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Short Communication

Effect of occupational pushing and pulling combined with improper working posture on low back pain among workers

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Abstract: This study aimed to investigate the impact of occupational pushing and pulling combined with improper working posture on work-related low back pain (LBP) among workers. A web-based survey was conducted in 2022 to collect data from 15,623 workers, who were categorized into proper and improper working posture groups. Multiple logistic regression analysis was used to analyze the association between pushing and pulling loads and LBP in each group. In the proper working posture group, the odds ratios (ORs) of LBP for workers who pushed and pulled were not significantly different compared with those of no-handling workers. However, in the improper working posture group, the ORs of LBP were significantly greater among workers who pushed and pulled compared with those of no-handling workers, and this association became stronger with increasing weights. Therefore, improper working posture combined with pushing and pulling were strongly associated with LBP among workers, particularly with heavier weights.

Key words: Low back pain, Pushing, Pulling, Working posture, Weight

Many manual material handling tasks have shifted from carrying loads to using carts that are pushed or pulled. In Japanese workplaces, four-wheeled carts operated by workers are frequently used. These carts vary in form, with some having handles and others resembling fenced palanquins. The act of occupational pushing and pulling objects increases compressive and shear forces exerted on the lumbar intervertebral disc[1, 2]. However, the association between pushing–pulling activities and work-related low back pain (LBP) has yielded positive and negative findings, indicating insufficient clarity in this regard[3].

Occupational pushing and pulling are performed in various postures. Workers often adopt forward-bending and half-crouching positions when a cartload is heavy or the handle is low. Similarly, workers tend to take twisting and unstable postures when changing the direction of the cart. While these postures are unlikely to be independent causes of LBP[4], they increase compressive and shear forces on the lumbar intervertebral disc[5]. However, the impact of working posture has not been sufficiently investigated in pushing and pulling tasks. Improper postures during pushing and pulling may increase disc compressive and shear forces, leading to the development of LBP. Therefore, this study aimed to investigate the impact of occupational pushing and pulling combined with improper working posture on LBP among workers.

The participants were Japanese male and female workers aged 20 to 75 yr working in the following four industries: manufacturing, wholesale and retail trade, construction, and transport and postal activities. The total

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working population in the four industries was 29.4 million working individuals in Japan[6]. Among them, data were collected from a total of 30,000 workers, 7,500 workers per industry, according to the sex and age distribution of the Labor Force Survey[6].

The questionnaire collected information on basic demographic and job characteristics, job stressors, manual handling status, load weight of pushing and pulling regularly, working posture, pushing and pulling characteristics, and LBP severity. The moment a worker experienced their first LBP episode on their current job was considered the starting point for questioning from their manual handling status to LBP severity.

Tables 1 and 2 show question items of basic demographic and job characteristics, job stressors, load weight of pushing and pulling, working posture, and pushing and pulling characteristics. Basic demographic and job characteristics included sex, age, body height and weight, body mass index, smoking status, industry, and the total number of working hours per week. Questions on job stressors were developed based on the job demand, job control, and worksite social support items of the Brief Job Stress Questionnaire[7]. A question about manual handling status was included: no handling, lifting and lowering, carrying, pushing, pulling, rolling, and others. This study examined the association between the human-powered pushing and pulling of carts and objects and LBP by focusing on no handling, pushing, and pulling. The load weight was defined as the weight value per person involved in regular pushing and pulling tasks. If two individuals performed pushing and pulling, the weight value was halved accordingly. Load weight was classified into four categories: no handling, 1–30 kg, 30–60 kg, and ≥60 kg. The responses to a question regarding working posture were assessed which included proper posture, forward-bending position, a half-crouching position, twisting posture, unstable posture, and other postures. Working posture was divided into proper and improper working posture groups. The proper working posture group was defined as having a proper posture which was a straight-back posture without bending-forward, half-crouching, or twisting. The improper working posture group was described as having postures other than a proper posture. Questions regarding pushing and pulling characteristics included hours spent per day in pushing and pulling, number of times pushing–pulling tasks were performed per day, and average pushing–pulling distance each time. LBP severity was divided into non-severe LBP (grades 0 and 1) and severe LBP (grades 2 and 3) based on four grades devised by Von Korff *et al*[8]. Manual handling status and working posture allowed multiple answers.

Data were collected through a web-based questionnaire administered to workers registered with multiple monitor research companies via an internet research company. The data collection period was from early January 2022 to late January 2022. For each industry, data collection ended sequentially when the number of participants reached 7,500. This study was approved by the ethics board of the National Institute of Occupational Safety and Health of Japan (registration ID: 2021N29). All participants provided informed consent before answering the questionnaire.

Workers who chose to lift, lower, carry, roll, and others were excluded from the analysis. This exclusion criterion remained applicable even when both push–pull and other actions were involved. Since the maximum load of commercially available carts typically does not exceed 500 kg and their dead weight remains below 100 kg, the workers who handled loads weighing more than 600 kg were excluded from the analysis. In addition, workers who did not record the weight of the load they were pushing and pulling were also excluded from the analysis. The Mann–Whitney U-test and the Chi-squared (χ^2) test were used to compare proper and improper working posture groups. Multiple logistic regression with the forced entry method, in which all parameters were forced into the model, was used to examine the association between LBP and load weights for each working posture group. The dependent variable was LBP, the independent variable was load weights of pushing and pulling, and adjusted variables of the model were sex, age, body height and weight, smoking status, industry, and job stressors. Three items about job stressors were treated as continuous variables. All statistical analyses were conducted using IBM SPSS version 27, and $p<0.05$ was considered significant for all tests.

Completed questionnaires were collected from 15,623 workers. Workers with proper working posture were 9,881, including 9,667 with no handling and 214 with pushing and pulling. Workers with improper working posture were 5,742, including 5,368 with no handling and 374 with pushing and pulling.

There were no differences in sex, body height and weight, body mass index, or worksite social support between the proper and improper working posture groups (Table 1). Compared to the proper working posture group, the improper working posture group contained slightly younger workers who smoked, worked over 45 h per week, felt their work was too demanding, had lesser job satisfaction, and pushed and pulled heavier loads. Approximately 40% of the improper working posture involved

Table 1. Basic and job characteristics, job stressors, manual handling status, load weight, and working posture of workers

(% or mean ± SD)	Total (N=15,623)	Proper working posture (n=9,881)	Improper working posture (n=5,742)	*p*-value
Sex				0.093
Male	64.3	64.8	63.5	
Female	35.7	35.2	36.5	
Age (yr)	47.4 ± 12.8	48.7 ± 12.3	45.1 ± 13.3	<0.001
Body height (cm)	166.3 ± 8.5	166.3 ± 8.4	166.2 ± 8.8	0.558
Body weight (kg)	63.3 ± 13.4	63.4 ± 13.3	63.3 ± 13.7	0.174
Body Mass Index	22.8 ± 3.9	22.8 ± 3.7	22.8 ± 4.1	0.189
Smoking status				<0.001
No smoking	55.9	57.1	53.9	
Smoked in the past	19.0	19.8	17.6	
Smoking	25.1	23.1	28.5	
Industry				<0.001
Manufacturing	26.8	27.5	25.7	
Wholesale and retail trade	24.3	23.9	25.0	
Construction	27.9	29.3	25.5	
Transportation and postal activities	21.0	19.4	23.8	
Total weekly working hours				<0.001
<35 h	19.6	19.5	19.9	
≥35 h, <40 h	24.3	24.3	24.2	
≥40 h, <45 h	28.8	29.9	27.1	
≥45 h, <50 h	13.2	12.7	13.9	
≥50 h	14.1	13.6	14.9	
Job stressors				
Job demand	7.2 ± 2.4	6.9 ± 2.4	7.8 ± 2.3	<0.001
Job control	6.9 ± 2.3	6.8 ± 2.3	7.1 ± 2.2	<0.001
Worksite social support	15.3 ± 4.3	15.3 ± 4.3	15.4 ± 4.2	0.198
Pushing and pulling load weights				<0.001
No handling	96.2	97.8	93.5	
≥1 kg, <30 kg	2.2	1.5	3.3	
≥30 kg, <60 kg	0.9	0.3	1.9	
≥60 kg	0.7	0.3	1.3	
Working posture during work				<0.001
Proper posture	63.2	100	0	
Forward-bending position	15.0	0	40.8	
A half-crouching position	4.6	0	12.6	
Twisting posture	6.3	0	17.1	
Unstable posture	2.9	0	7.9	
Other postures	1.5	0	4.1	
Multiple above improper postures	6.4	0	17.4	

the forward-bending position. In the improper working posture group, more workers pushed and pulled loads for 2 h or more per day, at least five times per day, and for a distance of 5 m or more each time than in the proper working posture group (Table 2).

In the proper and improper working posture groups, 16.5% (no handling: 16.5% and pushing–pulling: 17.8%) and 34.3% (no handling: 33.0% and pushing–pulling: 51.6%) of workers had severe LBP, respectively. The prevalence of severe LBP was greater in the improper working posture group than in the proper working posture group (p<0.001). In the proper working posture group, there was no significant difference in LBP prevalence between those who did not engage in handling and those who pushed or

Table 2. Pushing and pulling characteristics of workers

(%)	Total (N=588)	Proper working posture (n=214)	Improper working posture (n=374)	*p*-value
Hours spent in pushing and pulling per day				<0.001
<1 h	16.8	28.0	10.4	
≥1 h, <2 h	22.3	29.0	18.4	
≥2 h, <3 h	12.1	9.8	13.4	
≥3 h, <4 h	11.2	8.4	12.8	
≥4 h	19.6	10.7	24.6	
Number of times pushing-pulling performed per day				<0.001
<3 times	39.1	51.4	32.1	
≥3 times, <5 times	11.6	12.1	11.2	
≥5 times, <10 times	15.0	11.7	16.8	
≥10 times, <30 times	10.2	5.6	12.8	
≥30 times	6.1	5.1	6.7	
Average pushing-pulling distance each time				<0.001
<1 m	24.7	39.7	16.0	
≥1 m, < 5m	27.0	28.0	26.5	
≥5 m, <10 m	17.3	7.5	23.0	
≥10 m, <20 m	7.7	6.1	8.6	
≥20 m	5.3	4.7	5.6	

Table 3. Association of severe low back pain with pushing and pulling load weights and proper and improper working postures using multiple logistic regression analyses

	Proper working posture (n=9,881)			Improper working posture (n=5,742)		
	OR	95%CI	*p*-value	OR	95%CI	*p*-value
Load weights of pushing and pulling						
No handling	1.00	(Reference)		1.00	(Reference)	
≥1 kg, <30 kg	1.43	0.95–2.16	0.087	1.89	1.40–2.55	<0.001
≥30 kg, <60 kg	0.89	0.33–2.39	0.816	2.17	1.47–3.19	<0.001
≥60 kg	0.30	0.07–1.30	0.107	2.33	1.46–3.72	<0.001

Adjusted variables are sex, age, body height and weight, smoking status, industry, job demand and control, and worksite social support.

pulled loads (Table 3). In contrast, in the improper working posture group, the odds ratios (OR) of severe LBP among workers pushing and pulling load weights were significantly greater than those of no handling workers and increased with each additional weight category (OR of 1–30 kg: 1.89, OR of 30–60 kg: 2.17, OR of ≥60 kg: 2.33).

The aim of this study was to examine how occupational pushing and pulling, coupled with improper working postures, affect the occurrence of LBP among workers. The results showed no association between pushing–pulling with proper working posture and LBP. Previous studies have yielded mixed results on the association between pushing–pulling and LBP[3]. However, many negative results have been reported since 2000[9–11]. These findings may be due to the fact that although pushing and pulling can increase compressive and shear forces on the lumbar intervertebral disc[1, 2], they are not strong enough to cause LBP. Maintaining an upright posture while pushing or pulling is unlikely to exert strain on the lower back.

In contrast, this study revealed that pushing and pulling with improper working posture were associated with LBP. While improper working postures can increase compressive and shear forces on the lumbar intervertebral disc[5], they are unlikely to be the sole causes of LBP[4]. Also, only pushing–pulling is unlikely to lead to the development of LBP[9–11]. Nevertheless, our findings suggest that the concurrent effect of pushing and pulling[1, 2] with improper working posture[5] may heighten the risk of developing LBP. Addition of pushing and pulling to the strain caused by improper working posture may excessively burden the

lumbar region and lead to the onset of LBP.

Moreover, the association between pushing–pulling and LBP was found to be stronger when heavier weights were involved. Prior research indicates that heavier loads during pushing and pulling tasks elevate compressive and shear forces on the lumbar intervertebral disc, thereby increasing the likelihood of LBP[2, 12–14]. The addition of weight to pushing–pulling tasks and improper working posture further burden the lumbar region. Therefore, pushing and pulling heavy loads with improper working posture will likely result in LBP.

This study has several limitations that should be considered. First, the web-based questionnaire used in this study was completed solely by workers registered with monitor research companies. Hence, sampling bias may have affected the results. However, a sample size of 30,000 respondents, corresponding to approximately 0.1% of the target population[6], was used to reduce bias. Second, friction coefficients with the floor and the handle height of the cart were not examined. Although these factors could have influenced the findings, the work environment in Japan is typically well-maintained and the carts used are usually standardized. Third, this study focused exclusively on investigating pushing and pulling actions and excluded the task of lifting loads onto a cart and lowering them at a designated area—a common occurrence within workplace settings. Examples of work involving only pushing and pulling are as follows: pushing a cart loaded with items using an electric lift, loading a roll box pallet containing luggage onto a truck, and horizontally transferring equipment from a conveyor belt to the worker's hand for assembly purposes. Consequently, the outcomes obtained in this study can be attributed to the exclusive pushing and pulling effect. Finally, recall bias may have affected the results, as past work and physical conditions were reported retrospectively. Therefore, further research is necessary to address these limitations.

In conclusion, pushing and pulling while assuming an improper working posture can be associated with LBP. Furthermore, the association is stronger when heavier loads are involved. Therefore, to prevent LBP among workers pushing and pulling heavy loads, it is necessary to maintain a straight-back posture and reduce the weight of the loads carried.

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