Biomechanical strains and low back disorders: quantifying the effects of the number of years of exposure on various types of pain.

Sandrine Plouvier, Emilie Renahy, Jean-François Chastang, Sébastien Bonenfant, Annette Leclerc

Biomechanical strains and low back disorders: quantifying the effects of the number of years of exposure on various types of pain

Sandrine Plouvier[1, 2], Emilie Renahy[3, 4], Jean François Chastang[1, 2], Sébastien Bonenfant[5], Annette Leclerc [1, 2]

1 INSERM, U687, Saint-Maurice, F-94410, France ; Université Paris XI,

2 IFR69, Villejuif, F-94807, France ;

3 INSERM, UMR S 707, Paris, F-75012;

4 Universite Pierre et Marie Curie-Paris6, UMR S 707, Paris, F-75012;

5 CETAF-RPPC, INSERM U687, Saint-Maurice, F-94410, France ;

Corresponding author :

Sandrine Plouvier INSERM, U 687 Hopital National Saint Maurice, 14 rue de val d'Osne, 94410 St-Maurice, France

plouvier@st-maurice.inserm.fr

Tel: 0145183861   Fax: 0145183861

Key words: low back pain, bending, twisting, driving, manual material handling, cumulative duration of exposure

Word count:4429

ABSTRACT

Objective : To assess the effects of duration of exposure to biomechanical strains on various types of low back pain (LBP)

Methods : The population study was a random sample from the GAZEL cohort. Durations of exposure to selected biomechanical strains during subjects' working lifetime and potential confounders were assessed in 1996 by self-administered questionnaires. Data on LBP in the previous twelve months were collected in 2001. Relations between various dimensions of LBP and durations of exposure to the biomechanical strains were analysed with multivariate regression models. Polytomous models were built to determine whether some biomechanical strains were specifically associated with some types of LBP.

Results : Analyses were performed separately for men (n=2218) and women (n=383). Significant associations were observed (ORs reported are those for 20 years of exposure) between LBP and durations of driving and bending/twisting for men (OR 1.24 and 1.37 respectively); LBP for more than 30 days and duration of exposure to bending/twisting for men and women (OR 2.20 and 2.00 respectively) and duration of driving for women (OR 3.15); LBP radiating to the leg and duration of driving for men (OR 1.43) and bending/twisting for women (OR 1.95); LBP radiating below the knee and duration of exposure to pulling/pushing/carrying for men (OR 1.88). Bending/twisting in both men and women, and driving for women appeared to be stronger risk factors for LBP for more than 30 days. Pulling/pushing/carrying heavy loads appeared to be a risk factor specific for LBP radiating below the knee for men.

Conclusion: This study suggests that exposure to biomechanical strains has long-term effects and a dose-response relation with duration of exposure and specific effects for some types of LBP.

INTRODUCTION

The socioeconomic burden of low back pain (LBP) is heavy in many western countries. The associated costs are both financial (care seeking, sickness absences, disability pensions…) and human, especially in chronic forms. In a French study in the Paris area, more than 55% of workers reported LBP in the past 12 months. Sickness absence was associated with LBP in 4% of the sample.[1]

Many studies have sought to identify risk factors for LBP, which has multifactorial causes and involves individual and occupational characteristics. The level of evidence available varies according to the factor considered. Substantial consensus exists for some occupational factors, such as manual material handling, bending, twisting or whole body vibrations, mainly due to driving.[2, 3]

These strains may have acute or cumulative effects. Neither the long-term effects nor the effects of cumulative exposure have been well elucidated. In a Swedish study of shipyard workers musculoskeletal disorders attributable to heavy physical workload, particularly LBP, had not disappeared three years after retirement.[4] The report of LBP related to occupational exposure long after exposure stopped was also observed in Post Office pensioners.[5] In a sample of Parisian retirees (from a variety of occupations), the frequency and course of musculoskeletal disorders over a five-year period were related to their physical workload during their working lifetime.[6] Locomotor impairment of the lower back was also associated with the duration of work at the coal face in miners retired for at least 10 years.[7] In a working population, the risk of care-seeking for LBP generally increased when past physical exposures were considered in addition to the current ones.[8] Frequency of LBP increased with duration of exposure (measured in years) to heavy lifting among French blue-collar workers [9] and with duration of driving (also measured in years) among professional drivers.[10, 11] On the other hand, in a population-based study, no clear relation was found between the magnitude of the LBP risk related to manual material handling and the duration of exposure to this strain.[12] In another sample of English adults, the risk of LBP was more strongly associated with exposure to driving and lifting heavy loads in recent occupational activity than with exposure related to activity performed for half or more of their working lifetime.[13]

In addition, as some authors point out, “LBP” is a very general entity that covers a variety of disorders which do not necessarily share the same etiological factors.[14] Several authors report that risk factors vary according to type of LBP, with types distinguished according to duration, extent, intensity, diagnosis or consequences.[1, 14, 15-20] More precise definitions of LBP should thus make possible a better analysis of the role of risk factors.

Our study, using data from the GAZEL cohort, sought to quantify the effects of the number of years of exposure to three biomechanical strains considered to be pathogenic for the lower back — handling heavy loads, bending or twisting, and driving a car — on various types of LBP, defined by duration and extent, and to determine whether some risk factors were specifically associated with one or several types of LBP.

MATERIALS AND METHODS

Population

The GAZEL cohort was established in 1989, its members recruited among the employees of *Electricité de France-Gaz de France*, the French national company for the production and distribution of energy.[21,22] The company employs approximately 150,000 people of diversified trades and socioeconomic status throughout France. At baseline in 1989, the cohort included 20 624 volunteers, men then aged 40-50 years and women 35-50. In January of each year, participants received a general questionnaire about their lifestyle, health and occupational situation. More than 20 sub-projects explore specific themes, one of which about low back pain. In 1992, 1994, and 1996, a random sample of 4018 members received specific questionnaires on LBP. This sample comprised the occupational groups with the highest frequencies of exposure (at least 20% of exposed workers) to selected occupational strains in a list which included postures, vibrations, manual material handling and VDT. In 1996, 2970 subjects (74%) responded to the ‘GAZEL-LBP’ specific questionnaire. Results from this GAZEL-LBP sub-project have already been published.[17, 19, 23] In this study, we analyse information on occupational history, personal, social and demographic data from the 1996 general and specific questionnaires with information on LBP from the January 2001 general questionnaire. The study population was the subgroup of 2601 persons — 2218 men and 383 women — who completed those three questionnaires (87.6% of the 1996 participants in the GAZEL-LBP sub-project). Most were retired in 2001.

Low back pain

In January 1996 and 2001, information about LBP was collected with questions derived from the Nordic questionnaire for the analysis of musculoskeletal symptoms.[24] LBP was defined with reference to a diagram of the body as ‘pain, discomfort or disability *in this* area, whether or not the pain radiates to the leg’. Subjects reported the cumulative duration of LPB during the past 12 months (0 day, ≤ 7 days, 8-30 days, >30 days but not everyday, everyday) and the type of pain (pain radiating to the leg but not below the knee, pain radiating below the knee, lumbago, or other). From this information, we studied four categories of LPB: LBP of any type or duration, LBP for more than 30 days, LBP radiating to the leg, and LBP radiating below the knee.

Risk factors and confounding factors in the study

Information for these variables comes from the questionnaires completed in January 1996, that is, five years before the LBP was reported.

The main exposure variables in this study were cumulative durations of subjects' exposure to three separate biomechanical strains. Subjects were asked for how long as a whole, during their working lives, they had: to drive a car for more than two hours/day; to push, pull or carry heavy loads at least once a week; to bend (forward/backward) or twist repeatedly (daily or almost daily). The possible answers for each of the three exposures were: never, less than 10 years, 10-20 years, more than 20 years.

In addition to sex and age in 5-year categories (53-57 and 58-62 for men, and 48-52, 53-57 and 58-62 for women), 14 variables were considered as potential confounders. Psychological demand at work was evaluated with three items (permanent “strain”, “everything seems always urgent to do”, permanent work overload), decision latitude with three items (you are free to organize your work, your work is repetitive, much hierarchical control) and social support with two items (good atmosphere at work, good relations with colleagues). Subjects were asked whether they rather agreed or rather disagreed with each item. Scores were defined from the number of positive (negative) answers in each dimension (ranging from 0 to 3 for demand and decision latitude, and from 0 to 2 for social support). Each score was classified as high or low based on a cut-point as close as possible to the median of its distribution in the population (1 for demand and decision latitude, 0 for social support). Satisfaction at work was evaluated with a scale, from 0 (not at all) to 8 (very satisfied). A low level of satisfaction was defined as a score in the lowest quartile of the population distribution (3/8). For personal and lifestyle factors, three variables were included: ‘height’ as being taller than 180 cm for men and 168 cm for women (versus shorter), BMI in three categories corresponding to the tertiles of its distribution in the whole cohort (for men 23 or less, more than 23 but no more than 27, more than 27 kg/m^2; for women 21 or less, more than 21 but no more than 27, more than 27 kg/m^2) and smoking (non smokers versus smokers). For comorbidity, four variables (presence or absence) were considered: cardiovascular disorders (hypertension, myocardial infarction, angina, hypercholesterolemia, or arteritis), headache, psychosomatic problems (frequent palpitations, worries that make physically ill), frequent depressive mood. Three variables for leisure time activities were also considered: gardening; construction; do-it-yourself activities, on average more than one hour per week (present or absent).

Analyses

Preliminary analyses focused on the quantification of duration of exposure to each biomechanical strain. Durations could be considered as qualitative variables, as reported in the questionnaire or as quantitative variables by replacing categories by the value of their class center. In addition, duration could be considered in years or with a log transformation of the number of years. The conclusion, based on comparison between several logistic models with various types of LBP as outcomes, was that the best fit to the observed dose-response relationships was obtained with models considering exposure quantified as a number of years of exposure, that is, 0, 5, 15, and 25 for the answers never, less than 10 years, 10-20 years, and more than 20 years, respectively.

Our first objective was to study — separately for men and women — the relation between the presence of each type of LBP and duration of exposure to each biomechanical strain, taking into account the appropriate confounding factors for each type. We thus built eight logistic regression models (four for each sex). In each, the explanatory variables were age (forced in the models) and those factors (from among duration of exposure to biomechanical strains and confounding factors) that remained in the model after exclusion of the variables not associated with the relevant disorder at a p-level of 0.15. 'Final logistic models' (presented in Table 3) were obtained separately for men and women for each type of LBP. These models yielded ORs associated with one year of exposure to the biomechanical strain under consideration. To clarify the presentation, however, the results reported in the text are those for 20 years of exposure.

Next, four polytomous models (two for each sex) were built to determine whether some biomechanical strains were specifically associated with some types of LBP. Each model allowed to compare two different types of LBP according to:

- duration of disorder (more than 30 days versus less) — 1st model,
- presence of pain radiating below the knee (radiation below the knee versus other types of LBP) — 2nd model.

For each of these models, a new dependent variable was created, with three categories: the two LBP categories being compared and a reference category of no LBP. Independent variables included in the first step of these models were those included in at least one of the 'final logistic models' concerning each of the two types of LBP compared in the polytomous model. Variables except age were excluded if they were not associated with either type of LBP in the polytomous model at a p-level of 0.15. Each final polytomous model yielded an

OR associated with each of the two types of LBP (compared with no LBP) for each risk factor in the corresponding model. The two ORs associated with the same risk factor were then compared with a statistical test.

The analyses described above concerned LBP present in 2000 and reported in the January 2001 general questionnaire. It may or may not have been previously reported in 1996, that is, it was either persistent or 'incident' LBP in 2000. We examined whether biomechanical strains were associated more with persistence or 'incidence'. We divided the population into two groups ('persistence' or 'incidence') on the basis of the answers given in 1996 (presence or absence in 1995) for the disorder considered in 2001. In each of these subgroups, logistic regression models for men and for women were built for each subgroup for which there were enough cases. Independent variables included at the first step in each model came from the 'final logistic model' corresponding to the type of LBP studied. Variables except age were excluded from the model if they were not associated with the outcome of interest at a p-level of 0.15.

Statistical analyses used SAS V8.

RESULTS

Population characteristics

Table 1 summarizes the characteristics of the population and the distribution of their exposure to the risk factors considered. Exposure to the various biomechanical strains was frequent among men, and durations varied widely. Bending or twisting was fairly common among women, while relatively few had pushed, pulled or carried heavy loads or driven, and rarely for more than 10 years.

Table 1: Description of the sample and frequency of exposure to biomechanical strains

		Men N=2218	Women N=383
		n (%)	n (%)
Age in 2001	48-52	-	184 (48.0)
	53-57	1307 (58.9)	159 (41.5)
	58-62	911 (41.1)	40 (10.5)
Height*		273 (12.3)	46 (12.0)
Factors assessed in 1996:			
BMI**	Slim	342 (15.4)	106 (27.7)
	Medium	1174 (52.9)	217 (56.7)
	Overweight	702 (31.7)	60 (15.7)
Present smoker		388 (17.5)	52 (13.6)
Health	Cardiovascular disorders	681 (30.7)	48 (12.5)
	Depression	116 (5.2)	49 (12.8)
	Headache	452 (20.4)	153 (40.0)
	Psychosomatic problems	300 (13.5)	94 (24.5)
Psychosocial factors at work	High demand	1092 (49.2)	209 (54.6)
	Low decision latitude	478 (21.6)	98 (25.6)
	Low social support	844 (38.0)	134 (35.0)
	Low satisfaction	524 (23.6)	64 (16.7)
Leisure time activities	Gardening	1296 (58.4)	116 (30.3)
	Do it yourself activities	1736 (78.3)	86 (22.4)
	Construction activities	457 (20.6)	5 (1.3)
Driving a car for more than 2 hrs a day	Never	793 (35.8)	316 (82.5)
	< 10 years	435 (19.6)	50 (13.1)
	10-20	440 (19.8)	10 (2.6)
	>20 years	550 (24.8)	7 (1.8)

Table 1 (continued): Description of the sample and frequency of exposure to biomechanical strains

		Men N=2218	Women N=383
		n (%)	*n (%)*
Factors assessed in 1996 (continued):			
Bending/Twisting, repeatedly, everyday or almost everyday	Never	724 (32.6)	199 (52.0)
	< 10 years	424 (19.1)	66 (17.2)
	10-20	452 (20.4)	55 (14.4)
	>20 years	618 (27.9)	63 (16.4)
Usually Pushing/Pulling/Carrying heavy loads (at least once a week)	Never	939 (42.3)	325 (84.9)
	< 10 years	567 (25.6)	44 (11.5)
	10-20	359 (16.2)	10 (2.6)
	>20 years	353 (15.9)	4 (1.0)
Low back pain for at least one day in 1995		1248 (56.3)	195 (50.9)
Low back pain for more than 30 days in 1995		415 (18.7)	79 (20.6)
Low back pain radiating to the leg in 1995		466 (21.0)	88 (23.0)
Low back pain radiating below the knee in 1995		215 (9.7)	39 (10.2)
Low back pain for at least one day in 2000		1218 (54.9)	215 (56.1)
Low back pain for more than 30 days in 2000		335 (15.1)	71 (18.5)
Low back pain radiating to the leg in 2000		375 (16.9)	95 (24.8)
Low back pain radiating below the knee in 2000		174 (7.8)	44 (11.5)

* Men: Taller than 180 cm; Women: Taller than 168 cm

** Men: Slim: <=23; Medium:]23;27]; Overweight: >27 Kg/m²;

Women: Slim: <=21; Medium:]21;27]; Overweight: >27 Kg/m²

Prevalence and ‘incidence’ of LBP

Table 2 presents the prevalence and ‘incidence’ (the latter defined as the number of subjects suffering from a given LBP in 2000 among those free of it in 1995) of the various types of LBP in 2000. In 2001, more than half the sample reported LBP for at least one day during the preceding 12 months. Most of them had mentioned LBP for at least one day during 1995 in the 1996 questionnaire; the ‘incidence’ of ‘any’ LBP was thus around 30%. For the three other types of LBP, about half of the 2001 cases were free of the corresponding disorder in 1995 and ‘incidence’ was approximately 9 to 10% (see details in table 2). Prevalence and ‘incidence’ of radiating pain were higher for women.

Table 2: One year prevalence and ‘incidence’ of various types of low back pain (LBP) in 2000

	Men (n=2218)		Women (n=383)			
	Prevalence % (n*)	‘Incidence’ ** % (n1/n2)***	Prevalence % (n)	‘Incidence’ ** % (n1/n2)***	p value[1]	p value[2]
LBP at least 1 day	54.9 (1218)	29.5 (286/970)	56.1 (215)	31.4 (59/188)	ns	ns
LBP for more than 30 days	15.1 (335)	8.5 (154/1803)	18.5 (71)	10.5 (32/304)	ns	ns
LBP radiating to the leg	16.9 (375)	9.9 (174/1752)	24.8 (95)	17.6 (52/295)	0.0002	<0.0001
LBP radiating below the knee	7.8 (174)	4.7 (95/2003)	11.5 (44)	9.3 (32/344)	0.0175	0.0006

* number of subjects suffering from this type of LBP in 2000

** ‘Incidence’ is defined here as the number of subjects suffering from a given LBP in 2000 among those free of it in 1995

*** n1: number of subjects suffering from this type of LBP in 2000 and free of it in 1995

n2: number of subjects free of this type of LBP in 1995

[1] Comparison between men and women for prevalence

[2] Comparison between men and women for ‘incidence’

Biomechanical strains and low back pain

Globally, the prevalence of each type of LBP increased with duration of exposure to the biomechanical strains in the study. The dose-response relationship was especially steady for men, and for LBP for more than 30 days and radiating pain.

Duration of exposure to biomechanical strains and LBP, results from logistic models (Table 3)

LBP for at least one day

For men, LBP for at least one day was associated with duration of exposure to driving and bending/twisting. ORs associated with one year of exposure were 1.01 for driving and 1.02 for bending/twisting, which correspond respectively to 1.24 and 1.37 for 20 years of exposure. None of the biomechanical strains appeared to be a risk factor for women.

LBP for more than 30 days

For men, LBP for more than 30 days was associated with bending/twisting with an OR of 2.20 for 20 years of exposure. For women, this type of LBP was associated with driving and with bending/twisting, with ORs of 3.15 and 2.00 respectively for 20 years of exposure.

LBP radiating to the leg

LBP radiating to the leg was associated with driving among men, with an OR of 1.43 for 20 years of exposure, and with bending/twisting among women, with an OR of 1.95 for 20 years of exposure.

LBP radiating below the knee

For men, LBP radiating below the knee was associated with duration of exposure to pushing/ pulling/carrying heavy loads with an OR of 1.88 for 20 years of exposure. This association was also observed among women but was not significant.

Table 3: Associations between one year of exposure to biomechanical risk factors and various types of low back pain (LBP) based on logistic models

	LBP for at least 1 day			LBP for more than 30 days			LBP radiating to the leg			LBP radiating below the knee		
	OR*[1]	95%CI	p value	OR*[2]	95%CI	p value	OR*[3]	95%CI	p value	OR*[4]	95%CI	p value
	Men											
Driving a car >2 hrs/day	1.01	1.00-1.02	*0.0281*	-			1.02	1.01-1.03	*0.0013*	-		
Bending/Twisting	1.02	1.01-1.03	*0.0007*	1.04	1.03-1.05	*<0.0001*	-			-		
Pushing/Pulling/Carrying heavy loads	-			-			-			1.03	1.02-1.05	*<0.0001*
	Women											
Driving a car >2 hrs/day	-			1.06	1.01-1.12	*0.0319*	-			-		
Bending/ Twisting	-			1.04	1.01-1.06	*0.0094*	1.03	1.01-1.06	*0.0073*	-		
Pushing/Pulling/Carrying heavy loads	-			-			-			1.06	1.00-1.14	*0.0664*

[1] adjusted for age, smoking, headache, work demand for men
age, psychosomatic problems, work demand for women

[2] adjusted for age, headache, social support at work for men
age, psychosomatic problems for women

[3] adjusted for age, BMI, psychosomatic problems, social support at work for men
age, social support at work for women

[4] adjusted for age, BMI, headache for men
age for women

- variable not in the model because not associated with the type of LBP studied (p≥0.15) when exposure to other biomechanical strains and confounders were taken into account

Risk factors specific for some types of LBP

LBP for more than 30 days versus LBP of shorter duration (table 4)

In the polytomous model comparing LBP for more than 30 days versus briefer LBP, bending/twisting appeared to be a stronger risk factor for LBP for more than 30 days in both men and women. Among women, the number of years of driving was also associated more closely with this type of LBP than with LBP of shorter duration.

LBP radiating below the knee

For men, pushing/pulling/carrying heavy loads appeared to be a risk factor specific for LBP radiating below the knee (Table 5). For women, none of the biomechanical strains appeared to be a specific predictor of such LBP.

Biomechanical strains and persistent or 'incident' troubles

Globally, associations observed between any given strain and a type of LBP did not differ according to whether the LBP was persistent or 'incident' (results not shown). Analyses for radiating pain could not be performed for women, because there were too few.

DISCUSSION

The figures for LBP prevalence in this study are consistent with those from several other studies. Prevalence of LBP in the past 12 months was 54% among Danes aged 30-50 years and prevalence of LBP for more than 30 days 19%. [14] In a French working population, the prevalence of LBP radiating below the knee was around 7% for men and 10.5% for women.[1] The definition of 'incidence' in our study makes it more difficult to compare incidence rates.

Associations between duration of exposure to biomechanical strains and various types of LBP were studied in this population. Although the strength of the association was generally limited, some associations were specific: pushing/pulling/carrying heavy loads was associated with LBP radiating below the knee for men, bending/twisting with LBP for more

Table 4: Comparison between risk factors for low back pain for more than 30 days (LBP>30 days) and LBP of shorter duration (LBP≤30 days) for men and women

	Men					Women				
	LB≤30 days		LB>30 days			LB≤30 days		LB>30 days		
	OR*[1]	95%CI	OR*[1]	95%CI	p value**	OR*[2]	95%CI	OR*[2]	95%CI	p value**
Driving a car >2 hrs/day	1.01	1.00-1.02	1.01	1.00-1.03	ns	0.93	0.87-1.01	1.04	0.98-1.10	0.0082
Bending/Twisting	1.01	1.00-1.02	1.04	1.03-1.06	<0.0001	1.00	0.98-1.03	1.04	1.01-1.07	0.0431
Pushing/Pulling/Carrying heavy loads	-		-			-		-		

* OR for one year of exposure

[1] adjusted for age, smoking, headache, social support at work

[2] adjusted for age, psychosomatic problems

** Comparison between the two odds ratios (LBP for more then 30 days/ LBP of shorter duration)

- variable not in the model because associated with none of the types of LBP in the model (p≥0.15) when confounders were taken into account

Table 5: Comparison between risk factors for LBP radiating below the knee vs other LBP for men

	Men				
	LBP without pain radiating below the knee		LBP radiating below the knee		
	OR*	95%CI	OR*	95%CI	p value**
Driving a car >2 hrs/day	1.01	1.00-1.02	1.01	0.99-1.03	ns
Bending/Twisting	1.01	1.00-1.03	1.01	0.99-1.03	ns
Pushing/Pulling/Carrying heavy loads	1.00	0.99-1.02	1.03	1.01-1.05	0.0198

* OR for one year of exposure, adjusted for age, BMI, headache, psychosomatic problems

** Comparison between the two odds ratios (LBP radiating below the knee/other LBP)

ns variable in the model, not significant association (0.05<p<0.15) than 30 days for men and women, and driving with LBP for more than 30 days for women. Results for persistence and 'incidence' did not differ.

Among the risk factors we considered, driving has been studied most for the effects of the number of years of exposure. In our study, years of driving were associated with LBP in general and LBP radiating to the leg in men and with LBP for more than 30 days in women. The latter association was specific. Other authors have shown a relation between LBP and duration of driving. In male bus drivers in Italy, this duration was associated with risk of both LBP and LBP for more than 30 days.[11] The risk of LBP radiating to the leg was elevated for all duration classes, but there was no significant dose-response relation. Among urban transit operators, mostly men, back and neck pain at the time of the study was related to years of driving.[10] The effects of this duration were observed even when ergonomic factors associated with driving were considered. The magnitude of the associations found in these studies was greater than in ours, but our population is probably less exposed. The type of vehicle may also play a role. In a population survey in England, although the association between LBP and driving was not significant, the results were also consistent with the hypothesis of an effect from driving.[13]

Duration of bending/twisting was related to LBP in general for men and to LBP radiating to the leg for women. For both men and women, this exposure was also specifically associated with LBP for more than 30 days. In a study of a Swedish working population, the risk of seeking care for LBP increased when past exposures (5 and 10 years before the study) were added to current exposure, especially for those whose work combined forward bending and manual material handling. [8]

In our study, duration of exposure to pushing/pulling/carrying heavy loads appeared to be a risk factor for LBP radiating below the knee in men - a proxy for sciatica. The significance of this association in women was borderline, but few women were exposed. To our knowledge, no other authors have shown a relation between duration of manual material handling in years and sciatica. The prevalence of LBP in the past month among post office pensioners aged 70-75 years was nonetheless associated with regular lifting of weights at work for more than 20 years, and the association was significant for men.[5] In a study of blue-collar workers in France, the risk of LBP for at least six months increased with the length of exposure to carrying heavy loads.[9] In an English study, results were also consistent with the role of regular heavy lifting.[13] We did not find a relation between LBP in general and duration of exposure to pushing/pulling/carrying heavy loads here; this could be due to differences between studies in the definitions used for LBP. We note that in a one-year follow-up study of adults free of LBP at recruitment, risk of LBP was related to manual material handling but risks were highest for workers who had been exposed for shorter periods.[12]

Some associations differed for men and women in our sample. This may be related to differences in the kind and level of exposure because men and women in the GAZEL cohort held different kinds of jobs. Furthermore, some exposures are difficult to study among women because only a few women are exposed.

Some limitations, related especially to the population and the exposure assessment in this study must be discussed. The study population was a random sample of the GAZEL cohort, with 'manual workers' oversampled to ensure our ability to assess the relations of interest. In 2001, more than 87% of the 1996 GAZEL-LBP participants completed the self-administered questionnaire. However, some analyses could not be performed because of the small number of women in the sample.

Occupational exposure was assessed by self-administered questionnaires. Observation is generally considered a better method for precise exposure assessments. Here however, we sought to assess the cumulative duration of exposure to biomechanical strains during working lifetimes, which can hardly be estimated other than by questionnaire. This evaluation was retrospective, and recall bias may have occurred. Nonetheless, we verified that the answers to durations of exposure in the 1996 questionnaire were consistent with information on occupational exposures reported by the same subjects several years earlier, since the general questionnaire of the GAZEL cohort is also a source of information on occupational exposures. It is sometimes argued that people who suffer from LBP remember their past occupational exposures better than those without LBP, which would lead to overestimating the association between pain and exposure. Our study limited this bias by considering exposure assessments in 1996 and LBP reports in 2001. Furthermore, the effects of recall bias are expected to be negligible for the portion of the study dealing with specific associations. Not taking into account occupational exposures in the period 1996-2000 was reasonnable here because most of the subjects retired between 1996 and 2000. Those who remained active (and exposed to occupational strains) throughout this period could be a selected sample with a better health.

Finally, duration of exposure was recorded in ten-year classes and intensity of exposure was unknown. Some subjects classified as exposed may have had a rather low level of exposure. This exposure assessment may explain the generally rather low magnitude of the effects observed for one year of exposure. Selection effects could also play a role, but only six women had changed to another job due to LBP and among men, those who had moved to another job because of LBP had the longest exposure to the strains studied. We cannot, however, rule out the possibility that workers exposed for the longest periods may constitute a group less likely to suffer from LBP. Another explanation for these relatively small effects is that short-term effects are more important than cumulative effects.

The last limitation in our study concerns the definitions we used for persistence and 'incidence' of LBP. We only used data on LBP in 1995 and 2000. The 'incidence' here is not a first ever episode of LBP: LBP could have been present before 1995 or between 1995 et 2000. Results for these outcomes must therefore be interpreted with caution.

Despite these limitations, this study is one of the few prospective studies to explore the effects of duration of exposure to biomechanical strains on the risk of low back disorders and to take into consideration several potential personal, non occupational and occupational psychosocial confounders. Self-assessment of LBP made it possible to avoid the selection effects that may be associated with outcomes such as care-seeking or absenteeism. Duration and extent of LBP allowed us to distinguish between various types of LBP especially those that correspond to more severe disorders (LBP for more than 30 days including persistent or recurrent pain and LBP radiating below the knee, a proxy for sciatica). These entities were specifically analysed and the effects of a risk factor between various types of LBP could be compared.

CONCLUSION

Globally, this study shows that duration of exposure to biomechanical strains has long-term effects on various type of LBP. These results are consistent with the hypothesis that retired workers can suffer from low back disorders related to their past occupational history. They require further attention, especially because in France as in some other countries, age at retirement is increasing. Since people are now expected to work for longer periods, it would be important to have a better understanding of the effects of lifetime exposure. Moreover, specific associations between biomechanical strains and some types of LBP highlight the need to study specific LBP types to identify the appropriate risk factors.

Acknowledgments

The authors express their thanks to EDF-GDF, especially to the Service des Etudes Médicales and the Service Général de Médecine de Contrôle.

Main messages

- ✓ Years of exposure to biomechanical strains at work have long term effects on the risk of LBP
- ✓ Retired people can suffer from LBP related to their past occupational history
- ✓ Some biomechanical strains appears specifically associated with some types of LBP although the strength of the associations is generally weak
- ✓ Handling of heavy loads appeared to be a risk factor specific for LBP radiating below the knee and bending/twisting for LBP for more than 30 days
- ✓ Years of driving were also more closely associated with LBP for more than 30 days for women

Policy implications :

- ✓ Attention should be paid to lifetime exposure for a better understanding of its effects
- ✓ The type of low back pain needs to be taken into account to identify relevant risk factors in epidemiological studies

REFERENCES

1. Alcouffe J, Manillier P, Brehier M et al. Analysis by sex of low back pain among workers from small companies in the Paris area: severity and occupational consequences. *Occup Environ Med.* 1999;**56**:696-701.
2. Burdorf A, Sorock G. Positive and negative evidence of risk factors for back disorders. *Scand J work Environ Health.* 1997;**23**:243-56.
3. Hoogendoorn WE, Van Poppel MNM, Bongers PM et al. Physical load during work and leisure time as risk factors for back pain. *Scand J Work Environ Health.* 1999;**25**:387-403.
4. Berg M, Sanden A, Torell G et al. Persistence of musculoskeletal symptoms: a longitudinal study. *Ergonomics*. 1988;**31**:1281-1285.
5. Sobti A, Cooper C, Inskip H et al. Occupational physical activity and long term risk of musculoskeletal symptoms: a national survey of Post office pensioners. *Am J Ind Med*. 1997;**32**:76-83.
6. Derriennic F, Iwatsubo Y, Monfort C et al. Evolution of osteoarticular disorders as a function of past heavy physical work factors: longitudinal analysis of 627 retired subjects living in the Paris area. *Br J Ind Med*; 1993.**50**:851-860.
7. Calmels P, Ecochard R, Blanchon MA et al. Relation between locomotion impairment, functional independence in retirement, and occupational strain resulting from work carried out during working life. Study of a sample population of 350 miners in the Loire valley in France. *J Epidemiol Community Health.* 1998;**52**:283-288.
8. Vingard E, Alfredsson L, Hagberg M et al. To what extent do current and past physical and psychosocial occupational factors explain care-seeking for low back pain in a working population? Results from the musculoskeletal intervention center-norrtälje Study. *Spine.* 2000;**25**:493-500.
9. Derriennic F, Germain-Alonso M, Monfort C et al. Douleurs rachidiennes, âge et travail. In : Derriennic F, Touranchet A, Volkoff S eds. *Age, travail, santé. Etudes sur*

les salariés âgés de 37 à 52 ans. Enquête ESTEV 1990. Paris: Ed. INSERM. 1996 :159-178.

10. Krause N, Ragland DR, Greiner BA et al. Physical workload and ergonomic factors associated with prevalence of back and neck pain in urban transit operators. *Spine*. 1997;**22**:2117-2127.
11. Bovenzi M, Zadini A. Self-reported low back symptoms in urban bus drivers exposed to whole-body vibration. *Spine*. 1992;**17**:1048-1059.
12. Macfarlane GJ, Thomas E, Papageorgiou AC et al. Employment and physical activities as predictors of future low back pain. *Spine.* 1997;**22**:1143-1149.
13. Walsh K, Varnes N, Osmond C et al. Occupational causes of low back pain. *Scand J Work Environ Health.* 1989;**15**:54-59.
14. Leboeuf-Yde C, Lauritsen JM, Lauritzen T. Why have the search for causes of low back pain been non conclusive? *Spine.* 1997;**22**:877-881.
15. Heliovaara M, Makela M, Knekt P et al. Determinants of sciatica and low back pain. *Spine.* 1991;**16**:608-614.
16. Ozguler A, Leclerc A, Tubach F et al. Individual and occupational determinants of low back pain according to various definitions of low back pain. *J Epidemiol Community Health*. 2000;**54**:215-220.
17. Leclerc A, Tubach F, Landre MF et al. Personal and occupational predictors of sciatica in the GAZEL cohort. *Occup Med*. 2003;**53**:384-391.
18. Elders LAM, Burdorf A. Interrelations of risk factors and low back pain in scaffolders. *Occup Environ Med.* 2001;**58**:597-603.
19. Tubach F, Leclerc A, Landre MF et al. Risk factors for sick leave due to low back pain: A prospective study *J Occup Environ Med.* 2002;**44**:451-458.
20. Jansen JP, Morgenstern H, Burdorf A. Dose-response relations between occupational exposures to physical and psychosocial factors and the risk of low back pain.*Occup Environ Med*. 2004;**61**:972-979.

21. Goldberg M, Chastang JF, Zins M et al. Health problems were the strongest predictors of attrition during the follow-up of the GAZEL cohort *J Clin Epidemiol* 2006;**59**:1213-1221

22. Goldberg M, Leclerc A, Bonenfant S et al. Cohort profile: the GAZEL cohort study. *Int J Epidemiol* 2007;**36**:32-39

23. Tubach F, Beauté J, Leclerc A. Natural history and prognostic indicators of sciatica. *J Clin Epidemiol*. 2004;**57**:174-179.

24. Kuorinka I, Jonsson B, Kilbom A et al. Standardised Nordic questionnaire for the analysis of musculoskeletal symptoms. *Appl Ergonom.* 1987; **18**:233-237.