—Original—

An Epidemiological Study on Occupational Low Back Pain Among People Who Work in Construction

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Abstract

People who work at construction sites have one of the highest incidences of low back pain (LBP).

The purpose of this study is to evaluate the status of LBP, and to investigate the risk factors of LBP in construction workers.

The subjects were 33,530 workers who were sent our questionnaires in September and October 1996. Of the final respondents, 29.3% had LBP. The results of multi-regression analysis revealed that risk factors having significant relationships with the onset of LBP were 1) stress due to personal relations at work, 2) postures during work, and 3) unstable body balance on scaffoldings. In addition, two factors were found to be important in decreasing the incidence of LBP: 1) having sufficient space for taking a rest and 2) using pre-work exercises

These findings have led us to the conclusion that not only providing good physical working environments, but also giving instructive and psychological care are important in preventing the onset of LBP in construction workers. (J Nippon Med Sch 2001; 68: 310—317)

Key words: low back pain, construction workers, risk factors

Introduction

According to a report published by the Labor Ministry of Japan, the number of workers with occupational illness reported in 1979 was 13,807, and 11,564 of them had low back pain (LBP), which is a remarkable 83.8%. The number of occupational illnesses gradually decreased. In 1997, it stood at 6,034. The rate of cases with LBP, however, still remained as high as 83.5% (5,041 cases). Regarding the occupations with a high incidence of LBP, construction comes next highest to transportation[1]. In addition to that, more than 95% of the reported cases of LBP in construction workers were acute, and developed either in accidents or due to excessive external forces applied during working. Therefore, we consider that the actual incidence of LBP in construction workers could be several times higher than the reported rate when chronic occupational LBP is added. We also surmise that the medical costs for treating chronic LBP in construction workers and reduction in work efficiency due to LBP represent a tremendous social loss. The aim of this study is to evaluate the status of LBP, and to investigate the risk factors for the onset of LBP in construction workers.

Subjects and Methods

The subjects of the present study were construction workers in Japan. All of them were employees of one of the 141 construction companies, who well un-

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derstood the purpose of our study, and gave us their cooperation. A nationwide survey was conducted over one month from September to October 1996. A questionnaire survey was chosen for the method. The questionnaires were sent to 33,530 workers, and the number of respondents was 29,918 (89.2%). In order to make the survey more accurate, questionnaire sheets with incomplete answers, respondents with illnesses associated with LBP, and answers from office clerks were excluded from the subject group. The total number of subjects thus came to 19,948.

The questionnaire consisted of 48 items. Regarding LBP, the subjects were asked whether they had LBP at the time of the survey, if they had a past history of lumbar injury. Information on the onset or progression of LBP before and after employment was also requested. The subjects who already had LBP were asked about its severity, when and what kinds of works they did at the onset of LBP, and whether LBP occurred suddenly or gradually. Individual factors concerning their personal lives, such as whether they were married, if they smoked and/or drank, and the number of hours they slept, were investigated in addition to physical factors such as age, height and body weight. Concerning their occupations, the respondents were asked about the number of employees at their companies, their specialties if they were specialists, their length of employment, the number of working days and holidays per month, their working and resting hours per day, the postures they often maintained during work, and if they had to handle heavy objects, the weights of the objects were inquired after. Other questions such as whether they do light physical exercises before starting work, whether they wear a lumbar supporter while working, whether they have sufficient spaces to take a rest and proper scaffolding, and whether they suffer stress due to personal relations at work were given (**Table 1**).

In order to make a comparative analysis of the results, the subjects were divided into two groups: those with LBP (5,843); and those without LBP (14,105). A statistical analysis was conducted using Student's t-test on variants such as height and body weight, and chi-square distribution of frequencies (numbers) of such factors as life style, marital status and postures during work. For example, when the relationship between postures during work and the onset of low back pain was analyzed, "sitting job" was used as a standard. The workers having a "sitting job" were divided into two groups, those with or without low back pain, and the workers having a "body twisting job" were also divided into two groups, those with or without low back pain. Based on the numbers in the two groups in each category, a 2×2 table was made in order to obtain the chi-square distribution. The same analysis was conducted on each working posture, and when a significant result was obtained, the odds ratio was calculated as an index of its effect on the onset of LBP by having the "sitting job" as a standard. The same method was used for analyzing "life style" by setting "single life" as a standard, "marital status" by setting "married" as a standard, and "handling heavy objects" by setting "no handling of heavy objects" as a standard. The odds ratio of each factor was worked out as a numerical conversion of an effect to the onset of LBP by regarding each standard as one.

Based on the obtained data, the factors suspected to be strongly related to LBP were selected. With the use of Hayashi's quantification theory class I, a multi-regression analysis was made by regarding the presence and non-presence of LBP as objective variants, and various factors as descriptive variants. Further,

Table 1 Summary of questionnaire the questionnaire contains 48 items about low back symptoms, personal factors and occupational factors

1.	Low back symptoms Prevalence of low back pain, frequency and severity, associated symptoms, past history
2.	Personal factors Sex, age, body weight/height, smoking and drinking habits, marital status, living environment, sleeping time, working period
3.	Occupational factors Occupation, size of company, working environment, working postures, handling heavy objects, stress

t-value was calculated as an index of effect to the occurrence of LBP. When a descriptive variant indicated as a value, such as "number of cigarettes smoked per day" had to be converted into dichotomic variants, the residue was calculated, and a boundary value was determined based on the residue with dichotomization. In regard to unquantifiable factors, there were descriptive variants that were already dichotomized. One example was "with or without stress due to personal relations at work". In this case, the dichotomized variants were used for the analysis. Other factors were dichotomized based on the odds ratio per factor. These analyses were conducted using SPSS, Base 7.5 J.

Results

(1) Incidence and Severity of LBP

At the point of time of the questionnaire survey, 5,843 (29.3%) out of 19,948 subjects were having LBP. Of this group with LBP, the majority of 3,544 (73.4%) had moderate pain, that is, having pain either constantly or often. Severe pain which required taking a rest for relieving it during work was reported by 263 (5.4%) (**Fig. 1**). The numbers of subjects who had the experience of either taking a leave of absence from work or visiting a doctor for consultation were as high as 2,487 (50.2%) and 3,617 (67.5%) respectively.

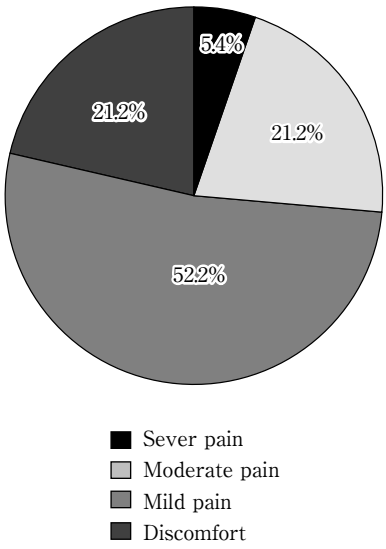


Fig. 1 Severity of Low Back Pain
Severe pain: Cannot work without taking a rest from time to time, Moderate pain: Fairly strong pain but no need to take a rest, Mild pain: Feel light pain from time to time, Discomfort: Feel dullness in the lumbar region

(2) Onset of LBP

The data concerning the LBP showed that 80% of the 5,843 subjects had the onset of LBP during work. Among them, the total number of subjects with gradual onset of LBP during work was 2,856 (53.2%), which is significantly greater than that of the subjects with sudden onset of LBP (1,645: 30.7%) (**Fig. 2**). Regarding to the time of the onset of LBP, "8: 00 a. m. —10: 00 a. m." was 994 (19.9%), and "2: 00 p. m. —4: 00 p. m." was 1,441 (28.9%). It makes nearly a half of the subjects with LBP, when these two groups are added together (**Fig. 3**).

(3) Personal Factors and LBP

The comparative study on the groups with or without LBP indicated no difference in the incidence of LBP between males and females. Height and body weight had no relationship with LBP. The mean age of the group with LBP (42.0 years), however, was significantly higher than that of the group without LBP (40.9 years) (**Table 2**).

The mean sleeping time of the group with LBP (6.9 hrs./day) was significantly shorter than that of the group without LBP (7.0 hrs./day). The mean number of cigarette consumption of the group with LBP (25.7 cigarettes/day) was greater than that of the group without LBP (24.0 cigarettes/day). The mean duration of smoking history of the group with LBP was

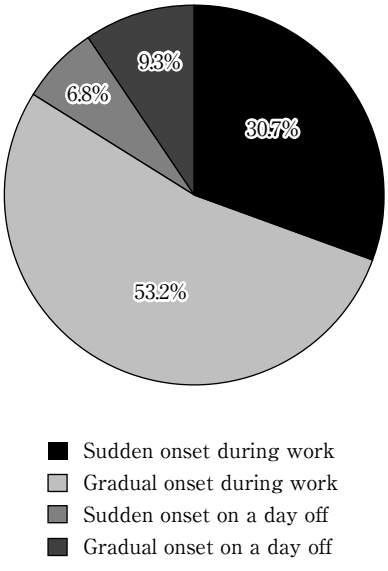
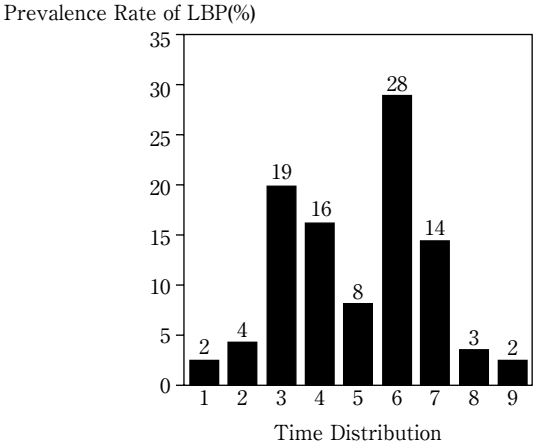


Fig. 2 Onset of Low Back Pain



1: midnight – 4:00a.m., 2: 4:00a.m. – 8:00a.m., 3: 8:00a.m. – 10:00a.m., 4: 10:00a.m. – 12:00a.m., 5: 12:00a.m. – 2:00p.m., 6: 2:00p.m. – 4:00p.m., 7: 4:00p.m. – 6:00p.m., 8: 6:00p.m. – 8:00p.m., 9: 8:00p.m. – midnight

Fig. 3 Prevalence Rate of Low Back Pain According to Distribution of Time

also longer than that of the group without LBP (**Table 3**).

The relation between LBP and qualitative data in personal factors was analyzed by using odds ratio. When "living alone" was set as a standard of the incidence of LBP, the odds ratio of "living together with family" was 1.26. Regarding marital status, the odds ratio of "single life" was as low as 0.70 when the odds ratio of "married life" was set as a standard (**Table 4**).

(4) Occupational Factors and LBP

The incidence of LBP was analyzed by comparing the occupational factors of the subjects. The occupations with incidences of 35% or greater were coal mining, reinforcing bar placing, plastering, interior finishing, roofing, bricklaying/tiling and welding. Those with incidences of 25% or less were only painting and demolishing/chipping.

The relation between the size of the company categorized by the number of employees and the incidence of LBP was analyzed. The incidence of LBP in small companies with 9 employees or fewer was as high as 30.2%. It was found out, however, that the incidence in large companies with 100 employees or more was also over 30%.

Regarding working hours per day, the mean in the group with LBP (8.2 hrs/day) was longer than that in the group without LBP (8.0 hrs./day). The mean number of working years in the group with LBP (14.4 years) was also longer than that in the group without LBP (12.5 years). However, no significant difference was observed in relation to the mean number of working days and holidays per month, the mean number of holidays per week, or the mean hours of rest per day (**Table 5**).

Postures during work were analyzed by having "sitting on chairs position" as the standard of the incidence of LBP. The odds ratio of "twisting position" was as high as 1.81, and that of "deep forward bending position" was also as high as 1.80. The odds ratios of "half sitting position" and "squatting down position" were 1.37 and 1.14 respectively (**Table 6**).

The relation between handling heavy objects and the incidence of LBP was analyzed by making "no handling of heavy objects" as a standard. The odds ratio of "handling objects of 40 kg or over in weight" was 1.67, that of "20 kg to lighter than 40 kg" was 1.44, "10 kg to lighter than 20 kg" was 1.25, and "5 kg to lighter than 10 kg" was 1.08. These findings show that when the objects workers carry are heavier, the odds ratio of LBP become higher (**Table 7**).

(5) Other Factors and LBP

The effect of doing pre-work exercises was analyzed. In the group without LBP, the rate of subjects who were doing exercises "every day", "sometimes" and "rarely" were 71.8%, 19.1% and 9.1% respectively. The same rates in the group with LBP were 69.4%, 21.1% and 9.6% respectively. These data showed that the group without LBP was doing pre-work exercises more frequently than the group with LBP.

The rate of usage of a lumbar supporter during work was 19.8% in the group with LBP, which is significantly higher than the 8.4% in the group without LBP. This means that the usage rate of a lumbar supporter in the group with LBP is higher than that in the group without LBP.

(6) Results of Multi-Regression Analysis

We consider that in the development mechanism of LBP, various factors are involved in its onset not individually, but in a related manner. Therefore, a multi-regression analysis using Hayashi's quantification theory class I was carried out on 17 factors, which were selected on the suspicion that they were involved in the development of LBP. The t-value of each risk factor was calculated as its index of the effect to the

Table 2 Comparison of personal factors between groups with or without LBP

	Group with LBP	Group without LBP	
Age (years old)	42.0 ± 12.3	40.9 ± 13.62	*p < 0.05
Height (cm)	167.6 ± 6.9	167.1 ± 6.9	
Body Weight (kg)	64.9 ± 9.7	64.2 ± 9.7	

*student's t-test
Group with LBP ; group composed of subjects who complained of low back pain at the time of survey

Table 3 Comparison of sleeping hours and smoking habits between groups with or without LBP

	Group with LBP	Group without LBP
Sleeping Hours (per day)	6.9 ± 1.2	7.0 ± 1.1 *
Smoking : Daily Consumption	25.7 ± 10.4	24.0 ± 9.7 *
Smoking : Experience (years)	19.9 ± 10.4	18.0 ± 11.1 *

*student's t-test $p < 0.05$
Group with LBP ; group composed of subjects who complained of low back pain at the time of survey

Table 4 Odds ratios for low back pain in living environment and marital status

Living Enbironment		Odds Ratio	95%Cl
	Living with Family	1.26	1.16—1.37
	Living with Others	1.09	0.98—1.21
	Living Alone	—	—
Marital Status		Odds Ratio	95%Cl
	Single	0.70	0.66—0.75
	Others	0.77	0.68—0.87
	Married	—	—

The Odds Ratio was calculated, when "living alone" was set as a standard of the incidence of LBP in the living environment. And the Odds Ratio also was calculated, when "married life"was set as a standard of the incidence of LBP in the marital status.

Table 5 Comparison of working conditions between groups with or without LBP

	Group with LBP	Group without LBP	
Working Experience (years)	14.4 ± 11.1	12.5 ± 10.7	*p < 0.05
Working Days (per month)	23.5 ± 2.6	23.5 ± 2.6	
Working Hours (per day)	8.2 ± 1.3	8.0 ± 1.2	*p < 0.05
Resting Hours (per day)	1.5 ± 0.6	1.5 ± 0.6	
Number of Days off (per week)	1.2 ± 0.6	1.2 ± 0.6	
Number of Days off (per month)	5.4 ± 1.9	5.4 ± 2.0	

*student's t-test
Group with LBP ; group composed of subjects who complained of low back pain at the time of survey

Table 6 Odds ratios for low back pain by working postures

	Odds Ratio	95%Cl
Twisting	1.81	1.46—2.24
Deep Forward Bending	1.80	1.47—2.20
Half Bending	1.37	1.23—1.53
Squatting	1.14	0.99—1.32
Stretching	0.89	0.61—1.29
Standing	0.83	0.75—0.92
Sitting on chairs	—	—

The Odds ratio was calculated, when "sitting on chairs position" was set as a standard of the incidence of LBP by postures during work.

Table 7 Odds ratios for low back pain by handling heavy objects

	Odds Ratio	95%Cl
Over 40kg	1.67	1.46—1.90
20—40kg	1.44	1.28—1.61
10—20kg	1.25	1.10—1.42
5—10kg	1.08	0.94—1.24
No Handling	—	—

The Odds ratio was calculated, when "on handling of heavy objects" was set as a standard of the incidence of LBP by handring heavy objects.

Table 8 Results of multiple regression analysis for low back pain using 17 factors

	Factors	Content	t value
Ⅰ	Smoking (Daily Consumption)	Above 21 cigarettes/day	7.9
	Working Hours	Above 9 hrs/day	7.2
	Sleeping Hours	Below 5 hrs/day	5.4
	Working Experience	Above 14 years	5.0
	Smoking (Experience)	Above 20 years	4.9
	Handling Heavy Objects	Above 20kg by oneself	3.7
	Scale of Company	Above 300 laborers	3.3
	Age	Above 41 years	NS.
Ⅱ	Stress	Large strss of personal relations	16.5
	Scaffolding	Unstable scaffolding at work	10.1
	Vibration Exposure	Frequently at work	3.1
	Drinking Alchohol	Drinking alchohol	2.7
	Resting Place	Having enough place to rest	− 3.4
Ⅲ	Working Posture	Half bending, Deep forword bending or Twistng	11.0
	Marital Status	Married	4.8
	Living Environment	Living with family	2.8
	Pre-Work Exercise	Always	− 2.3

R ; 0.248 R square ; 0.062 F value ≧ 2.0

Ⅰ ; The factor (descriptive variant) is of a quantifiable value, and is dichotomized by setting a boundary value.

Ⅱ ; The factor (descriptive variant) is dichotomized originally.

Ⅲ ; The factor (descriptive variant) is unquantifiable, and dichotomized by setting a boundary value based on chi-square distribution and odd's ratio.

onset of LBP. When a descriptive variant indicated as a value, such as "number of cigarettes smoked per day", had to be converted into dichotomic variants, the residue was calculated, and a boundary value was determined based on the residue with dichotomization. In regard to unquantifiable factors, there were descriptive variants that were already dichotomized. One example is "with or without stress due to personal relations at work". In this case, the dichotomized variants were used for the analysis. Other factors were dichotomized based on the odds ratio per factor. The results showed that the multiple correlation coefficient (R) and contribution ratio (R^2) of the multi-regression were 0.248 and 0.062, respectively (**Table 8**). The t-values of occupational factors were superior. The highest three were "stress due to personal relations at work" (16.5), "postures during working" (11.0) and "unstable body balance on scaffolding" (10.1). Among the factors in everyday life, comparatively strong effects were observed in

"smoking over 21 cigarettes per day" (7.9) and "sleeping duration of shorter than 5 hours per day" (5.4). The factors of "having sufficient space for taking a rest" (−3.4) and "doing pre-work exercises every day" (−2.3) showed negative effects on the incidence of LBP, which means that these factors play protective roles in the incidence of LBP.

Discussion

According to a report issued by the Labor Ministry of Japan in 1994[1], the incidence of LBP in construction workers is next highest to transportation workers. The prevalence rate of LBP among construction workers in the present research is higher than that in the data of occupational illnesses reported by various other researchers[2–8]. A comparison was made between our data and those on construction workers reported in various papers in the literature. In 1992, Holmstrom et al. reported that 54% of 1,772 workers had LBP in the previous year[9]. In 1971, Yoshida reported that the incidence in the previous month was 45.1%[2]. The LBP prevalence rate in the present research was 29.3%, which is very low in comparison with those two results. However, we consider that these differences are caused by different methods of collecting data. Many construction workers in Japan work on either a daily or short-term employment basis. Therefore, they often change their companies, which means their working environments are also changed. Taking these facts into consideration, we limited the condition of LBP to be reported by asking them if they had LBP at the time of our questionnaire survey.

Regarding the development manner of LBP, many of our subjects reported a gradual onset, which is different from the data on occupational LBP reported by the Labor Ministry of Japan. We consider that this means there are many characteristics in our subject population which are different from those defined by the Labor Ministry in occupational LBP. A similar tendency toward a high incidence of chronic LBP in other occupations is also found in the literature. Nakagiri et al. reported that this tendency had become clear in recent years. Concerning the cause of the increase in the onset of chronic LBP, Ohara reported that the accidental onset of LBP, such as acute LBP caused by an external force, had decreased due to mechanization and the consequent reduction of manual labor with kinetic muscle movements[4]. As a result, labor with static strain of the muscles such as half-sitting and deep-forward-bending of the body had increased. The construction industry in Japan has recently become more sophisticatedly mechanized. We surmise, therefore, that labor requiring static strain of the muscles has increased relatively, which has resulted in the increase in the onset of chronic LBP.

Workers in occupations with 35% or greater rates of incidence of LBP coal miners, reinforcing bar placers, plasterers, interior finishers, roofers, bricklayers/tilers and welders often have to adopt anti-physiological postures for a long time during work due to the special characteristics of their work. We consider that these unnatural and restrictive postures are deeply involved in the onset of LBP. The multi-regression analysis on the risk factors of LBP showed that, among working conditions, postures during work such as "twisting", "deep forward bending", "half bending", and "unstable body balance on scaffolding" had the strongest relations with the onset of LBP. This suggests that the mechanisms of developing LBP among construction workers are often operations on improper scaffolding involving the adoption of postures that require strained lumbar muscles and unnatural and restrictive postures for long periods of time.

There have been various reports on the strong relationship between the duration of work and the prevalence of LBP which put stress on its importance in securing well-conditioned working environments[4,5,7,10]. The data obtained in this research also suggest a strong relation between the onset of LBP and working conditions such as long working hours and insufficient space for taking a rest. When the duration of work becomes longer, the stress on the lumbar region is also increased, and when the duration of rest becomes shorter, fatigue in the lumbar region is aggravated. Consequently, this creates a favorable condition for the onset of LBP.

The relation between stress and LBP has also been reported recently. Riihimaki made a review of various reports in the literature, and suggested a psychologi-

cal factor as one of the risks in LBP[11]. Holmstrom and Bigos reported that job dissatisfaction in young workers was related to the development of LBP[9,12]. Svensson researched on people aged between 40 and 47 years old, and reported that those with LBP had more complaints about their jobs than those without LBP[10]. In Japan, Koda conducted a study on nurses, and pointed out that psychological stress due to the characteristic of their job of dealing with patients was strongly connected with the onset of LBP[5]. In this research, the relation between psychological factors and LBP was also shown. According to the results of our multi-regression analysis, psychological factors have the strongest effect on LBP. In this research, stress solely due to personal relations at work was investigated. At a construction site, many people from various companies have to work together for comparatively short periods of time, although they do not know much about each other. The stress they feel can be increased through communications with unfamiliar bosses and co-workers. We surmise that this affects LBP.

We consider that doing pre-work exercises has a good effect in preventing LBP, based on the data obtained in our research. The group without LBP did pre-work exercises more frequently than the group with LBP, and the t-value obtained by multi-regression analysis was-2.3. Regarding the preventive effect of lumbar support against LBP, it was found that the rate of usage of a lumbar supporter in the group with LBP was significantly higher than that in the group without LBP. The overall rate of wearing lumbar support was also as low as 11.7%. These data indicate that supporters may ease LBP but not prevent it.

It is not easy to identify a general cause of LBP. In clinical practice, the choice of treatment depends upon the cause and characteristics of LBP in each patient. The multiple correlation coefficient (R) obtained in the present research was as small as 0.248, which means it is insufficient to explain the general pathogenesis of LBP. However, we consider that at least several factors to be improved upon have been pointed out by this research. Improvements in working conditions to reduce the handling of heavy objects by implementing mechanization, and strict control on proper working hours are necessary in order to prevent the onset of LBP. In addition, instruction on how to avoid adopting bad postures should be given to workers. We also consider that doing pre-work exercises, and wearing lumbar supporters should be recommended because they are not only comparatively easy to do but are also effective in preventing LBP. Lastly, psychological approaches including counseling workers on "stress due to personal relations at work" should be instituted as prevention against LBP.

LBP is one of the outcomes of physical and psychological failure in an individual. Therefore, careful countermeasures should be established to prevent LBP by taking the risk factors into consideration.

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(Received, December 29, 2000)
(Accepted, February 26, 2001)