^2 increment 0.96, [0.93−0.99]). The work-related risk factors of ND were sustained or repeated arm abduction (OR 2.08 [1.35−3.21] in men and 2.22 [1.27−3.86] in women) and neck flexion (OR 1.64 [1.26−2.12] in women). Work pace dependent on customers (OR 1.42 [1.10−1.83]) and psychological demand of the task (OR 1.49 [1.15−1.92]) increased the risk of ND in men. Work pace dependent on quantified targets (OR 1.37 [1.05−1.79]) and low supervisor support (OR 1.68 [1.30−2.17]) increased the risk of ND in women. This study highlighted the multifactorial nature of ND.
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Key words: Musculoskeletal disorder, Neck disorder, Occupational, Personal, Risk factors

The cervical spine is the most mobile and least stable part of the human spine, and neck disorders (ND) may arise from any of its complex systems of structures. In the general population, neck pain and dysfunction are common, affecting up to 67% of the general population at some time during their life. About one-fifth of adults who were previously pain free report a new episode of neck pain in a one-year period[1, 2]. Although not associated with high morbidity, ND is one of the four most commonly reported musculoskeletal disorders (MSD) among workers, with the year prevalence varying from 27.1% to 47.8%, and results in work absenteeism, job change and disability[3]. As for other MSDs, the development of nonspecific ND is thought to be related to multiple factors including individual worker characteristics such as gender, age, psychological distress, occupation, workplace environment and organizational and management policies[4–6]. Women are considered to be at higher risk than men; this could reflect both biological predisposition (sex-effect) and overexposure to physical and psychosocial factors, both at work and in the family setting (gender-effect)[5]. Some physical risk factors (repetitive jobs and awkward postures) and psychosocial risk factors (low job content and high psychological demands) have been found to be strong-

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ly related to ND, but most studies are performed among highly exposed workers, which can limit their conclusions in terms of causality and external validity[7, 8].

Using the data of the surveillance program for musculoskeletal disorders (MSD) in the working population of the French Loire Valley region, the aim of this study was to assess the prevalence and relative importance of personal factors and various occupational factors associated with ND, in a large sample of active workers exposed to various levels of work constraints.

Methods

This cross-sectional 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)[9]. 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. Eighty-three of the 460 OPs in the region (18% participation), representative of the region's OPs in terms of medical practice, working time, geography and economic sectors covered, participated in the study. Each OP was trained by the investigators to randomly include workers undergoing a mandatory regularly-scheduled annual health examination between April 2002 and April 2005. The inclusion process followed a two-stage sampling procedure: firstly, 15 to 30 half-days of scheduled examinations for each physician were randomly chosen by the investigators; secondly, each physician was asked to randomly select 1 of 10 workers on the selected half-days of worker examinations. All the participants signed an informed consent form. Fewer than 10% of the selected workers were not included (no shows, refusals and duplications).

Study population

The study population comprised 3,710 workers [2,161 men (58%) and 1,549 women (42%), mean age 38.7 years, standard deviation (SD) 10.3 years] out of 184,600 surveyed (sampling rate 2%) by the 83 OPs (Table 1). Comparison of their socioeconomic status with data from the 1999 French census (http://www.insee.fr) showed no major differences from the regional workforce for either gender[9]. Length of service in the current job was high for the majority of workers, whatever the gender: >10 years for 38%, >2 years for 72% and >1 year for 88%. Subjects worked mainly in the service industries (58.6%), the meat and manufacturing industries (33.7%) and more rarely in the construction (5.8%) and agriculture (1.9%) sectors. Overall, the distribution of occupations was close to that of the regional workforce, except for the rare occupations not surveyed by OPs (e.g., shopkeepers and independent workers). Men were mainly skilled and unskilled blue-collar workers (56%), workers in intermediate occupations and technicians (25%) and managers and professionals (10%). Most women were low-grade white-collar workers (52%), skilled and unskilled blue collar workers (24%) and workers in intermediate occupations and technicians (19%).

Outcomes

The presence of nonspecific neck pain during the preceding 7 days was identified using the self-administered Nordic questionnaire[10]. A mannequin was used to denote the cervical region.

Potential risk factors

Information was collected on personal and work-related factors known to be or suspected of being risk factors for ND on the basis of epidemiological and ergonomic reviews[4, 9, 11, 12]. Personal factors were collected during the physical examination and with a self-administered questionnaire. Work-related factors were assessed using a self-administered questionnaire.

The personal factors assessed were age, body mass index (BMI), prior history of upper-extremity musculoskeletal disorders (UEMSD) (rotator cuff syndrome, lateral epicondylitis, ulnar tunnel syndrome, carpal tunnel syndrome, De Quervain's disease and flexor-extensor peritendinitis, or tenosynovitis of the forearm-wrist region), arthritis disease, diabetes mellitus and thyroid disorder. The working postures and biomechanical constraints taken into account were defined and quantified according to the "European consensus criteria document"[8], except for perceived physical exertion which was assessed using the Borg Rating of Perceived Exertion scale (20-RPE) graduated from 6 ("very, very light") to 20 ("maximal exertion"). Postures of the head and upper limbs were assessed using picture forms to facilitate the workers' understanding. Response categories were presented on a 4-level Likert-type scale, as follows: never or practically never, rarely (less than 2 hours per day), often (2 to 4 hours per day) and always (more than 4 hours per day). The following characteristics in relation to work organization were evaluated: working time, time constraints (including paced work and norms of production), visual load, weekly job rotation and working with temporary workers. 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 (skill discretion and decision authority), psychological demands, and social support

(from supervisors and colleagues). Scores were dichotomized using the median scores of the large French national Medical Surveillance of Occupational Risk Exposures (SUMER) study[13].

Statistical methods

Analyses were performed separately for men and women to take into account possible differences in exposure to work constraints between genders[5, 6, 14, 15]. Relationships between ND and potential risk factors were studied by binary logistic regression modeling according to a 3-stage process. Age and BMI were considered as continuous variables, after verification of the linearity of the logit, and then odds ratios (OR) were computed for a 1-year increment or 1-kg/m^2 increment. In stage one, univariate analyses were performed with each potential explanatory variable, and nonsignificant variables ($p \geq 0.20$) were excluded from further analyses. In stage two, the remaining variables were grouped into four groups of potential determinants (personal factors, factors related to work organization, psychosocial factors at work, working postures and biomechanical constraints), and manual backward multivariate logistic regression was performed within each group of factors. Age was forced into all models. Nonsignificant variables ($p \geq 0.10$) were excluded from these "within-group" models. In stage three, the remaining factors 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 manual backward multivariate logistic regression, if there was a change in the beta coefficients of ≥15% when a variable was deleted, the variable was considered a confounder and was forced into the model. Each model was tested with the Hosmer-Lemeshow goodness-of-fit test[16].

Results

The prevalence of ND during the preceding 7 days was higher among women (25.3%) than men (14.4%) ($p<0.001$). Numerous factors related to the personal characteristics, working postures and biomechanical constraints, work organization, and psychosocial factors at work, were associated with ND (Table 1).

The prevalence of ND was consistently associated with increasing age (OR for a 1-year increment 1.02 [95% CI 1.01 to 1.03] in men and 1.03 [95% CI 1.01 to 1.04] in women). Prior history of arthritis disease was associated with a higher prevalence of ND for both genders (OR 2.39 [95% CI 1.17 to 4.91] in men and OR 3.95 [95% CI 1.92 to 8.12] in women) and prior history of UEMSD in men (OR 1.58 [95% CI 1.17 to 2.13]). Increasing BMI in women was associated with a lower prevalence of ND (OR for a 1-kg/m^2 increment 0.96 [95% CI 0.93 to 0.99]). Length of service was only associated with ND in women after 10 years in the current job and was not associated with ND after adjustment for age.

Performing highly repetitive actions and high perceived physical exertion (20-RPE ≥13) were not associated with ND for either gender in the final multivariate model. The occurrence of sustained and repetitive arm abduction >60° combined with arm abduction >90° for more than 2 hours a day was strongly associated with ND for both genders (OR 2.08 [95% CI 1.35 to 3.21] in men and OR 2.22 [95% CI 1.27 to 3.86] in women) but other arm working postures were not associated with ND for either gender. The occurrence of neck flexion more than 4 hours a day was also associated with ND in women (OR 1.64 [95% CI 1.26 to 2.12]) but neither neck extension nor working on a computer was related to ND for either gender. The result was the same for use of vibrating hand tools.

Regarding organizational factors, work pace dependent on customer demand was associated with ND in men (OR 1.42 [95% CI 1.10 to 1.83]), and work pace dependent on quantified targets was associated with ND in women (OR 1.37 [95% CI 1.05 to 1.79]). An association between work pace dependent on colleagues' work and ND was observed at the limit of significance in women.

The final logistic models highlighted different psychosocial associated factors for ND according to gender: high psychological demand of a task (OR 1.49 [95% CI 1.15 to 1.92]) for men and low supervisor support (OR 1.68 [95% CI 1.30 to 2.17]) for women. Low skill discretion was not associated with ND in women after adjustment.

Discussion

This study found a high prevalence of ND among male and female workers (14.4% and 25.3% respectively) in a large representative sample of salaried workers exposed to various levels of working constraints. The strength of the study was that it took into consideration both personal and occupational factors, especially several occupational factors such as work organization, which has rarely been considered.

Among the potential personal factors, the effect of age on ND has been discussed previously[4, 5, 17]. Our findings are in accordance with the degenerative changes seen on radiographs of the cervical spine in most adults aged ≥30 years of age with a continuum of severity[18] and the increasing susceptibility of neck tissues and joints to physical loads. Length of service is difficult to disentangle from the effects of cumulative occupational exposure and age, thus explaining why evidence linking length of service to

Table 1. Multivariate model for risk factors for neck disorder (ND) in the male and female working populations. [N_{ND}=number of ND cases; OR=odds ratio; 95%CI=95% confidence interval]

Risk factors	Men (N=2,041)* N_{ND}=297					Women (N=1,378)* N_{ND}=349				
	N	%	OR	95%CI	*p*-value	N	%	OR	95%CI	*p*-value
Personal factors										
Age (1 year)			1.02	1.01–1.03	0.003			1.03	1.01–1.04	<0.001
BMI (1 kg/m^2)								0.96	0.93–0.99	0.005
Prior history of UEMSD					0.003					
No	1,682	13.1	1							
Yes	359	21.2	1.58	1.17–2.13						
Arthritis disease					0.017					<0.001
No	2,003	14.2	1			1,344	24.6	1		
Yes	38	31.6	2.39	1.17–4.91		0.02	52.9	3.95	1.92–8.12	
Organizational factors										
Work pace dependent on customers demands					0.007					
No	1,149	12.5	1							
Yes	892	17.3	1.42	1.10–1.83						
Work pace dependent on quantified targets										0.019
No						810	21.7	1		
Yes						568	30.5	1.37	1.05–1.79	
Work pace dependent on colleagues' work**										0.089
No						996	23.3	1		
Yes						382	30.6	1.28	0.96–1.69	
Biomechanical factors										
Sustained or repeated arm posture in abduction (≥2 hours/days)					0.007					0.042
No	1,540	13.3	1			1,098	24.0	1		
>60°	216	16.2	1.35	0.91–2.02		123	30.1	1.16	0.76–1.79	
>90°	155	15.5	1.21	0.76–1.92		95	25.3	1.01	0.61–1.66	
Both	130	25.4	2.08	1.35–3.21		62	38.7	2.22	1.27–3.86	
Forward neck flexion (≥4 hours/day)										<0.001
No						904	21.2	1		
Yes						471	33.1	1.64	1.26–2.12	
Psychosocial factors										
High psychological demand					0.002					
No	1,043	11.8	1							
Yes	998	17.4	1.49	1.15–1.92						
Low supervisor support										<0.001
No						855	21.5	1		
Yes						523	31.5	1.68	1.30–2.17	

*Hosmer-Lemeshow goodness-of-fit test: *p*-value=0.218 for the model for men and *p*-value=0.554 for the model for women.
**"Work pace dependent on colleagues' work" confounded with "work pace dependent on quantified targets" in women.

incidence of ND varies between studies[19]. UEMSD and ND share several common personal and work-related risk factors, and it has been established that a history of MSD increases the risk of ND in workers[4, 17, 20–24]. Moreover, neck pain and shoulder pain are closely interlinked, since pain that arises from deep structures around the neck (ligaments, muscles, joint, discs or bone) is poorly localized to the neck and shoulders, unless arising from irritation of the nerve roots. Neck pain radiation mostly occurs to the upper superior shoulder and vice versa[12]. Our study indicated a protective effect of increased BMI for ND in women. This association is disputed, and findings vary between studies[24, 25]. However, Brandt *et al*. and Gerr *et al*. did not support such a relationship in American office workers and Danish technicians, respectively[20, 23].

Sustained or repeated working posture with the arm abducted was the main work-related risk factor for ND in this large representative working population, in both men and women. The strength of association was high (OR>2) for sustained or repeated abduction >60° combined with arm abduction >90° for more than 2 hours a day. Other workplace studies support these findings: the incidence of ND was higher in municipal employees who worked with their hands above their shoulders compared with those who did not and in nursing home workers who worked with their hands compared with those who did not report awkward postures[22, 25]. The shoulders and neck are biomechanically linked, and any sustained or repeated arm abduction induces activation of scapular muscles and, in particular, increases trapezius activity. However, the evidence for an association between muscle activity and pain is conflicting, and pathogenic mechanisms of pain development are likely to be multifactorial[26–29]. Our multivariate analyses confirmed an increased risk of ND associated with forward neck flexion for more than 4 hours a day only in women[30, 31]. However, disentangling the separate contributions of repetitive arm movements and neck posture is difficult, since most women are exposed to both repetitive arm movements and neck flexion[30]. The relationship between hand-transmitted vibration and ND is disputed[6, 32], and we did not found this relationship.

The relationships between organizational factors and ND have been rarely studied. The present study allowed us to highlight the increased risk of ND associated with time constraints. Organizational related-factors differed according to gender: work pace dependent on customers demands in men and on quantified targets in women. Organizational risk factors may have different effects on men and women[5] (differential exposure, social roles, psychology pain tolerance or coping strategies)[14, 15].

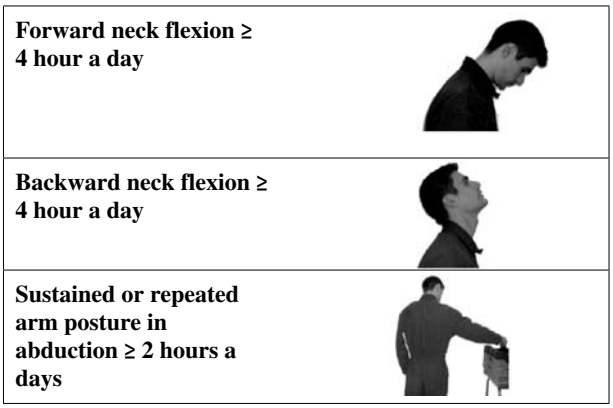

Fig. 1. working postures (neck and arm).

The psychosocial work environment is generally considered to be an important determinant of ND depending on several hypothetical mechanisms: muscle contractions[11, 31], increased perception of pain, less control[30, 34] of occupational constraints and less compliance with treatment[5, 17, 33]. Here, we found an association between ND and high psychological demand of a task in men and lack of supervisor support in women using the the demand-control-support model of stress at work[13]. These results and gender differences were consistent with previous findings[35, 36].

Our 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 and various levels of exposure to work-related constraints. Few workers failed to participate, but due to the cross-sectional design of the study, a "healthy worker effect" could have occurred and caused underestimation of the estimates of risk, and no causal conclusion can be drawn. 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 potential personal and occupational risk factors for ND described in the literature were taken into account. While the potential determinants of ND are numerous, few studies conducted among workers have taken personal, biomechanical, organizational and psychosocial factors into account together. However, we did not collect information on psychological distress, mental stress and strain or headache, despite their possible association with ND[4, 6, 11, 22]. Non-work-related activities, such as household duties, leisure and physical activities were not assessed, although they may increase the risk of ND[11, 37]. As much as possible, standardized and validated instruments were used to reduce exposure classification errors[8]. For example, awkward postures

were presented in picture form to facilitate the workers' understanding and increase the validity of posture self-assessment. The recall period of the preceding 7 days that was chosen limited recall errors regarding self-reported exposure[38]. The most serious drawback to exposure assessment in this study was that occupational risk factors were assessed through a self-administered questionnaire[39]. We cannot exclude the possibility that self-reporting of exposure may have produced biased risk estimates, since workers experiencing musculoskeletal pain may overrate their exposure levels. However, underrating was also possible, especially for workers who moved to lighter work because of recurrent symptoms[40].

In conclusion, the study confirmed the multifactorial origin of ND and showed that the relative importances of individual, biomechanical, organizational and psychosocial risk factors for ND were similar. This study highlighted several work-related risk factors that can potentially be modified and may help occupational health departments to reduce occupational exposures that potentially predispose their employees to ND.

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