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Work-related factors of low back pain among Indonesian manufacturing workers in Taiwan

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Abstract

Background: The manufacturing industry, one of the largest employers of migrant workers in Taiwan, reports a high incidence of musculoskeletal disorders, particularly low back pain (LBP), among its workforce overall. Understanding the prevalence and risk factors of LBP among Indonesian migrant workers, who make up a substantial portion of this workforce, is essential for developing effective preventive programs.

Methods: This cross-sectional study surveyed Indonesian migrant workers in the manufacturing sector. The Indonesian version of the Oswestry Disability Index was used to assess LBP prevalence and disability levels. The chi-square test was used to evaluate the association between work-related factors and LBP outcomes. Multivariable logistic regression was used to identify the independent factors associated with LBP, adjusted for other variables.

Results: According to the LBP disability index, 63.14% of the participants had minimal disability, 29.80% had moderate disability, and 7.05% had severe disability. Mild trunk flexion was associated with a lower risk of LBP disability compared with neutral trunk flexion (odds ratio [OR] [95% CI]: 0.11 [0.03-0.31], p = 0.01). Among women, lifting <25 kg was associated with a lower risk of severe LBP compared with lifting more than 25 kg (OR [95% CI]: 0.01 [0.01-0.61], p = 0.03). In men, whole-body vibration was associated with a lower risk of severe LBP compared with no vibration exposure (OR [95% CI]: 0.41 [0.19-0.88], p = 0.02).

Conclusion: Trunk flexion, lifting, and whole-body vibration consistently emerged as significant determinants of LBP disability. More detailed assessments of these factors are necessary to clarify their associations.

Keywords: Low back pain; Migrant workers; Taiwan

1. INTRODUCTION

Low back pain (LBP) refers to pain experienced in the lower back, specifically between the lower margin of the twelfth ribs and the lower gluteal folds.[1] LBP is a widespread global issue: in 2017, approximately 7.5% of the world's population, nearly 557 million people, was affected by LBP.[2] The Global Burden of Disease study reported an increasing worldwide disability burden associated with LBP since 1990. This trend was evident across all age groups from 1990 to 2019, peaking in the 50 to 54 age group in 2019.[3]

Numerous factors are consistently associated with chronic LBP, encompassing individual, lifestyle, and work-related factors. Biological factors such as age,[4] height, body mass index (BMI),[5] and sex[6] significantly influence LBP. Psychological and psychosocial factors also play critical roles in LBP.[7] Lifestyle factors such as smoking and excess body mass are also risk factors for chronic LBP.[8] Leisure-time physical activity shows a *U*-shaped relationship with LBP, where engaging in physical activity more than three times per week increases the risk of LBP.[9]

Work-related factors constitute another significant domain influencing LBP. It is estimated that one-third of LBP cases may be attributable to occupational or ergonomic factors.[10] Mechanical, postural, traumatic, and psychological variables are closely linked to occupational LBP.[11] The prevalence of LBP is particularly high in the manufacturing sector, where workers are exposed to significant ergonomic risks. Previous studies have reported a 1-year LBP prevalence ranging from 40% to 61.6% in the manufacturing sector.[12,13] Identified risk factors include prolonged sitting or static posture, repetitive work, awkward back posture, hand force, physical effort, whole-body vibration, frequent bending and twisting, and manual handling (lifting, lowering, pushing, pulling, and carrying).[14]

The manufacturing sector in Taiwan employs a substantial number of migrant workers. As of April 2022, the Taiwan Ministry of Labor reported 420 446 migrant workers in the manufacturing industry, with the largest populations originating from Vietnam (195 706), the Philippines (112 743), and Indonesia (58 857).[15]

Migrant workers are a vulnerable group, with high prevalences of LBP reported in various countries. In Malaysia, 60% of Filipino migrant workers in manufacturing settings reported LBP.[16] Similarly, Myanmar migrant workers in Thailand's food

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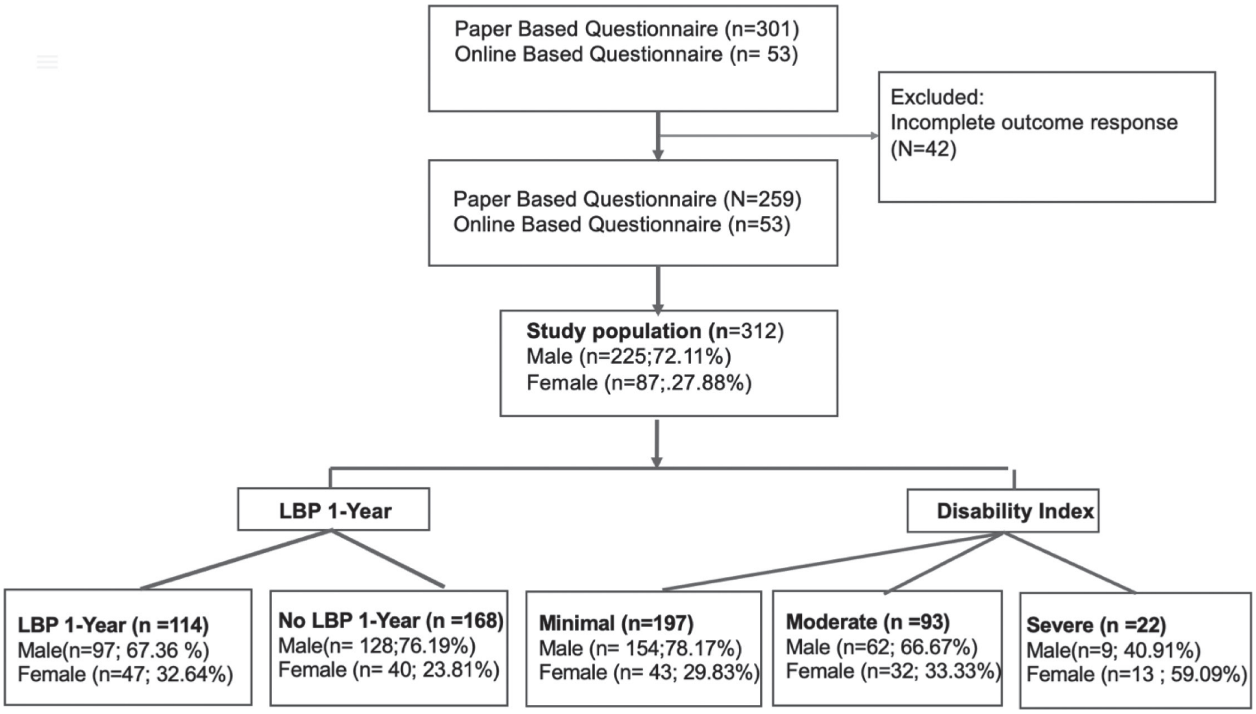

Fig. 1 Study population flowchart. LBP = low back pain.

processing industry had a prevalence of LBP of 28.5%.[16] In Argentina, migrant workers reported a higher prevalence of LBP compared with local workers (80% vs 42%).[17] Placement in high-risk workplaces and insufficient training have been identified as key contributors to the LBP burden among migrant workers.[17]

Taiwan has a large population of migrant workers, especially in the manufacturing sector. However, no prior study has analyzed the prevalence and risk factors of LBP among migrant workers in Taiwan. It is essential to do so, and this study seeks to fill this research gap.

2. METHODS

2.1. Study area and design

This study utilized a cross-sectional design. Self-administered Oswestry Disability Index (ODI) questionnaires, available in both online and paper formats, were distributed to the recruited industrial workers. The ODI questionnaire has been validated for the Indonesian-speaking population.[18] The participants completed the questionnaire under the supervision of the researcher after providing consent.

2.2. Subject population

The study focused on blue-collar workers (production workers) in the manufacturing sector. Convenience sampling was conducted, with specific inclusion and exclusion criteria used to select the study sample. Job criteria information was provided at the beginning of the questionnaire to help the participants determine their eligibility based on workplace and workload definitions. This information included descriptions of occupational groups with similar work conditions, such as mucking/loading, supervisory, and engineering roles, which are directly related to production and involve prolonged standing, twisting, turning, and handling heavy loads.

The physical load was assessed through detailed random interviews with the participants about their working conditions and postures. Additionally, figures illustrating various working postures were included in the questionnaire to help the workers accurately evaluate their working positions.

2.3. Eligibility criteria and sample size

We recruited Indonesian-speaking workers aged 20 to 65 years who were willing and able to provide informed consent. Workers with a history of occupational or nonoccupational accidents affecting the lower back or musculoskeletal diseases were excluded from the study, as were pregnant workers. The sample size was estimated using a 95% CI, an acceptable error margin of 5%, and an expected LBP prevalence of 28.3%, based on a similar study.[12] The minimum required sample size was 310, which was increased by 10% to account for missing data, resulting in a final sample size requirement of at least 340 participants.

2.4. Questionnaire and data collection procedure

The questionnaire was distributed from March 2022 to July 2022. The participants completed either an online-based questionnaire (OBQ) or a paper-based questionnaire (PBQ), which contained three assessment sections. The content was identical in both formats, and the PBQ was provided to participants who were unfamiliar with online surveys. The complete flowchart of the data collection is depicted in Fig. 1. Because of the COVID-19 pandemic, the researchers were unable to accompany the participants while they filled out the questionnaire. The researchers therefore selected a representative from the workers who had access to the company and trained this person to guide the questionnaire completion process. The researchers also provided a phone number for direct guidance. The Indonesian Migrant Workers Association and the Global Workers Organization played a crucial role in distributing the

OBQ by sharing it through their platforms, allowing for broader reach of the target population.

The questionnaire was designed to automatically apply the inclusion and exclusion criteria at the outset for the OBQ. For the PBQ, however, this automated process was not possible. Instead, the representative overseeing the PBQ process was trained to manually check the inclusion and exclusion criteria before distributing the PBQ to the participants. This ensured that the participants' eligibility was confirmed before they received the PBQ. Participants who did not meet the eligibility criteria were not able to proceed with the OBQ, and only eligible participants could complete the assessment in both formats. This approach ensured consistency in eligibility across both formats.

The first section collected information on sociodemographic and lifestyle factors, including sex, age, weight, height, educational level, smoking habits, and physical activity. Variables were categorized for clarity based on the literature. Age was grouped into 10-year intervals because muscle mass decreases by approximately 3% to 8% per decade.[19] Weight and height were used to calculate BMI, which was then categorized according to the World Health Organization criteria for the Asia-Pacific population.[20,21] The second section addressed work-related factors, including length of employment (years), working hours, trunk flexion, lifting loads, pushing or pulling, exposure to whole-body vibration, and static work postures. The third section assessed the degree of LBP disability using the Indonesian version of the ODI questionnaire.

2.4.1. ODI scoring and interpretation

The ODI contained 10 questions covering pain intensity, self-care, lifting, walking, sitting, standing, sleeping, social life, traveling, and occupation or household activities. Each question offered six possible responses, scored from 0 to 5 points (0 for the first answer, 1 for the second, and so on). The total score for the 10 questions was summed, resulting in a range of 0 to 50. The scores were then converted to percentages and used to categorize LBP disability as follows: 0% to 20% (0-10 points) indicated minimal disability, 21% to 40% (11-20 points) moderate disability, 41% to 60% (21-30 points) severe disability, and 61% to 80% (31-40 points) crippled, and 81% to 100% (41-50 points) indicated complete disability.[18] There were no participants with scores in the 81% to 100% (41-50 points) range in our dataset. To address the issue of a small sample size in the severe disability group, we modified the categories from trichotomous to dichotomous in the regression model (Table 1).

2.5. Statistical analysis

Data were analyzed using SAS version 9.4 (SAS Institute, Cary, NC) via three different analyses, with all of the variables treated as categorical data. Descriptive statistics and prevalence for LBP were estimated using chi-square analysis for all of the categorical variables. The association between individual, lifestyle, and work-related factors and the primary outcome (LBP disability) was assessed using the chi-square test. To screen more variables as potential determinants of LBP, a significant association was defined as a two-tailed p value <0.05. Variables with a two-tailed p value <0.25 in the bivariate model were filtered for analysis in the multivariable model, and this threshold was used to capture variables that might be nonsignificant individually but significant in a multivariable setup, thus avoiding the pitfalls of solely relying on a two-tailed p value <0.05.[22] The stepwise method was used to obtain a stable set of variables. Odds ratio estimation and a 95% CI were included to illustrate the magnitude of associations. The final determination of significant associations was based on a two-tailed p value of 0.05 and a nonoverlapping 95% CI.

2.6. Ethical issues

This study was approved by the Institutional Review Board, National Yang-Ming Chiao Tung University (YM110176EF). The completed informed consent form was obtained from participants before they filled out the survey and was stored on the computer of the primary investigator with a protected password.

3. RESULTS

3.1. Prevalence of LBP

We recruited 312 participants from various counties and cities in Taiwan across different manufacturing settings. Taoyuan had the highest participant proportion (44.23%), followed by Taichung (26.28%), Yunlin (17.95%), New Taipei City (5.13%), Changhua (1.92%), Hsinchu (1.28%), Taipei City (0.96%), Nantou (0.96%), Tainan (0.64%), and Miaoli (0.64%). Among the participants, 53 (16.98%) completed the OBQ and 259 (83.01%) completed the PBQ. In terms of LBP, 63.14% were categorized as having minimal disability, 29.8% as having moderate disability, and 7.05% as having severe disability.

3.2. Respondent characteristics

We present the characteristics of the respondents along with the trichotomous and dichotomous outcomes for LBP disability in Table 1. Most participants fell into the young age group (20-29), which also had the highest proportion of respondents with severe LBP compared to older age groups. Men showed a higher percentage of severe LBP than women in both outcome categories. Individuals with a normal BMI had a higher proportion of severe LBP than those with either above-normal or below-normal BMI. Participants with a senior high school education had a higher percentage of severe LBP compared to those with other educational levels. Those who never exercised had a higher percentage of severe LBP than those who exercised. Nonsmokers had a higher percentage of severe LBP than smokers.

In terms of work-related factors, workers with <5 years of service tended to have a higher percentage of severe LBP compared to those with 5 or more years of service. Participants working 8 hours daily had a higher proportion of moderate to severe LBP disability compared to those working more than 8 hours daily. Participants who performed pulling and pushing movements more than once per hour had the highest distribution of severe LBP than those who never had or performed such movements less frequently. Lifting ≤25 kg was associated with a higher prevalence of severe LBP compared to lifting more than 25 kg. Non-exposure to whole-body vibration was more common among those with severe LBP compared to those exposed to whole-body vibration. Participants with dynamic work postures showed a higher percentage of severe outcomes than those with static work postures (Table 1).

3.3. LBP disability risk factors

A multivariable logistic regression of significant work-related factors with a dichotomous LBP disability index was performed to understand the magnitude of each factor (Table 2). Variables included in the final model were years of service, working hours, trunk flexion, lifting, and whole-body vibration. In the crude model, only working hours, trunk flexion, and whole-body vibration significantly affected the LBP disability index. Working for more than 8 hours showed a significantly lower risk factor for LBP disability. Having a mild trunk flexion position was associated with a lower risk of severe disability.

Table 1

Characteristics of participants

	LBP disability							LBP disability				
	Minimal		Moderate		Severe		p	Minimal		Moderate to severe		p
	n (197)	%	n (93)	%	n (22)	%		n (197)	%	n (115)	%	
Demographic												
Age												
20-29	111	56.35	63	67.74	13	59.09	0.03[a]	111	56.35	76	66.09	0.01[a]
30-39	67	34.01	29	31.18	9	40.91		67	34.01	38	33.04	
40-49	19	9.64	1	1.08	0	0.00		19	9.64	1	0.87	
Sex												
Female	43	21.83	31	33.33	13	59.09	0.01[a]	43	21.83	44	38.26	0.01[a]
Male	154	78.17	62	66.67	9	40.91		154	78.17	71	61.74	
BMI												
Underweight	7	3.55	8	8.60	2	9.09	0.09[a]	7	3.55	10	8.70	0.06[a]
Normal	148	75.13	74	79.57	18	81.82		148	75.13	92	80.00	
Overweight	42	21.32	11	11.83	2	9.09		42	21.32	13	11.30	
Education												
None	3	1.52	0	0.00	0	0.00	0.35	3	1.52	0	0.00	0.07[a]
Elementary	9	4.57	3	3.23	0	0.00		9	4.57	3	2.61	
Junior	36	18.27	9	9.68	3	13.64		36	18.27	12	10.43	
Senior	104	52.79	62	66.67	15	68.18		104	52.79	77	66.96	
Associate or bachelor	45	22.84	19	20.43	4	18.18		45	22.84	23	20.00	
Physical activity												
Everyday	43	21.83	30	32.26	7	31.82	0.04[a]	43	21.83	37	32.17	0.03[a]
2-3 d/wk	82	41.62	30	32.26	3	13.64		82	41.62	33	28.70	
Never	72	36.55	33	35.48	12	54.55		72	36.55	45	39.13	
Smoking												
Yes	80	40.61	58	62.37	14	63.64	0.01[a]	80	40.61	72	62.61	0.01[a]
No	117	59.39	35	37.63	8	36.36		117	59.39	43	37.39	
Years of service												
≤5 y	139	70.56	70	75.27	20	90.91	0.1[a]	139	70.56	90	78.26	0.12[a]
>5 y	58	29.44	23	24.73	2	9.09		58	29.44	25	21.74	
Working hours												
8 h	148	75.13	51	54.84	11	50.00	0.01[a]	148	75.13	62	53.91	0.01[a]
>8 h	49	24.87	42	45.16	11	50.00		49	24.87	53	46.09	
Trunk flextion												
Neutral	92	46.70	24	25.81	5	22.73	0.01[a]	95	48.22	30	26.09	0.01[a]
Mild	86	43.65	29	31.18	9	40.91		83	42.13	40	34.78	
Extreme	8	4.06	25	26.88	6	27.27		9	4.57	28	24.35	
Very extreme	10	5.08	15	16.13	2	9.09		10	5.08	17	14.78	
Pull and push												
Never	51	25.89	21	22.58	1	4.55	0.01[a]	47	23.86	23	20.00	0.60
≤1 time per hour	80	40.61	37	39.78	6	27.27		81	41.12	46	40.00	
>1 time per hour	66	33.50	35	37.63	15	68.18		69	35.03	46	40.00	
Lifting												
None	62	31.47	16	17.20	2	9.09	0.01[a]	57	28.93	19	16.52	0.03[a]
≤25 kg	118	59.90	52	55.91	14	63.64		119	60.41	65	56.52	
>25 kg	17	8.63	25	26.88	6	27.27		21	10.66	31	26.96	
Whole body vibration												
Yes	37	18.78	42	45.16	8	36.36	0.01	38	19.29	50	43.48	0.01[a]
No	160	81.22	51	54.84	14	63.64		159	80.71	65	56.52	
Work posture												
Static	74	37.56	33	35.48	8	36.36	0.94	73	37.06	41	35.65	0.80
Dynamic	123	62.44	60	64.52	14	63.64		124	62.94	74	64.35	

LBP = low back pain.

[a] Indicates the significance when p value is <0.05.

An adjusted model including significant confounders such as age, sex, BMI status, education, physical activity, and smoking status was also analyzed. Only working hours and trunk flexion were significantly correlated with the LBP disability index. Working more than 8 hours and having a mild trunk flexion position were associated with a lower risk of severe disability.

3.4. LBP disability index risk factors based on sex

3.4.1. Men

Among men, years of service, trunk flexion, lifting, and whole-body vibration significantly affected the LBP disability index. Working for more than 5 years was associated with a lower risk of severe disability. Mild trunk flexion negatively affected

Table 2

Multivariable logistic regression for LBP disability index factors

	Crude			Adjusted	
	n (312)	OR (95% CI)	p	OR (95% CI)	p
Years of service					
≤5 y (ref)					
>5 y		1.35 (0.72-2.50)	0.34	1.11 (0.56-2.22)	0.74
Working hours					
8 h (ref)	210				
>8 h	102	0.49 (0.29-0.85)	0.01[a]	0.43 (0.23-0.81)	0.01[a]
Trunk flexion					
Neutral (ref)	125				
Mild	123	0.76 (0.41-1.39)	0.01	0.11 (0.03-0.31)	0.357
Extreme	37	0.14 (0.05-0.37)	0.01[a]	0.71 (0.34-1.45)	0.01[a]
Very extreme	27	0.32 (0.12-0.83)	0.36	0.22 (0.07-0.67)	0.19
Lifting					
None (ref)	76				
≤25 kg	184	0.50 (0.21-1.18)	0.73	0.72 (0.31-1.70)	0.60
>25 kg	52	1.014 (0.52-1.97)	0.08	0.33 (0.13-1.07)	0.06
Whole body vibration					
Yes (ref)	88				
No	224	2.03 (1.15-3.59)	0.01[a]	1.82 (0.97-3.42)	0.06

Adjusted for age, sex, BMI, education, physical activity, and smoking years of service, working hours, trunk flexion, lifting and whole-body vibration.
BMI = body mass index; LBP = low back pain; OR = odds ratio.
[a] Indicates the significance when p value is <0.05.

the LBP disability index, while extreme trunk flexion and lifting more than 25 kg were risk factors for severe disability. Nonexposure to whole-body vibration was associated with a lower risk of severe LBP disability even after adjustment for confounders (Table 3).

3.4.2. Women

For women, trunk flexion and lifting were significantly associated with the LBP disability index. Mild trunk flexion was associated with a lower risk of severe LBP, while extreme trunk flexion was strongly correlated with severe LBP. Lifting <25 kg was associated with a lower risk of severe LBP among women even after adjustment for confounders (Table 4).

3.5. Lifestyle characteristics and LBP disability, stratified by working hours

To evaluate potential bias related to the healthy worker effect (a phenomenon where healthier individuals are more likely

Table 3

Multivariable logistic regression for LBP disability index factors for male

	Crude			Adjusted	
	n (225)	OR (95% CI)	p	OR (95% CI)	p
Years of service					
≤5 y (ref)	164				
>5 y	61	0.32 (0.14-0.71)	0.01[a]	0.35 (0.14-0.87)	0.02[a]
Working hours					
8 h (ref)	160				
>8 h	65	1.10 (0.54-2.23)	0.78	1.30 (0.60-2.80)	0.50
Trunk flexion					
Neutral (ref)	83				
Mild	101	0.33 (0.15-0.72)	0.01[a]	0.43 (0.18-1.01)	0.01
Extreme	21	3.35 (0.86-13.04)	0.05	3.27 (0.78-13.60)	0.07
Very extreme	20	2.66 (0.69-10.63)	0.14	2.02 (0.47-8.59)	0.39
Lifting					
None (ref)	44				
≤25 kg	140	1.80 (0.71-4.52)	0.70	1.90 (0.72-4.99)	0.78
>25 kg	41	4.25 (1.34-13.43)	0.01[a]	4.47 (1.32-15.14)	0.01[a]
Whole body vibration					
Yes (ref)	65				
No	160	0.36 (0.17-0.75)	0.01[a]	0.41 (0.19-0.88)	0.02[a]

Adjusted for age, BMI, education, physical activity, and smoking.
BMI = body mass index; LBP = low back pain; OR = odds ratio.
[a] Indicates the significance when p value is <0.05.

Table 4

Multivariable logistic regression for LBP disability index factors for female

	Crude			Adjusted	
	n (87)	OR (95% CI)	*p*	OR (95% CI)	*p*
Years of service					
≤5 y (ref)	65				
>5 y	22	1.45 (0.37-5.73)	0.58	1.14 (0.25-5.25)	0.85
Working hours					
8 h (ref)	50				
>8 h	37	0.37 (0.10-1.33)	0.12	0.18 (0.02-1.25)	0.08
Trunk flexion					
Neutral (ref)	42				
Mild	22	0.19 (0.04-0.84)	0.01[a]	0.23 (0.03-1.53)	0.28
Extreme	16	0.45 (0.08-2.44)	0.40	0.27 (0.01-5.14)	0.41
Very extreme	7	6.04 (6.46-78.44)	0.04[a]	3.40 (0.06-179.66)	0.28
Lifting					
None (ref)	32				
≤25 kg	44	0.05 (0.01-1.08)	0.04[a]	0.01 (0.01-0.61)	0.03[a]
>25 kg	11	0.88 (0.21-3.65)	0.86	0.52 (0.07-3.68)	0.52
Whole body vibration					
Yes (ref)	23				
No	64	2.81 (0.68-11.64)	0.15	1.51 (0.18-12.49)	0.69

Adjusted for age, BMI, education, physical activity, and smoking.
BMI = body mass index; LBP = low back pain; OR = odds ratio.
[a] Indicates the significance when *p* value is <0.05.

Table 5

Lifestyle characteristics and LBP disability, stratified by working hours

	LBP disability									
	8 h					>8 h				
	Minimal		Moderate to severe		*p*	Minimal		Moderate to severe		*p*
	n (186)	%	n (24)	%		n (77)	%	n (25)	%	
Physical activity										
Everyday	41	22.04	6	25.00	0.80	21	27.27	12	48	0.04
2-3 d/wk	67	36.02	7	29.17		38	49.35	3	12	
Never	78	41.94	11	45.83		18	23.38	10	40	
Smoking										
Yes	87	46.77	14	58.33	0.28	35	45.45	16	64	0.11
No	99	53.23	10	41.67		41	53.25	9	36	

LBP = low back pain.

to remain employed, while those with poorer health are less likely to be working),[19] we conducted a stratified analysis based on the workers' daily working hours (<8 hours and >8 hours) and their physical activity levels (Table 5). Our analysis revealed that workers with <8 daily working hours had a lower frequency of healthy physical exercise (2-3 times per week) than those working more than 8 hours per day. Given the significant inverse association between physical activity and LBP disability shown in Table 1, this finding suggests that workers who worked more than 8 hours per day were less likely to experience LBP, possibly because of their healthier exercise habits.

4. DISCUSSION

In our analysis, we explored the association between work-related factors and LBP disability, uncovering a diverse range of effect sizes for different determinants. Notably, we found that workers who logged more than 8 hours a day had lower odds of experiencing LBP than those with shorter work hours. This finding diverges from the literature, which typically suggests that longer hours correlate with higher LBP disability.[23–25] Intriguingly, we observed that workers with longer daily shifts tended to engage in higher levels of physical activity, potentially contributing to their reduced likelihood of LBP. Previous studies have also suggested relatively similar health conditions among migrant workers, likely due to stringent routine medical checkups, which could mitigate the healthy worker effect.[16]

Regarding trunk flexion, we observed that mild flexion had a lesser impact on severe LBP disability than the neutral position. Additionally, dynamic mild trunk flexion, as opposed to static neutral trunk flexion, seemed to offer benefits in terms of increased activity of the multifidus, a lumbar spine stabilizer.[26]

Among men, lifting more than 25 kg emerged as a significant risk factor for severe LBP disability. This aligns with recommendations from the National Institute of Occupational Safety and Health, which suggests limiting workplace lifting to loads under 25 kg.[27] Among women, lifting loads <25 kg appeared to have a protective effect against severe LBP. This underscores the importance of adhering to safe lifting practices with appropriate weights and posture to prevent chronic LBP.[28,29]

We also observed that workers exposed to whole-body vibration tended to have a lower likelihood of developing advanced LBP disability, with the frequency and dose of whole-body vibration being significant factors. Because we did not assess the frequencies of vibration of the participants, further evaluation is required to evaluate this result.

This study underscores the significance of subject homogeneity within the blue-collar workforce, which bolsters the generalizability of our findings. To the best of our knowledge, this study is the first comprehensive exploration of the various risk factors associated with LBP within a manufacturing context in Taiwan. However, it is essential to acknowledge several limitations inherent in our study. First, the absence of data on psychosocial risk factors and potential information bias resulting from divergent data collection methods (online vs PBQs) may have led to an underestimation of the prevalence or severity of LBP disability risk. This underestimation could have occurred because the online respondents might have been less engaged or provided less detailed answers because of the impersonal nature of the format compared with the paper-based respondents. Upon closer examination, this issue could be more accurately framed as a form of non-differential misclassification. Non-differential misclassification refers to a measurement error that affects all participants equally regardless of their exposure or outcome status, which generally biases the results toward the null hypothesis.[30] Therefore, any underestimation of LBP disability risk would likely stem from such a measurement error rather than a systematic bias between groups.

Furthermore, the cross-sectional nature of our study precludes us from adequately addressing reverse causation. Additionally, the lack of workplace assessments underscores the need for further investigation into job-related activities. Therefore, future research endeavors should delve deeper into psychosocial factors and conduct comprehensive assessments of workplace dynamics to enrich our understanding of the etiology of LBP within manufacturing settings.

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