Original Article

Risk Factors of Low Back Pain among the Chinese Occupational Population: A Case-control Study*

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Abstract

Objective To explore the risk factors of low back pain among the Chinese occupational population in several major industries.

Methods A total of 7200 subjects (3600 cases and 3600 controls) were randomly sampled from a cross-sectional study, and they were investigated for individual and occupational factors of low back pain. The potential risk factors were first selected by using chi-square tests. Secondly, collinearity diagnosis proceeded by using the Kendall's rank correlation. Finally, binary logistic regression model was used for multi-factor analysis.

Results Collinearity diagnosis showed that there was a severe collinearity problem among the potential risk factors of low back pain. Logistic regression model included 20 variables with statistical significance. *Bending neck forward or holding neck in a forward posture for long periods* (OR=1.408) was the most important risk factor inducing low back pain in this study, followed by *bending heavily with the trunk* (OR=1.402), *carrying out identical work almost for the whole day* (OR=1.340). Additionally, *sufficient normal break* was a protective factor of low back pain.

Conclusion Low back pain among the Chinese occupational population was associated with body height, occupation, work organization, physical work, working posture, and others. All these risk factors could be regarded as the indicators of low back pain, and some relevant preventive measures should be taken to reduce low back pain risk.

Key words: Case-control studies; Low back pain; Occupational health; Risk factors

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INTRODUCTION

Low back pain (LBP) is one of the most common work-related musculoskeletal disorders (WMSDs). As early as in 1713, an epidemiological study was undertaken on back pain of porters[1]. In 2007, twenty five percent of workers from the 27 European Union member states complained about LBP[2]. Researches on LBP were involved in various occupational population groups

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such as office staffs, nurses, doctors, soldiers, forestry workers, construction workers, and others, of whom the prevalence rates of LBP were from 15% to 84%[3-7].

The People's Republic of China is the world's largest developing country with a huge number of occupational populations. Since the 1980s, the occupational health researchers have started their investigation focusing on chronic musculoskeletal disorders like LBP and cervical syndrome. The prevalence rates of LBP among the Chinese occupational population were from 26.4% to 84.6% by reviewing the articles about WMSDs published in Chinese. The latest LBP data obtained from articles written in English in the mainland of China showed that the 1-year prevalence of LBP in rural working populations was 64%[8]. LBP has become an important occupational health problem. Therefore, it is necessary to identify the risk factors affecting the prevalence of LBP and provide strategic responses to control relevant causes generating these factors.

LBP is a multifactor disorder with many possible etiologies including individual characteristics, working conditions, and psychological factors[9]. Individual risk factors were identified as age, gender, anthropometric parameters, personal habits, etc. The occupational risk factors were mainly associated with biomechanical and/or ergonomic factors, identified as heavy physical work, awkward static and dynamic working postures, as well as manual handling and lifting. The psychosocial risk factors identified included negative affectivity, low level of job control, high psychological demands and work dissatisfaction[10] .

There have been large amounts of studies on the prevalence of occupational LBP in China, but with relatively few studies focusing on risk factors inducing LBP. Many studies were substantially limited by methodological or reporting flaws that usually resulted in improper outcome of these studies with significant drawbacks, including lack of a clarified and unified definition of LBP, insufficient well-designed epidemiological methodology and incomplete database, and the other necessary details.

To begin with, a case-control study of risk factors of LBP was conducted in a large Chinese occupational population representing a variety of different workplace exposures. The objective of this study was to identify individual and occupational factors potentially associated with LBP among the Chinese working population by using methods of analytical epidemiology.

MATERIALS AND METHODS

Study Design

From 2009 to 2010, a cross-sectional study was conducted by a study group consisting of researchers and occupational health service providers from four universities, a municipal center for disease control and prevention and a provincial institute of occupational disease prevention and treatment. The study was based on a self-administration survey and the questionnaires were hand-delivered to adult employees (18 year olds and over) selected from over forty-one work sites of Beijing municipality, and Henan, Hubei, and Guangdong provinces covering fourteen occupational groups, and a total of 17 322 employees responded. Finally, 16 421 valid questionnaires were obtained with a responding rate of 94.80%. The present category matching case-control study was based on the population from the above study.

Selection of Cases and Controls

Cases and controls were recruited from the subjects of the cross-sectional study who had to meet the following common criteria: (a) at least 12 months of employment at the work site; and (b) absence of a current traumatic injury, rheumatoid arthritis, cancer, or infection diagnosed by the physician. Cases were taken from the subjects who answered YES to the question: "*Did you have positive musculoskeletal symptoms of low back last year?*", while controls were selected from those who answered NO to this question. The cases and controls were matched by age and gender categories. Low back was defined by a diagram showing a spinal location between T7-S1.

Subjects who answered YES or NO to the question were separately divided into five groups by age (18-24, 25-29, 30-34, 35-39, and over 40 years), and then, each group was divided into two subgroups by gender. Cases and controls were randomly selected by 1:1 ratio from the subjects of the five-multiplied-two groups. In the study, males were obviously more than females, so the ratio of males and females in cases and controls was set to be 5:1.

Questionnaire

The self-administered questionnaire used for the study was modified by Yang Lei et al.[11] based on the Nordic Musculoskeletal Questionnaire (NMQ)[12] and the Dutch Musculoskeletal Questionnaire (DMQ)[13] and integrated with the experience in actual situation in China. The items of musculoskeletal disorders from NMQ were used for the analysis of prevalence of musculoskeletal symptoms. The disorders were explained to subjects as positive musculoskeletal symptoms such as ache, pain or discomfort of nine body segments including low back, which lasted for more than 24 h and had no relieve after rest, and the disorders were divided into “lifetime”, “lasting for years”, and “lasting for weeks” according to the duration of their occurrence. The items of main risk factors of musculoskeletal disorders included individual factors and occupational factors from DMQ, while the items of the social-psychological factors were canceled. The survey covered seven aspects of occupational risk factors which were effort, dynamic load, static load, repetitive load, environmental ergonomics, vibration and climate, and laid special emphasis on manual material handling, awkward work posture, repetitive operations and work space. The subjects were asked whether they had experienced the above-mentioned exposure without further explanations or definitions upon the exposure variables, so the assessment of risk factors was qualitative in this study.

Statistical Analysis

Descriptive statistics were used to describe demographic characteristics of the subjects by using count, percentage, and average with standard deviation. Analyzing the risk factors of LBP, the potential risk factors were firstly selected which *P* value was less than 0.1 by using chi-square test. Secondly, collinearity diagnosis proceeded using the Kendall's rank correlation between selected variables and collinearity was confirmed if the correlation coefficient *r* was above 0.5 and the *P* value was less than 0.01. Finally, binary logistic regression model was used for multi-factors analysis and evaluated by unconditional Wald test. Results of the logistic regression analysis are presented with odds ratios (OR) along with the 95% confidence interval (CI). A probability level of $P<0.05$ was considered as statistically significant.

All statistical analysis was performed by using the statistical package for the social sciences software (SPSS version 11.0).

This study was approved by the Ethics Committee of Peking University.

RESULTS

Demographic Description of Subjects

In a previous cross-sectional study, 57.9 percent of 16 421 employees were reported to have LBP, and 10.6 percent of the employees were absent from work for LBP for years. According to the selection criteria, 3600 cases and 3600 controls were recruited for the study, and the demographic description is presented in Table 1.

Table 1. Demographic Description of Cases and Controls

Items	Cases	Controls
Gender		
Female	600	600
Male	3000	3000
Age(yr)		
18-24	720	720
25-29	720	720
30-34	720	720
35-40	720	720
⩾40	720	720
Height (cm)*	170.38 (6.40)	170.18 (6.40)
Weight (kg)*	66.12 (10.89)	65.56 (10.43)
BMI (kg/m^2)*	22.71 (3.11)	22.57 (2.95)
Education level		
Primary school	26	31
Secondary school	661	706
High school	1922	1666
College / University	991	1197

Risk Factors of LBP

Selection of Potential Risk Factors The association of 77 variables and 1-year prevalence of LBP were analyzed by using chi-square tests, and 54 variables were regarded as potential risk factors which *P* values were less than 0.1.

Collinearity Diagnosis The correlativity problem was prevalent among 54 variables, descriptively measured by the Kendall's rank correlation. The results that correlation coefficient *r* was above 0.5 and *P* value was less than 0.01 are listed in Table 2, and it is obvious that there was a severe collinearity problem in the potential risk factors because the correlativity of variables of manual material handling, as well as the correlativity of variables of awkward work posture and variables of work space had statistical significance.

Table 2. The Significant Results of Collinearity Diagnosis by the Kendalls' Rank Correlation ($P<0.01$)

Variables	Variables	*r*
Lifting heavy loads (more than 5 kg)	Lifting very heavy loads (more than 20 kg)	0.528
Carrying heavy loads (more than 5 kg)	Lifting very heavy loads (more than 20 kg)	0.502
Carrying heavy loads (more than 5 kg)	Pushing or pulling very heavy loads (more than 20 kg)	0.556
Lifting heavy loads (more than 5 kg)	Carrying very heavy loads (more than 20 kg)	0.509
Pushing or pulling heavy loads (more than 5 kg)	Carrying very heavy loads (more than 20 kg)	0.533
Lifting very heavy loads (more than 20 kg)	Pushing or pulling very heavy loads (more than 20 kg)	0.574
Twisting slightly with trunk	Bending slightly with trunk	0.525
Twisting heavily with trunk	Bending heavily with trunk	0.593
In a heavily bent posture for long periods	Bending heavily with trunk	0.563
In a heavily bent posture for long periods	Twisting heavily with trunk	0.561
In a slightly bent posture for long periods	In a slightly twisted posture for long periods	0.520
In a heavily bent posture for long periods	In a bent and twisted posture for long periods	0.599
In a slightly twisted posture for long periods	In a bent and twisted posture for long periods	0.524
Twisting neck or holding neck in a twisted posture for long periods	In a bent and twisted posture for long periods	0.516
Twisting neck or holding neck in a twisted posture for long periods	Bending neck backward or holding neck in a backward posture for long periods	0.527
Making repetitive movements with head	Making repetitive movements with trunk	0.574
Insufficient space above you which forces you to bend forward	Limited body height or arm length unable to reach the tool box	0.530
Insufficient space above you which forces you to bend forward	Difficult to exert proper force because of awkward posture	0.514

Logistic Regression Model Binary logistic regression analysis used the backward stepwise method to analyze the association of 1-year prevalence of LBP with 54 potential risk factors and 26 variables entered into the equation, among which 20 variables were statistically significant ($P<0.05$) (see Table 3).

Among individual factors, body *height*, *BMI* and *education level* entered into the equation of logistic model. Height was associated with LBP for low risk of LBP in groups of 165.0-169.9 cm and 170.0-174.9 cm whose ORs were less than 1. For *occupation by industry*, the LBP risk of *mechanical manufacturing* workers *was 1.254 times higher than that of coal mining workers;* and the LBP risk of the *garment* workers was 0.246 times than that of miners. It was suggested that occupation was also a related factor. *Working for 50 h and above per week*, *carrying out the same work almost for the whole day*, *working almost at the same workplace(s)*, *sufficient normal breaks*, *shortage of personnel at the site, and overtime regularly* all belonged to the factors of work organization. Except *sufficient normal breaks* which appeared to be a protective effect upon LBP, the other five variables were risks for low back. Lifting very heavy loads (more than 20 kg) was a risk with OR=1.150. There was a statistical relationship between LBP and working posture, e.g. *bending heavily with your trunk* (OR=1.402) and *bending neck forward or holding neck in a forward posture for long periods* (OR=1.408). Besides, the factors of work space and force exertion were associated with low back pain, including *having difficulties to exert enough force because of uncomfortable postures, nothing to lean on, performing short, but maximal force-exertions*. *Slipping or falling during work sometimes* was an obvious risk for LBP as its OR was 1.314.

ORs of *standing for long periods* and *insufficient height or room to be able to reach things with your tools* were less than 1, indicating that the two factors appeared to be protective against LBP, which was opposed to the common sense.

Table 3. The Results of Assessing Risk Factors of LBP by Logistic Regression Model

Variables		Control (*n*=3600) *n* (%)	Case (*n*=3600) *n* (%)	*P* Value	OR (95% CI)
Height (cm)	<160.0	203 (5.6)	198 (5.5)	0.000	
	160.0-164.9	386 (10.7)	426 (11.8)	0.850	1.026 (0.790-1.331)
	165.0-169.9	708 (19.7)	615 (17.1)	0.005**	0.700 (0.546-0.898)
	170.0-174.9	1367 (38.0)	1328 (36.9)	0.017*	0.749 (0.592-0.949)
	≥175	936 (26.0)	1033 (28.7)	0.091	0.811 (0.636-1.034)
BMI (kg/m^2)	<18.5	227 (6.3)	246 (6.8)	0.004	
	18.5-23.9	2300 (63.9)	2155 (59.9)	0.126	0.851 (0.692-1.046)
	24.0-26.9	760 (21.1)	877 (24.4)	0.626	1.058 (0.844-1.325)
	≥27	313 (8.7)	322 (8.9)	0.341	0.881 (0.678-1.144)
Education level	Primary school	33 (0.9)	31 (0.9)	0.040	
	Secondary school	700 (19.4)	652 (18.1)	0.999	1.000 (0.581-1.722)
	high school	1629 (45.3)	1952 (54.2)	0.522	1.193 (0.695-2.045)
	College / University	1238 (34.4)	965 (26.8)	0.890	1.039 (0.603-1.791)
Occupation by industry	Coal mining	287 (8.0)	275 (7.6)	0.000	
	Petroleum extraction	35 (1.0)	34 (0.9)	0.639	0.879 (0.513-1.506)
	Steelmaking	441 (12.3)	300 (8.3)	0.481	0.913 (0.708-1.176)
	Machinery manufacturing	2281 (63.4)	2603 (72.3)	0.030*	1.254 (1.022-1.539)
	Chemical industry	107 (3.0)	127 (3.5)	0.273	1.208 (0.862-1.692)
	Garments manufacturing	94 (2.6)	11 (0.3)	0.000**	0.246 (0.125-0.482)
	Railway transportation	35 (1.0)	43 (1.2)	0.369	1.266 (0.757-2.115)
	Teaching and training	166 (4.6)	94 (2.6)	0.388	1.171 (0.818-1.677)
	Non-metallic mineral roducts	154 (4.3)	113 (3.1)	0.810	1.041 (0.749-1.449)
Working for 50 h and above per week	No	2352 (65.3)	1980 (55.0)		
	Yes	1248 (34.7)	1620 (45.0)	0.001**	1.208 (1.081-1.350)
Carrying out the same work almost for the whole day	No	549 (15.3)	360 (10.0)		
	Yes	3051 (84.8)	3240 (90.0)	0.000**	1.340 (1.146-1.566)
Working almost at the same workplace(s)	No	1166 (32.4)	900 (25.0)		
	Yes	2434 (67.6)	2700 (75.0)	0.000**	1.276 (1.136-1.434)
Sufficient normal breaks	No	2060 (57.2)	2690 (74.7)		
	Yes	1540 (42.8)	910 (25.3)	0.000**	0.669 (0.599–0.747)
Shortage of personnel at the site	No	2085 (57.9)	1639 (45.5)		
	Yes	1515 (42.1)	1961 (54.5)	0.000*	1.213 (1.092-1.348)
Overtime work regularly	No	2100 (58.3)	1477 (41.0)		
	Yes	1500 (41.7)	2123 (59.0)	0.000**	1.306 (1.166–1.463)
Lifting very heavy loads (more than 20 kg)	No	2753 (76.5)	2262 (62.8)		
	Yes	847 (23.5)	1338 (37.2)	0.031*	1.150 (1.013-1.306)
Standing for long periods	No	1377 (38.3)	992 (27.6)		
	Yes	2223 (61.8)	2608 (72.4)	0.004**	0.822 (0.720–0.938)
Sitting for long periods	No	2519 (70.0)	2670 (74.2)		
	Yes	1081 (30.0)	930 (25.8)	0.058	0.883 (0.776-1.004)
Bending heavily with your trunk	No	2158 (59.9)	1374 (38.2)		
	Yes	1442 (40.1)	2226 (61.8)	0.000**	1.402 (1.238-1.588)
Bending and twisting simultaneously with your trunk	No	1757 (48.8)	1085 (30.1)		
	Yes	1843 (51.2)	2515 (69.9)	0.019*	1.165 (1.026-1.323)
In a bent and twisted posture for long periods	No	2663 (74.0)	1985 (55.1)		
	Yes	937 (26.0)	1615 (44.9)	0.038*	1.149 (1.008–1.310)

(Continued)

Variables		Control (n=3600) n (%)	Case (n=3600) n (%)	P Value	OR (95% CI)
Bending neck forward or holding neck in a forward posture for long periods	No	1743 (48.4)	1180 (32.8)		
	Yes	1857 (51.6)	2420 (67.2)	0.000**	1.408 (1.260-1.573)
Making repetitive movements with trunk	No	2228 (61.9)	1529 (42.5)		
	Yes	1372 (38.1)	2071 (57.5)	0.017*	1.170 (1.028-1.332)
Making repetitive movements with head	No	2443 (67.9)	1861 (51.7)		
	Yes	1157 (32.1)	1739 (48.3)	0.095	1.113 (0.982-1.263)
Often holding vibrating tools	No	2718 (75.5)	2445 (67.9)		
	Yes	882 (24.5)	1155 (32.1)	0.089	0.901 (0.799–1.016)
Insufficient space above you which forces you to bend forward	No	2695 (74.9)	2332 (64.8)		
	Yes	905 (25.1)	1268 (35.2)	0.062	0.876 (0.762-1.007)
Insufficient height or space to be able to reach things with your tools	No	3016 (83.8)	2719 (75.5)		
	Yes	584 (16.2)	881 (24.5)	0.046*	0.853 (0.730-0.997)
Having difficulties to exert enough force because of uncomfortable postures	No	2453 (68.1)	1826 (50.7)		
	Yes	1147 (31.9)	1774 (49.3)	0.049*	1.145 (1.001-1.310)
Nothing to lean on	No	2174 (60.4)	1591 (44.2)		
	Yes	1426 (39.6)	2009 (55.8)	0.033*	1.138 (1.011-1.280)
Performing short, but maximal force-exertions	No	2223 (61.8)	1556 (43.2)		
	Yes	1377 (38.3)	2044 (56.8)	0.029*	1.152 (1.015–1.307)
Slipping or falling during work sometimes	No	2233 (62.0)	1629 (45.3)		
	Yes	1367 (38.0)	1971 (54.8)	0.000**	1.314 (1.170-1.475)

Note. $^{*}P<0.05$, $^{**}P<0.01$.

Assessment of the Fit of Logistic Regression Model As presented in Table 4, the goodness of the fit of logistic regression model is not good, because Cox & Snell R square and Nagelkerke R square are not close to 1, though –2 Log likelihood is high. The overall percentage correctly predicted seems to be good at 65.1%. Hosmer–Lemeshow test statistic is 14.237, and P value is 0.076, so the null hypothesis is accepted that there is no difference between the observed and predicted values of the dependent, implying that the model's estimates fit the data at an acceptable level.

Table 4. Assessment of the Fitness of Logistic Regression Model

–2 Log Likelihood	Goodness of Fit		Predicted	Hosmer - Lemeshow Test	
	Cox & Snell R^2	Nagelkerke R^2	Percentage Correct	X^2	P
8987.849	0.129	0.172	65.1%	14.237	0.076

DISCUSSION

In a previous cross-sectional study, the 1-year prevalence rate of LBP was 58.3%, and was similar to the other relevant study, implying that LBP is one of the major health problems of Chinese employees. The risk factors of LBP are discussed as follows.

Individual Factors

The findings of this study demonstrated an association between body *height* and LBP. The risks in groups of *165.0-169.9 cm* and *170.0-174.9 cm* were lower than in the reference group. Other factors like *BMI* and *education level* had no significant association with LBP.

The relationships between body height, obesity, education level, smoking and LBP were controversial. Han et al.[14] found that taller subjects developed LBP symptoms less frequently in comparison with shorter subjects. No significant interactions were seen between waist and height. A newly published meta-analysis including 33 studies showed that obesity was associated with increased prevalence of

LBP in the past 12 months (pooled odds ratio, OR = 1.33 (95% CI: 1.14-1.54)[15]. Bener's research revealed that there was association between BMI and some socio-demographic variables with respect to LBP[16]. Education level was an independent risk factor of LBP (RR=2.65, 95%CI: 1.53-4.78), and obesity (BMI>30 kg/m^2) was positively associated with LBP in a moderate way (RR=1.91, 95% CI: 1.57-2.35).

Occupational Factors

Occupation Our study suggests that occupations are associated with self-reported LBP. For this study, we selected nine representative industries in China, and occupations were classified by the types of the industry, because there were more than 200 job titles that seemed too hard to analyze if the type of work was used to describe the job of the subjects. If *coal mining* is used as a reference industry, the LBP risk appeared to be higher among subjects of *mechanical manufacturing industry*, and it was lower in *garments manufacturing industry*. At the same time, there were no significant differences in LBP risks between the reference industry and *petroleum extraction*, *steelmaking, chemical industry*, *railway transportation*, teaching and training, *non-metallic mineral products manufacturing*.

As a developing country, China has established various pillar industries, for example, coal mining, steelmaking, mechanical manufacturing, garments manufacturing, and transportation. The occupational health status in these industries is always viewed as a great concern by the Chinese researchers.

In the world, 37% of LBP are attributed to occupation[17]. Actually, surveys of various types of occupations have shown that wide variations in the incidence and prevalence of LBP are related to specific industries. Manchikanti's review has revealed that trucking and warehousing, construction, law enforcement, health-care services are associated with high prevalence of LBP in the 1990s[18]. During this decade, many researchers still paid close attention to health-care workers[19-21], occupational drivers[22-23], and construction workers[24]. Sven Schneider et al.[25] found that occupational categories with a lower-than-average back pain prevalence were highly qualified professionals, senior management, and production occupations which were characterized with a comparatively low degree of manual labor. To some extent, these results reflect that LBP risk may be higher in some industries, in which the workers need to take heavy physical work, or work with awkward posture.

Work Organization We found that *sufficient normal breaks* was a protective factor for LBP. Rests may ease the stress and fatigue of workers, especially in combination with proper work-rest schedule. Van Dieen et al.[26] found that an optimal work-rest schedule considering visco-elastic deformation of the spine would probably involve frequent short breaks.

In contrast, *working for 50 h and above per week* and *overtime work regularly i.e.,* working for more than 8 hours a day become the risk factors of LBP, which may be due to prolonged exposure to occupational hazards and over fatigue. In a retrospective nested case-control study, researchers found that excess risk for LBP among men was seen in heavy physical workload, sedentary work, high perceived load from extra work outside, and the combination of poor social relations and overtime[27]. Office workers working for over 8 hour a day were faced with a greater risk inducing low back symptoms (adjusted OR=1.66, 95% CI: 1.25-2.22)[28].

Carrying out the same work for almost the whole day and *working almost at the same workplace(s)* means that workers would complete work tasks with unchanged posture and work load. Workers could be prone to suffering from LBP under the same load and work environment.

Heavy Physical Work and Manual Materials Handling (MMH) Our results showed that *lifting very heavy loads (more than 20 kg)* could be a risk factor of LBP. Repetitive lifting, carrying, pushing or pulling might increase the risk of LBP[29-30]. Prado-Leon et al.[31] carried out a case-control study mainly focused on occupational lifting. They found greater association with LBP as weight increased and this was significant for both categories (crude and adjusted OR), meaning that there was an exposure-response relationship between lifting load and LBP. Da Costa et al. reviewed 12 recent Longitudinal studies, and found that heavy physical work and lifting were occupational risk factors for LBP with reasonable evidences[10].

But there is a controversy. A Two-Year Prospective Study of a General Working Population was carried out, and the contributions of work-related physical and psychosocial factors, individual factors, and health-related factors to the development of new cases of back pain were analyzed. There were no significant dose-response relationships between lifting, pushing or pulling and LBP[32].

Wai et al.[33] reviewed several high-quality studies and found that the study did not consistently support any of the Bradford-Hill criteria for causality. Although subgroup analyses identified certain types of lifting and LBP that had statistically significant results, it was concluded that occupational lifting was unlikely to be an independent causative relevance to LBP in the working populations studied. The similar results were found in the reviews about causalities between carrying, pushing or pulling and LBP[34-35].

Working Postures We found that LBP was associated with working postures which included bending heavily with one's trunk, bending and twisting simultaneously with one's trunk, a bent and twisted posture for long periods, and making repetitive movements with the trunk. This finding was consistent with other studies. Repetitive twisting or bending with the trunk, as well as prolonged twisting or bending, can increase the risk of LBP because of unrecovered fatigue[36-37] Wai et al.[38] took causal assessments of occupational twisting or bending and LBP, suggesting that occupational twisting or bending was unlikely to be an independent causation of LBP in the working population studied.

Standing for long periods appeared to be a protective effect on LBP on account that OR was less than 1, which was opposed to its well-known occupational hazard. However, its OR was over 1 when we conducted a univariate logistic analysis. It meant that there could be interactions between this variable and the others. Some studies identified that prolonged standing could be associated with LBP[32,39]. However, results from the review of Roffey et al.[40] indicated that occupational standing did not meet any of the accepted criteria required to establish causation for LBP.

Interestingly, regression model of this study did include *bending neck forward or holding neck in a forward posture for long periods*. It suggested that neck postures could be associated with LBP that might occur with sitting, bending, or other trunk posture.

Besides, the factors of work space and force exertion were related to LBP. In fact, working postures, physical work or MMH were related to the situation of work space and force exertion. Therefore, there could be some interactions among these factors for LBP.

Limitations of the Study

There are some limitations in this study. Firstly, the selection of cases and controls depended on self-reported LBP, and results could be effected by the awareness and expression of the subjects. Secondly, there was a problem of selection bias on account that the subjects of the case-control study were from a large convenience sample, although cases and controls were sampled randomly. Finally, there was a severe collinearity problem in the potential risk factors, and the backward-stepwise logistic regression model did not solve the collinearity problem satisfactorily.

CONCLUSION

In conclusion, this study identified the risk factors inducing LBP among the Chinese occupational population. LBP among the Chinese employees was associated with body height, occupation, work organization, physical work, working posture, and others. And these risk factors could be regarded as the indicators of LBP, although the relationship was not strong enough. Therefore, targeted preventions of LBP should be taken, for example, adopting ergonomically designed workstation and equipment and taking appropriate work-rest schedule to decrease work load and the work time of workers.

This study firstly analyzed the collinearity of the potential risk factors, then a logistic regression model was established, and lastly, the fitness of logistic regression model was evaluated. Therefore, a correct statistical method and appropriate assessment of the statistical approach were emphasized.

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