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Association of Physical Job Demands, Smoking and Alcohol Abuse with Subsequent Premature Mortality: A 9-year Follow-up Population-based Study

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Abstract: Association of Physical Job Demands, Smoking and Alcohol Abuse with Subsequent Premature Mortality: A 9-year Follow-up Population-based Study: Eve BOURGKARD, *et al.* Institut National de Recherche et de Sécurité (INRS), WHO Collaborative Centre, Département d'Epidémiologie en Entreprises, France—This study assessed the relationships of physical job demands (PJD), smoking, and alcohol abuse, with premature mortality before age 70 (PM-70) among the working or inactive population. The sample included 4,268 subjects aged 15 or more randomly selected in north-eastern France. They completed a mailed questionnaire (birth date, sex, weight, height, job, PJD, smoking habit, alcohol abuse (Deta questionnaire)) in 1996 and were followed for mortality until 2004 (9 yr). PJD score was defined by the cumulative number of the following high job demands at work: hammer, vibrating platform, pneumatic tools, other vibrating hand tools, screwdriver, handling objects, awkward posture, tasks at heights, machine tools, pace, working on a production line, standing about and walking. The data were analyzed using the Poisson regression model. Those with PM-70 were 126 (3.81 per 1,000 person-years). The leading causes of death were cancers (46.4% in men, 57.1% in women), cardiovascular diseases (20.2% and 11.9%), suicide (9.5% and 7.1%), respiratory diseases (6.0% and 4.8%), and digestive diseases (2.4% and 4.8%). PJD≥3, smoker, and alcohol abuse had adjusted risk ratios of 1.71 (95% CI 1.02–2.88), 1.76 (1.08–2.88), and 2.07 (1.31–3.26) respectively for all-cause mortality. Manual workers had a risk ratio of 1.84 (1.00–3.37) compared to the higher socio-economic classes. The men had a two-fold higher mortality rate than the women; this difference became non-significant when controlling for job, PJD, smoker and alcohol abuse. For cancer mortality the factors PJD≥3, smoker, and alcohol abuse had adjusted risk ratios of 2.00 (1.00–3.99), 2.34 (1.19–4.63), and 2.22 (1.17–4.20), respectively. Health promotion efforts should be directed at structural measures of task redesign and they should also concern lifestyle.
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Health hazards at work are still a major determinant of poor health and they contribute to social inequalities in health, injuries, disabilities, and mortality[1–12]. In the European Union, 3.6% of the total burden of disease is directly related to the work environment[13]. Among various jobs, manual workers are the most affected, especially for all-cause, cancer and coronary heart disease mortality[1, 8, 14–16]. In France, the social disparities in morbidity, mortality and premature mortality are higher than in other west European countries[15, 16]. Manual workers have a death ratio of 1.2 compared to the French people[14], and 20% of cancers are attributed to work-related factors (vs. 5% among the population as a whole)[17]. Among occupational hazards physical job demands (repetitive and forceful movements, tool use, adverse environment, awkward posture, pace, handling objects, tasks at heights, etc.) are common and result in, among others, musculoskeletal disorders,

fatigue, stress, substance use, occupational injuries, disabilities[2, 3, 5, 9, 10, 12, 18, 19], and death[20]. The role of physical job demands is little documented. Indeed, research undertaken on premature mortality has focused on manual workers and socioeconomic-related factors such as low income, unhealthy nutrition, altered living conditions, obesity, smoking, alcohol use, and lack of leisure time physical activities[1, 6, 15, 17, 21–25]. It should be noted that physical job demands also concern a number of other occupations such as craftsmen, farmers, and clerks. The impact of occupational hazards on heath and mortality should increase in the next few years, because of a higher duration of work exposure due to the lengthening of working life, a consequence of the ageing of the population[25]. Physical job demands are a relatively neglected research area on premature mortality. This may be due to a large population being needed and the necessity of following-up on subjects over a long period and after retirement.

In the last few decades, research has shown the important role of health-related behaviors, especially smoking and alcohol abuse, on health, injuries and mortality[1, 6, 21, 26–28]. Worldwide, smoking and alcohol use continue to result in substantial morbidity (9.0% and 8.4% of the total burden in the European Union[13]) and mortality[22, 29]. Consequences of smoking include, among others, respiratory and cardiovascular diseases, cancer, injuries, disabilities, and over 1.2 million deaths in the WHO European Region, annually[1, 6, 21, 27, 29]. Consequences of alcohol abuse include, among others, cirrhosis, cardiovascular diseases, cancer, gastrointestinal problems, neurocognitive deficits, bone loss, emotional challenges, depression, deteriorated postural control, injuries, job loss, sickness absence, and 1.8 million deaths worldwide[1, 6, 22, 28, 30–32]. Note that manual workers have a higher prevalence of smoking than higher socio-economic classes[33–35]. In many industrialized countries smoking has been very common since youth, increasing the risk of the development of avoidable tobacco-related illnesses at an early age[36, 37]. France is a wine producting country where alcohol consumption is higher than elsewhere, while smoking remains prevalent[6, 33, 38]. Obesity is also a major public health concern and contributes to 3.6% of the total burden of diseases in European countries[1, 13]. It increases the risk for many chronic conditions, such as cardiovascular diseases, diabetes, cancers, and excess mortality[1, 24, 39, 40]. It affects mostly manual workers[1], and consequently increases their risk of obesity-related mortality[1, 40].

The respective roles of physical job demands, smoking, alcohol abuse, and obesity and job, age and gender differentials in premature mortality is a key question. The knowledge of their risk patterns may help public health officials to determine the importance of prevention and to identify and monitor subjects most at risk. To our knowledge this issue has been little documented. The present study assessed through a 9-yr follow-up the associations of cumulative physical job demands, obesity, smoking, excess alcohol consumption, sex and age with subsequent premature mortality due to various causes in a the population from the north-eastern France. This study focused on premature death before 65 yr (PM-65), but also that before 70 yr (PM-70). Indeed, premature mortality may also concern the ages 65–70 yr due to the ageing of the population. The results are important because they show the importance of monitoring workers after retirement.

Materials and Methods

Subjects

The initial sample consisted of everyone aged 15 yr or more living in 8,000 randomly selected households in the Lorraine region of north-eastern France (2.3 million inhabitants). They represent 1/100 of the population studied. Only households with a telephone were eligible.

Study design

Before the initial survey, a 3-month media campaign (television, print, and radio) was conducted in order to raise awareness. The investigation was approved by the Commission Nationale de l'Informatique et Libertés, and written informed consent was obtained from the respondents. The study protocol included: (a) an application to participate to ascertain the number of persons in the household, then (b) three standardized self-completion questionnaires with a covering letter and a pre-paid envelope for the reply, were mailed at 1-month intervals. When the number of individuals was unknown, two questionnaires were sent first, and a complementary one was sent later. The standardized self-administered questionnaires were completed by the subjects themselves. Adolescents were free to ask their parents if they did not understand a question. The questionnaire included: demographical characteristics, smoking habit, alcohol abuse, job (in the past for the retired people; coded according to the Insee classification, Paris, 1983), and physical job demands during working life. Alcohol abuse was defined using the Deta questionnaire (at least two positive responses to four items: (i) consumption considered excessive by the subject; (ii) consumption considered excessive by people around the subject, (iii) subject wishes to reduce consumption, and (iv) consumption on waking)[2, 6, 33]. Concerning the physical job demands (PJD), 12 items were selected, with the following question "Please indicate the high job demands for your work": hammer, vibrating platform, pneumatic tools, other vibrating hand tools, screwdriver, handling objects, awkward posture, tasks at heights, machine tools, pace, working on a production line, standing about and walking[2, 3, 5]. Seven job categories were considered:

Table 1. Distribution (%) according to gender and age of the sample studied and of the Lorraine general population[43)]

	The sample studied	The Lorraine general population
No. of subjects	6,216	1,848,579
Percentage of women	52.4	51.5
Age (yr)		
15–19	5.4	9.6
20–24	8.0	9.8
25–29	9.7	9.7
30–34	10.4	9.6
35–39	10.5	9.6
40–44	7.9	9.3
45–49	8.5	5.9
50–54	6.0	6.6
55–59	6.3	6.8
60–64	7.2	6.6
65–69	7.5	5.7
70 or over	12.6	10.8

People aged 15 or more were only considered.

higher socio-economic classes (managers, intellectual professionals, heads of firms, medical doctors, engineers, independent professionals, intermediary jobs), manual workers, farmers, craftsmen/tradesmen, clerks, technicians, foremen, others and unknown[6, 7, 33, 41)]. Obesity was defined as body mass index ≥30 kg/m^2 [42)].

Of the 8,000 households included in the sample, mailings to 193 (2%) were lost (due to addressing error or death). Of the 7,807 households contacted, 3,460 (44.3%) participated (all eligible members of the family took part in 86% of those). In total, 6,235 subjects filled in a questionnaire, 19 were of unknown sex or age, leaving 6,216 subjects who were similar in age and sex distribution to the overall population of north-eastern France (Table 1). The subjects with unknown smoking habit or unknown alcohol abuse were excluded (296 subjects, 4.8%). Only the subjects having worked at the time of the initial survey were retained for this analysis: 4,897 subjects.

Follow-up

The cohort was followed up for mortality from 1 July 1996 to 31 December 2004. The vital status of all subjects was assessed by (1) searching using the national computerized database listing all deceased subjects in France from 1978, (2) contacting the registry offices of the birth places for people born in France, and (3) contacting the registry office devoted to foreign born French people (Ministry of Foreign Affairs). Cause of death was determined by matching the file of the deceased subjects with the French national file of causes of death which was set up in 1968. As this file is anonymous, the matching was done using sex, date of birth, date of death, and place of death. Causes of death were ascertained from death certificates and coded using the International Classification of Disease (WHO): 9th revision for deaths occurring between 1979 and 1999, and 10th revision for deaths occurring after 2000. In this study, two levels of premature mortality were considered: (1) death before the age of 65, and (2) death before the age of 70. This led us to follow the subjects who were alive and who were aged less than 65 yr or less than 70 yr, respectively, at the baseline of the study (1 July 1996): 3,872 and 4,268 subjects respectively. In total, 126 deaths were observed before age 70 (3.0%) and 85 before age 65 (2.2%). The unknown causes of death represented 4%.

Statistical analysis

The person-years at risk were calculated for each subject from 1 July 1996 to 31 December 2004, or earlier in the case of death or 65th/70th birthday. To verify the unidimensionality of the PJD, principal component analysis was used[44)]. For each subject a PJD score was computed as the cumulative number of various items. To assess the role of PJD, sex, age, smoking habit and alcohol abuse in premature mortality we used the Poisson regression model, which yields relative risks (RR) and 95% CIs. The analyses were performed taking into account all available potential confounders, i.e. age, gender, smoking habit, alcohol abuse, and overweight. The statistical analyses were performed using STATA software (Stata, College Station, TX, USA).

Results

The results obtained with the principal component analysis show that physical job demands (PJD) are unidimensional which consequently validates the physical job demands score (PJD). Indeed, the first eigenvalue is much higher than the other eigenvalues (the 3 first eigenvalues are 2.16, 0.49, and 0.27 for subjects in MP-70 analysis; and 2.23, 0.53, and 0.30 for subjects in MP-65 analysis)[44)]. The characteristics of the subjects are shown in Table 2. There were 126 PM-70 and 85 PM-65 (rate 3.81 and 2.82 per 1,000 person-years). The leading causes of PM-70 were cancers (46.4% in men and 57.1% in women; mainly lung, digestive system, and breast cancers), cardiovascular diseases (20.2% and 11.9%), suicide (9.5% and 7.1%), respiratory diseases (6.0% and 4.8%), and digestive diseases (2.4% and 4.8%). A similar pattern is observed for PM-65. A higher all causes PM-70 rate was found for the subjects with PJD≥3 (9.71 vs. 3.48 per 1,000 person-years for the others), men, obese subjects, smokers, subjects with alcohol abuse, manual workers, farmers, craftsmen, and traders. Similar results were found for PM-65 except for obese subjects.

Table 2. Premature mortality rate (per 1,000 person-years) according to various factors

	Premature death ≤70 yr (4,268 subjects)		Premature death ≤65 yr (3,872 subjects)	
	No. of person-years	Death rate	No. of person-years	Death rate
All the cohort	33,030	3.81	30,123	2.82
Age (yr)				
<50	21,177	1.32	21,177	1.32
50–59	6,229	4.33	6,229	4.33
≥60	5,624	12.6	2,718	11.0
Sex				
Women	15,869	2.65	14,522	2.20
Men	17,161	4.89	15,601	3.40
Obese (body mass index ≥30 kg/m^2)				
No	30,590	3.76	28,104	2.88
Yes	2,440	4.51	2,019	1.98
Smoking habit				
Non-smokers	12,950	2.70	11,565	2.25
Ex-smokers	9,561	5.54	8,398	3.45
Current smokers	10,519	3.61	10,160	2.95
Alcohol abuse				
No	30,220	3.34	27,519	2.47
Yes	2,810	8.90	2,604	6.53
Job category				
Higher socio-economic classes	5,100	2.94	4,733	1.90
Manual workers	7,363	5.98	6,770	4.43
Farmers, craftsmen, traders	1,807	4.98	1,449	2.76
Clerks	11,566	2.59	10,822	2.13
Technicians	1,664	1.80	1,580	1.90
Foremen	1,709	2.93	1,497	2.00
Others and unknown	3,820	5.24	3,273	3.97
Physical job demands score				
0–2	31,278	3.48	28,601	2.62
≥3	1,751	9.71	1,522	6.57

	Men	Women	Total	Men	Women	Total
No. of deaths	84	42	126	53	32	85
Main cause of death (%)						
Cancers	46.4	57.1	50.0	49.1	62.5	54.1
Lung	16.7	9.5	14.3	20.8	9.4	16.4
Digestive system	13.1	11.9	12.7	13.2	9.4	11.7
Breast (in women)	0.0	19.0	6.3	0.0	25.0	9.4
Upper respiratory tract	3.6	4.8	4.0	3.8	6.2	4.7
Others	13.1	11.9	12.7	11.3	12.5	11.9
Cardiovascular disease	20.2	11.9	17.5	17.0	9.4	14.1
Suicide	9.5	7.1	8.7	9.4	9.4	9.4
Respiratory disease	6.0	4.8	5.6	3.8	0.0	2.4
Digestive disease	2.4	4.8	3.2	3.8	3.1	3.5
Other causes	15.5	14.3	12.7	17.0	15.6	16.5

Table 3 shows that PJD≥3, current smoking, and alcohol abuse have significant contributions to PM-70 (risk ratios RR between 1.71 and 2.07). When introducing the job category in the Poisson regression model, a slightly lower but non-significant RR was found for PJD≥3; manual workers had a significant RR of 1.84 while the RRs of smoking and alcohol abuse did not change. It should be noted that most PM-70 occurred at the age ranges of 50–59 and 60+ (RRs 3.41 and 10.21 respectively, vs. the younger age ranges). Similar findings were observed for PM-65, although only manual workers, alcohol abuse, and age groups had significant RRs. Table

Table 3. Contributions of physical job demands and individual characteristics to premature death: risk ratio and 95% confidence interval computed with Poisson regression models

	Premature death ≤70 yr [a] (4,268 subjects, 126 deaths)			Premature death ≤65 yr (3,872 subjects, 85 deaths)		
	Risk ratio	*p*-value	95% CI	Risk ratio	*p*-value	95% CI
Models with no job category						
Physical job demands score (PJD) ≥3	**1.71**	0.043	1.02–2.88	1.56	0.197	0.79–3.06
Men	1.28	0.226	0.86–1.93	1.17	0.513	0.73–1.88
Aged 50–59 yr vs. aged <50 yr	3.22	0.000	1.88–5.51	3.17	0.000	1.86–5.42
Aged ≥60 yr vs. aged <50 yr	9.98	0.000	6.32–15.78	9.74	0.000	6.18–15.4
Obese	0.75	0.357	0.40–1.39	0.46	0.135	0.17–1.27
Current smokers vs. non-smokers	**1.76**	0.025	1.08–2.88	1.54	0.127	0.88–2.70
Ex-smokers vs. non-smokers	1.52	0.074	0.96–2.40	1.20	0.531	0.68–2.09
Alcohol abuse	**2.07**	0.002	1.31–3.26	**2.13**	0.008	1.22–3.70
Models with job category						
PJD ≥3	1.52	0.129	0.88–2.62	1.39	0.356	0.69–2.80
Men	1.36	0.170	0.88–2.09	1.23	0.428	0.74–2.06
Aged 50–59 yr vs. aged <50 yr	**3.41**	0.000	1.99–5.85	**3.57**	0.000	2.07–6.13
Aged ≥60 yr vs. aged <50 yr	**10.21**	0.000	6.43–16.2	**9.32**	0.000	5.43–16.0
Obese	0.71	0.292	0.38–1.33	0.45	0.119	0.16–1.23
Current smokers vs. non-smokers	**1.76**	0.026	1.07–2.90	1.52	0.148	0.86–2.67
Ex-smokers vs. non-smokers	**1.59**	0.048	1.00–2.52	1.25	0.429	0.72–2.19
Alcohol abuse	**1.99**	0.003	1.26–3.13	**1.99**	0.016	1.14–3.47
Job category (vs. higher socio-economic classes)						
Manual workers	**1.84**	0.049	1.00–3.37	**2.18**	0.046	1.01–4.70
Farmers, craftsmen, traders	1.17	0.711	0.51–2.69	1.12	0.848	0.34–3.67
Clerks	1.21	0.551	0.64–2.29	1.45	0.353	0.66–3.20
Technicians	0.66	0.514	0.19–2.29	1.07	0.923	0.29–3.96
Foremen	0.61	0.337	0.22–1.69	0.71	0.607	0.19–2.65
Others and unknown	1.87	0.073	0.94–3.69	**2.38**	0.048	1.01–5.64

[a] Similar risk ratios were found for all factors for premature death ≤75 yr; consequently these results are not presented.
Bold type: significant risk ratios.

4 reveals that the risk pattern of PM-70 by cancer was similar (but with slightly higher RRs) to that by all causes. Cardiovascular disease PM-70 was not significantly related to PJD, smoking and alcohol abuse, job group and obesity.

Discussion

The present study demonstrates that PJD≥3, smoking, and alcohol abuse were associated with premature death before age 70 (PM-70) with risk ratios between 1.71 and 2.07. It shows that manual workers had a risk ratio of 1.84 vs. higher socio-economic classes. In addition, the men had a two-fold higher mortality rate than the women (4.89 vs. 2.65 per 1,000 person-years), and this gender difference was mediated by the other factors considered. Most PM-70 occurred at the age range of 60+. Our study shows that it is pertinent to assess the role of PJD or lower socio-economic classes in PM-70. Indeed, manual workers had a much higher risk for PM-70 (about 1.84 in this study) than for overall mortality (1.19, 95% CI 1.15–1.22 for male manual workers in France[45]). Our study reports that PM-65 was mainly related to alcohol abuse, whereas PM-70 was associated with PJD, alcohol abuse, and smoking. Cancer was here the leading cause of death and it accounted for half of PM-70 as well as of PM-65, in men as well as in women. The other main causes of premature death were cardiovascular diseases and suicide which accounted for about 15% and 9%, respectively, while the other causes represented less than 6%. The role found for smoking and alcohol abuse in our study is consistent with other results in the literature[1, 29, 31]. It should be noted that the two categories PM-70 and PM-65 overlap each other.

The selection bias of the sample was small. Indeed,

Table 4. Contributions of physical job demands and individual characteristics to premature death ≤70 yr due to all cancers and cardiovascular diseases (4,268 subjects): risk ratio and 95% confidence interval computed with Poisson regression models

	All cancers (63 deaths)			Cardiovascular disease (22 deaths)		
	Risk ratio	*p*-value	95% CI	Risk ratio	*p*-value	95% CI
Models with no job category						
Physical job demands score (PJD) ≥3	**2.00**	0.050	1.00–3.99	0.49	0.492	0.07–3.71
Men	0.96	0.876	0.54–1.68	2.53	0.087	0.87–7.36
Aged 50–59 yr vs. aged <50 yr	**8.69**	0.000	3.57–21.2	0.98	0.983	0.20–4.79
Aged ≥60 yr vs. aged <50 yr	**24.55**	0.000	10.7–56.2	**7.53**	0.000	2.86–19.8
Obese	0.64	0.338	0.25–1.60	0.76	0.717	0.17–3.32
Current smokers vs. non-smokers	**2.34**	0.014	1.19–4.63	1.44	0.540	0.45–4.62
Ex-smokers vs. non-smokers	1.45	0.269	0.75–2.81	1.20	0.746	0.40–3.62
Alcohol abuse	**2.22**	0.014	1.17–4.20	2.40	0.099	0.85–6.78
Models with job category						
PJD ≥3	1.78	0.117	0.86–3.68	0.50	0.510	0.06–3.91
Men	1.00	0.988	0.55–1.85	2.73	0.077	0.90–8.33
Aged 50–59 yr vs. aged <50 yr	**9.00**	0.000	3.69–22.0	1.05	0.954	0.21–5.13
Aged ≥60 yr vs. aged <50 yr	**24.78**	0.000	10.8–56.9	**7.47**	0.000	2.77–20.2
Obese	0.64	0.344	0.26–1.61	0.66	0.585	0.15–2.91
Current smokers vs. non-smokers	**2.33**	0.016	1.17–4.62	1.51	0.497	0.46–4.92
Ex-smokers vs. non-smokers	1.48	0.247	0.76–2.88	1.30	0.644	0.43–3.95
Alcohol abuse	**2.15**	0.019	1.14–4.08	2.34	0.110	0.83–6.63
Job category (vs. higher socio-economic classes)						
Manual workers	1.35 [a]	0.470	0.60–3.08	1.58	0.518	0.40–6.27
Farmers, craftsmen, traders	0.82	0.747	0.25–2.70	1.35	0.744	0.22–8.17
Clerks	1.09	0.831	0.48–2.52	0.71	0.674	0.14–3.59
Technicians	0.00	0.987	0.00–(1)	1.05	0.969	0.11–10.1
Foremen	0.97	0.959	0.32–2.97	0.00	0.000	0.00–(1)
Others and unknown	1.17	0.753	0.44–3.09	3.08	0.118	0.75–12.6

Bold type: significant risk ratios. (1) Not computable. [a] RR 1.63 (0.74–3.58) with model including age, sex and job category only.

the households possessing a telephone represented 96% of all households, and the households with confidential telephone number represented only 16% of them. According to several associations for persons with disability, telephone directory listings would not be related to health status and life conditions. The participation rate was modest but similar to that achieved in surveys with mailed questionnaires in France[46, 47]. The distributions according to age and sex of the sample are close to those of the Lorraine population[43]. The percentage of manual workers (18%) was similar with that of the Lorraine population (21%)[43]. Note also that the incidence rate of occupational injury and the prevalence of various types of diseases and disabilities, for example, are similar to those of the general population[5–7, 48]. The quality of the filling-in of the questionnaire was very good (non-responses for various items <4%). Although this study was conducted on a large sample, the interpretation of the results needs some caution due to the presence of a possible selection bias and the use of a self-administered questionnaire. However, a self-administered occupational health history questionnaire is reliable and valid[49]. The non-response bias in mailed health surveys is small[50, 51]. Note that the prevalence of various variables of the sample was similar to the directly standardized adjusted rate computed in reference to the Lorraine population[47]. This is due to, as quoted above, the similarities of the distributions of age and sex of the sample and the Lorraine population.

As previously mentioned all factors studied have been validated and used in other studies[2, 3, 5, 33, 38, 42]. The physical job demands were those reported as demanding by the subjects. They have been used elsewhere[2, 3, 5]. The calculation of the score PJD was valid because the physical job demands considered were unidimensional[44]. The occupational exposure was therefore underestimated because moderate occupational hazards were excluded. Furthermore, many hazards, for example chemical hazards, dust, etc. were not considered[52]. It should be noted that most subjects generally have one main job

during their working life, so they should be aware of their job demands. Smoking habit, alcohol abuse, and obesity were those at the baseline of the study. They would not greatly change during the follow-up period, especially among the subjects aged over 50 yr who were more at risk of premature death. Finally, our study did not focus on alcohol intake but on alcohol abuse.

Our study found that the workers with PJD≥3 had a 2.79-fold higher rate of PM-70 than the others (9.71 vs. 3.48 per 1,000 person-years), and they had a significant risk ratio of 1.71 when controlling for sex, age, obesity, smoking and alcohol abuse. It showed that a slightly lower and non-significant risk ratio of 1.52 (p=0.13) is found with further controlling for job category, while the risk ratios of smoking and alcohol abuse do not change. So, the 2.79-fold higher risk associated with PJD≥3 decreased to 61% when controlling for sex, age, obesity, smoking and alcohol abuse, and to 54% when job was also taken into account. These observations show that the risk associated with PJD was mediated by these factors. The physical job demands considered were found to be related to occupational injury, psychotropic drug use, and various types of disabilities[2, 3, 5] which may favour premature death. Kristal-Boneh *et al.*[20] found a similar hazard ratio (1.82) of all-cause mortality in workers with a high physical workload compared with the others. We found that the excess risk associated with PJD≥3 is partly mediated by smoking, alcohol abuse, and job category. These results are consistent with the findings of Diderichsen *et al.*[13] who stated the high total burden of diseases of tobacco and alcohol in the EU (respectively 9.0% and 8.4%; 3.6% for work environment). The result of PM-70 found for manual workers confirms the roles of lower socioeconomic-related factors (unhealthy lifestyle, poor nutrition, altered living conditions, low income, low educational level, peer relationship, lack of leisure time physical activity, access to health care)[1, 23, 34, 45]. Note that job demands could favour drug use that has a great role in disease burden[1]. In France, one-third of the working population uses medications or other legal psychoactive substances in order to cope with work-related difficulties, and such use is more common in manual workers[53]. Intake of drugs is a leading cause of diseases and injuries[1, 2, 6]. Note that smoking and alcohol abuse are common and could increase the risk among workers with higher job demands[33]. For instance, smoking and alcohol abuse alter physical and mental abilities of workers and increase the risk of injuries due to job demands[6, 21]. Some cause-specific mortality in adulthood is attributed to socially patterned childhood exposures (such as poor childhood growth, indoor and outdoor pollution, housing dampness and mold, passive smoke exposure, poor nutrition) which affect the lower socio-economic groups[54].

An important finding of our study is that PJD≥3 is associated with cancer PM-70 independently of gender, smoking, and alcohol abuse. It reveals that PJD≥3, smoking and alcohol abuse had similar adjusted risk ratios of about 2. But PJD≥3 has a slightly lower and non-significant risk ratio when also controlling for job category. Manual workers have a non-significant risk ratio whether or not PJD is taken into account. The high risk found for PJD≥3 is thus slightly mediated by job category. Note that PJD≥3 concerned mostly manual workers, and also foremen, farmers, craftsmen, tradesmen, clerks and technicians. This is an original finding because most previous studies have focused on job category and not on physical job demands, smoking, and alcohol abuse[1, 15, 17, 34, 55, 56]. Therefore the factors associated with cancers that are more common among the lower socio-economic groups (poor nutrition, altered living conditions or health-related behaviors, etc.)[1, 41, 57, 58] do not conceal the role of job demands. Kristal-Boneh *et al.*[20] also found a higher risk of cancer mortality in workers with high physical workload compared with the others. The high risk of cancer found in workers with PJD≥3 could be explained by a concomitant exposure to a number of carcinogenic hazards[2, 4, 59]. In the present study, we did not analyze the various types of cancers because of the small number of subjects.

Cardiovascular disease PM-70 was not here related to PJD, but a high risk ratio close to significance was found for males (2.73, p=0.08) and alcohol abuse (2.34, p=0.11). An increased risk was expected, because heavy drinking favours cerebral thrombosis, cerebral haemorrhage, and coronary artery disease deaths[60]. Note that the percentage of PM-70 due to cardiovascular diseases was here 2.86-fold lower than that due to cancer while their overall mortality rates were close[56]. Kristal-Boneh *et al.*[20] found a higher risk of cardiovascular disease mortality in workers with a high physical workload compared with others.

The difference of risk patterns between the two sexes are well known[45, 56]. We found that all cancers concerned the women more than the men due to breast cancers, and that lung cancer and cardiovascular diseases were two-fold higher in men than in women. In our study, higher PJD, smoking and alcohol abuse were markedly more common in men than in women. Manual workers are three-fold over-represented and clerks and service staff are three-fold under-represented among men than among women[45]. These results are in agreement with the findings of other authors who have reported excess deaths from cardiovascular diseases and lung cancers in men[34, 55, 56]. An interesting finding of our study is that the excess PM-70 due to all causes and all cancers in men became non-significant when controlling for PJD, smoking, alcohol abuse, and job. This suggests that the gender differences were mediated by these factors. However, these factors did not entirely conceal the gender difference for

cardiovascular disease PM-70 (adjusted risk ratio 2.73, p=0.077).

Our study shows that the PM-70 rate per 1,000 person-years was 1.32 for the subjects aged under 49 yr, and it was particularly high among the subjects aged 50–59 yr (4.33) and over 60 yr (12.6). Thus preventive measures aiming at reducing premature mortality should include follow-up of the subjects with high physical job demands at an early age, and particularly after 50 yr and after retirement. In population-based studies, exposure self-reports by study subjects are usually somewhat less good than expert assessment, but better than generic job-exposure matrices[53]. Our study shows that a simple self-administered questionnaire is valid. Consequently, it may be used by occupational physicians as well as by other health professionals to detect and monitor the subjects most at risk.

Our study sheds light on the associations of job and physical job demands with premature mortality in the population, and on gender and age differentials. We demonstrate that physical job demands and health-related behaviours such as smoking and alcohol abuse are strong risk factors. The higher risk in men for all causes and cancer premature death is mediated by job, job demands, smoking and alcohol abuse. The workplace can be a natural setting for a broad discussion on preventing diseases and promoting health which, in addition to addressing the determinants of health directly related to working conditions, also addresses such issues as smoking and alcohol abuse[1]. Physical job demands are a simple index that may be useful for health professionals who may need to monitor the subjects most at risk during working life and after retirement, and for public prevention policies aiming at improving health and reducing social inequalities in health.

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