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ORIGINAL ARTICLE

Smoking is associated with greater pain intensity and pain-related occupational disability in Japanese workers

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Abstract

Purpose Pain symptom, such as that caused by musculoskeletal disorders, is a major cause of occupational disability. As nicotine intake from smoking increases pain sensitivity, smokers may experience stronger pain and be more likely to experience pain-related disability than non-smokers. The study aim was to examine whether smoking was associated with pain-related occupational disability via pain intensity.

Methods Participants were 1189 workers with pain aged 20–74 years in Japan. Participants completed a self-report questionnaire, which included a question to measure pain-related occupational disability with ordinal-option: (1) without pain-related disability, (2) pain-related presenteeism, and (3) pain-related absenteeism. An ordinal logistic regression model was used to calculate multivariable-adjusted proportional odds ratios (OR) with 95% confidence intervals (CI) for the prevalence of pain-related occupational disability according to smoking status. A multiple mediation analysis was also conducted to assess whether pain sensitivity mediated the association between smoking and pain-related occupational disability. Adjusted variables were demographic variables, socioeconomic status, work-related psychosocial factors, general psychological factors, and pain duration.

Results Current smoking and pain were associated with pain-related occupational disability compared with non-smoking and pain (multivariable OR 1.78; 95% CI 1.26–2.52). Greater pain intensity partially mediated the association of current smoking and pain with pain-related occupational disability. The mediation rate (indirect/total effect) was 25%.

Conclusion Smoking and pain were associated with pain-related occupational disability, partially through greater pain intensity, among Japanese workers.

Keywords Smoking · Disability studies · Occupational medicine · Pain · Pain measurement

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Introduction

Pain symptom, such as that caused by musculoskeletal disorders, is a major cause of occupational disability [1]. Pain symptom often induce absenteeism and presenteeism [2]. Absenteeism is equivalent to sickness absence. Although there is no consensus definition of presenteeism, it is generally defined as reduced job performance owing to health issues and is associated with work disability [3]. Pain symptom is also associated with economic burden. In North America, the total cost associated with work-related musculoskeletal pain is over 25 billion USD per year, and in Japan the total annual medical cost associated with work-related low back pain is 746.7 million USD (1 Japanese yen = 110 USD). [4].

Pain severity is an important determinant of physical disability [5–7]. As the nicotine in tobacco increases pain sensitivity [8], smokers may experience stronger pain than non-smokers; [9, 10] thus, current smokers may be more likely to experience pain-related occupational disability than non-smokers.

The aim of this study was to examine whether smoking was associated with pain-related occupational disability via pain intensity.

Methods

Study population

We used data from the 2015 Quality of Working Life Influenced by Chronic pain (QWLIC) study, a survey of occupational pain among Japanese workers [11]. The QWLIC study protocol has been described previously [11, 12]. Of 2544 workers aged 20–74 years from three large companies, 1992 completed a self-report questionnaire (response rate 1992/2544 = 78.3%). Companies A and B were manufacturing firms, and company C was a large retail chain store. In companies A and B, survey data were gathered during the annual health check. During the health check, smoking status, drinking, and regular exercise were assessed via interviews in company A and a questionnaire in company B; these data were used in the current study.

Figure 1 shows the enrollment process for the current study. Of 1992 participants, we excluded 18 with missing data for pain and smoking status; of the 1974 participants, we excluded 772 without pain; of the 1202 participants, we also excluded 13 with missing data for pain-related occupational disability. Finally, we analyzed data for 1189 workers with pain.

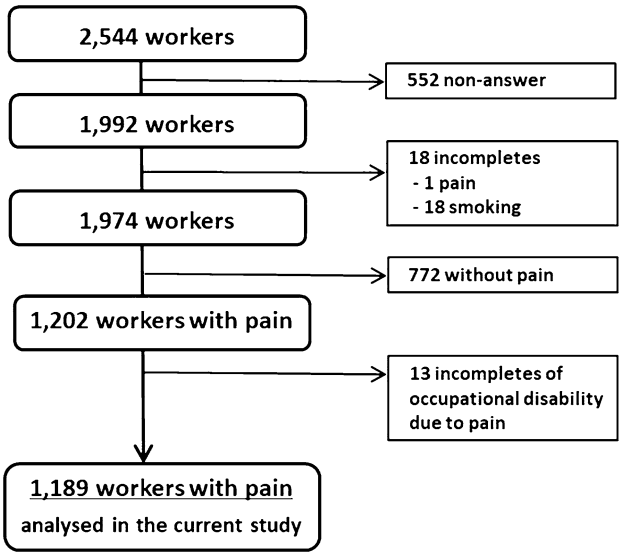

Fig. 1 Participant enrollment process. Participants were recruited in 2015

Main measures

Pain-related occupational disability: outcome variable

A single multiple-choice question was used to measure pain-related occupational disability: "Has your pain influenced your job performance during the last 4 weeks? Please choose the option that best describes your experience: (1) no reduction in job performance despite pain, (2) reduction in job performance due to pain, but no absence from work due to pain, and (3) absence from work due to pain"; (2) is equivalent to presenteeism and (3) is equivalent to absenteeism, and we treated this variable as an ordinal variable.

Smoking status: explanatory variable

In their surveys, companies A and C used three smoking status categories: never smoker, ex-smoker, and current smoker; company B used a binary smoking status category: non-smoker (never smoker and ex-smoker) and current smoker. We categorized smoking status in the current study as non-smoker (never plus ex-smoker) and current smoker.

Pain intensity: mediation variable

A numerical rating scale (NRS) was used to measure current pain intensity between 0 (none) and 10 (worst pain imaginable) [13].

Adjusted confounding variables

Dummy variables were created for missing data during variable adjustment.

Demographic variables

The following demographic variables were assessed: company (A, B, or C); age (20–29, 30–39, 40–49, 50–59, or 60–74 years), sex (women or men); body mass index (quartiles); drinking (non-drinker <23 g/day, ≥ 23 g/day and <46 g/day, and ≥ 46 g/day); regular exercise (≥ 30 min more than twice a week: yes, no); and sleep duration (<5 h/day, ≥ 5 h/day and <6 h/day, ≥ 6 h/day and <7 h/day, ≥ 7 h/day and <8 h/day, ≥ 8 h/day and <9 h/day, or >9 h/day).

Socioeconomic status

Educational status (less than high school, junior college/vocational school/college of technology, university, or graduate school) and employment status (regular employment or irregular employment) were also measured.

Work-related psychosocial factors

The 10-item version of the Dutch Work Addiction Scale (DUWAS) was used to measure workaholic tendency; responses on a 4-point scale (1–4) were summed to yield a total score between 10 and 40 [14]. Tertiles of the total score were used as adjusted variables. The Brief Job Stress Questionnaire was used to assess job demands, job control, two types of work-related social support (supervisor support and coworker support), and job satisfaction [15]. Tertiles of the total score (ranging from 3 to 12) were used to measure job demands, job control, and the two types of work-related social support. Job satisfaction was categorized as dissatisfied, somewhat dissatisfied, relatively satisfied, and satisfied.

General psychological factors

We considered ≥ 13 points on the Kessler Psychological Distress Scale (K6) as indicating mood or anxiety disorder [16].

Pain duration

We defined pain duration as <3 months, ≥ 3 months and <6 months, or ≥ 6 months.

Statistical analysis

We compared means and proportions for all adjusted covariates between non-smokers and current smokers. *T* tests were used to compare groups on continuous variables and Chi square analyses were used to compare groups on categorical variables. p values <0.0025 (0.05/20 consecutive two-tailed tests) were considered statistically significant using Bonferroni's correction.

A proportional odds ordinal logistic regression analysis was used to calculate multivariable-adjusted proportional odds ratios (OR) with 95% confidence intervals (CI) for the prevalence of pain-related occupational disability according to smoking status. For this analysis, the different levels of pain-related occupational disability were assigned the following ordinal rankings: (1) no reduction in job performance despite pain, (2) reduction in job performance due to pain, but no absence from work due to pain, and (3) absence from work due to pain. This approach yields a uniform log cumulative odds ratio of progression across the three categories of pain-related occupational disability, using the group (1) no reduction in job performance despite pain as the reference group. A series of binary logistic regressions are run; first, (1) versus (2) and (3); second, (1) and (2) versus (3). We adjusted for the above potential confounding variables. Model 1 was a crude model and model 2 was adjusted for demographic variables, socioeconomic status, work-related psychosocial factors, general psychological factors, and pain duration. We considered pain intensity as a mediator variable between smoking and pain-related disability in the present study. Mediators are different from cofounders, and mediators should not be adjusted in a multivariate analysis [17]. Therefore, we did not adjust for pain intensity in this analysis.

A multiple mediation analysis was conducted to assess whether pain intensity mediated the association between smoking and pain-related occupational disability. Bias-corrected bootstrap 95% CIs were produced for pain intensity as a potential mediator and were used to test the significance of the total and mediation effects. We adjusted for demographic variables, socioeconomic status, work-related psychosocial factors, general psychological factors, and pain duration.

In the proportional odds ordinal logistic regression analysis and the multivariable mediation analysis, two-tailed p values <0.05 were considered statistically significant. All statistical analyses other than the multiple mediation analysis were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). The multiple mediation analysis was conducted using MATLAB 2016a (MathWorks, Inc., Natick, MA, USA).

Ethical considerations

All procedures were in accordance with the ethical standards of the Helsinki Declaration of 1975, as revised in 2013. The study was approved by the institutional review boards of Osaka University (no. 14441-3) on May 20, 2015, and Keio

University (No. 20140296) on January 26, 2015. Informed consent was obtained from all participants.

Results

Table 1 shows variable means and proportions. The proportion of current smokers was 235/1189 (19.8%). The proportions of current smokers and non-smokers were statistically different across the three companies. Compared with non-smokers, current smokers were more likely to have an alcohol intake of > 46 g/day and a sleep duration of < 5 h and were less likely to exercise regularly. Current smokers experienced higher pain intensity than non-smokers.

Table 2 shows that current smoking and pain were associated with pain-related occupational disability compared with non-smoking and pain, even after adjusting for various demographic variables, socioeconomic states, work-related psychosocial factors, general psychosocial factors, and pain duration (multivariable OR 1.78; 95% CI 1.26–2.52). As for confounding variables, workers with the second quartiles of BMI had lower prevalence of pain-related occupational disability than those with the first quartiles of BMI; workers with ≥ 7 h and < 8 h of sleep duration had lower prevalence of pain-related occupational disability than those with < 9 h/day; and workers with somewhat dissatisfied and dissatisfied with their job had higher prevalence of pain-related occupational disability than those with satisfied with their job.

Greater pain intensity partially mediated the association of current smoking and pain with pain-related occupational disability (Fig. 2 and Table 3). The mediation rate (indirect/total effect) was 25%.

Table 1 Variable mean values and proportions

	Total		Non-smoker		Current smoker	
Participants	1189		954		235	
Company	*n*	%	*n*	%	*n*	%
						$P < 0.001$
A	259	21.8%	240	92.7%	19	7.3%
B	428	36.0%	337	78.7%	91	21.3%
C	502	42.2%	377	75.1%	125	24.9%
		SD		SD		SD
Age, years	44.5	10.4	44.3	10.6	45.4	9.9
	n	%	*n*	%	*n*	%
Women	464	39.0%	378	39.6%	86	36.6%
BMI ≥ 25 kg/m^2	254	21.4%	207	21.7%	47	20.0%
Alcohol intake > 46 g/day	44	3.7%	22	2.3%	22	9.4%†
No regular exercise	303	25.5%	262	27.5%	41	17.4%†
Sleep duration < 5 h/day	181	15.2%	129	13.5%	52	22.1%†
Graduate	576	48.4%	576	60.4%	104	44.3%
Irregular employment	893	75.1%	126	13.2%	38	16.2%
Workaholism	390	32.8%	301	31.6%	89	37.9%
High job demands	370	31.1%	302	31.7%	68	28.9%
Poor job control	474	39.9%	380	39.8%	94	40.0%
Poor support from supervisors	426	35.8%	328	34.4%	98	41.7%
Poor support from coworkers	411	34.6%	325	34.1%	86	36.6%
Dissatisfied with job	97	8.2%	81	8.5%	16	6.8%
Mood or anxiety disorder	122	10.3%	96	10.1%	26	11.1%
Pain duration ≥ 3 months	833	70.1%	666	69.8%	167	71.1%
		SD		SD		SD
NRS	3.9	1.9	3.7	1.9	4.3†	2.0

Non-smoker includes never smokers and ex-smokers

SE standard deviation, *BMI* body mass index, *NRS* numerical rating scale

P values were calculated for the comparison between non-smokers and current smokers. $^{\dagger}P < 0.0025$

Table 2 The association between smoking and pain-related occupational disability

	OR (95% CI)
Number of workers with pain-related occupational disability	319
Model 1	
Smoking	
Non-smoker	1
Current-smoker	1.72 (1.27–2.33)***
Model 2	
Smoking	
Non-smoker	1
Current-smoker	1.78 (1.26–2.52)**
Company	
Company A	1
Company B	1.19 (0.23–6.14)
Company C	1.35 (0.27–6.77)
Age	
20–29	1
30–39	1.48 (0.89–2.45)
40–49	1.11 (0.67–1.82)
50–59	0.73 (0.44–1.22)
60–74	0.54 (0.22–1.36)
Sex	
Men	1
Women	1.29 (0.87–1.91)
BMI	
Q1	1
Q2	0.64 (0.43–0.96)*
Q3	0.75 (0.50–1.23)
Q4	0.61 (0.28–1.34)
Alcohol intake	
Non-drinker	1
< 23 g	0.78 (0.55–1.11)
≥ 23 g and < 46 g	0.54 (0.22–1.29)
≥ 46 g	0.73 (0.33–1.60)
Regular exercise	
Non-regular exercise	1
Regular exercise	1.25 (0.87–1.81)
Sleep duration	
< 5 h/day	1
≥ 5 h/day and < 6 h/day	0.80 (0.53–1.22)
≥ 6 h/day and < 7 h/day	0.72 (0.48–1.09)
≥ 7 h/day and < 8 h/day	0.54 (0.33–0.90)*
≥ 8 h/day and < 9 h/day	1.01 (0.50–2.06)
> 9 h/day	2.18 (0.39–12.10)
Education	
Less than high school	1
Junior college/vocational school/college of technology	0.83 (0.55–1.25)
University	1.30 (0.73–2.34)
Graduate school	1.69 (0.68–4.23)
Employment status	
Regular employment	1
Irregular employment	0.90 (0.50–1.62)
Workaholic tendency	
Q1	1
Q2	0.86 (0.58–1.25)
Q3	1.00 (0.67–1.48)
Job demands	
Q1	1
Q2	0.79 (0.55–1.16)
Q3	0.82 (0.53–1.26)
Job control	
Q1	1
Q2	0.94 (0.61–1.43)
Q3	1.21 (0.84–1.74)
Supervisor support	
Q1	1.00 (0.66–1.50)
Q2	0.99 (0.67–1.45)
Q3	1
Coworker support	
Q1	0.90 (0.59–1.36)
Q2	0.72 (0.50–1.05)
Q3	1
Job satisfaction	
Dissatisfied	3.11 (1.36–7.10)**
Somewhat dissatisfied	2.99 (1.46–6.11)**
Relatively satisfied	1.61 (0.83–3.14)
Satisfied	1
Mood or anxiety disorder	
< 13 points on K6	1
≥ 13 points on K6	1.45 (0.92–2.29)
Pain duration	
< 3 months	1
≥ 3 months and < 6 months	0.87 (0.52–1.45)
≥ 6 months	1.09 (0.80–1.49)

Non-smoker includes never smokers and ex-smokers

Model 1: crude model

Model 2: adjusted for company, age, sex, body mass index, drinking, regular exercise, sleep duration, education, employment status, workaholic tendency, job demands, job control, work-related social support, job satisfaction, mood or anxiety disorder, and pain duration

OR odds ratio, *CI* confidence interval, *K6* the Kessler Psychological Distress Scale

Test for significant difference from non-smokers: $*p<0.05$, $**p<0.001$, $***p<0.001$. $n=1189$

Discussion

In this cross-sectional study of Japanese workers, a combination of smoking and pain symptom was associated with

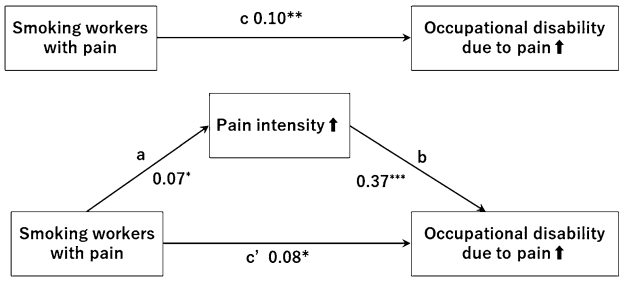

Fig. 2 Mediating effect of pain intensity on the association of smoking and pain with pain-related occupational disability

Table 3 Bootstrapped multiple mediation analysis testing the indirect effect of smoking on pain-related occupational disability via pain intensity

	Standardized path coefficient	Bootstrap SE	t	BC 95% CI
Outcome: pain-related occupational disability				
Path a	0.07	0.03	2.3*	LL = 0.01, UL = 0.13
Path b	0.37	0.03	11.4***	LL = 0.31, LU = 0.43
Path c′	0.08	0.03	2.4*	LL = 0.01, LU = 0.14
Indirect effects				
a × b	0.03	0.01	2.3*	LL = 0.004, LU = 0.05
Total effect				
Path c	0.10	0.04	3.2**	LL = 0.04, LU = 0.16

Table shows path standardized coefficients for the total and indirect effects

Analysis controlled for company, age, sex, body mass index, drinking, regular exercise, sleep duration, education, employment status, workaholic tendency, job demands, job control, work-related social support, job satisfaction, mood or anxiety disorder, and pain duration

Path a, effect of smoking on pain intensity

path b, effect of pain intensity on pain-related occupational disability

Path c, effect of smoking on pain-related occupational disability

Path a × b, indirect effect of smoking on pain-related occupational disability

Path c′, total effect of smoking on pain-related occupational disability

SE standard error, *BC 95% CI* bias-corrected bootstrap 95% confidence intervals, *LL* lower limit, *LU* upper limit

Path coefficients are based on 5000 bootstraps for the indirect effect. LL and UL CIs were used to determine statistical significance of indirect effects. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$. $n = 1189$

pain-related occupational disability, and this association was partially mediated by greater pain intensity.

Not only work-related pain such as low back pain and neck pain, but also general pain symptoms can effect job presenteeism and absenteeism. For example, Spanish clinical study reported that tension type headache was related to presenteeism and health-related loss of productivity [18]. In the United States, 13% of the workers have been reported to have experienced a loss in productive time during a 2-week period due to a common pain symptom [19].

It is well known that pain sensitivity is associated with pain intensity [5–7]. Sleep shortage, negative psychosocial factors such as depression, and smoking often increase pain sensitivity [20, 21]. A previous study reported that the pain intensity of smokers was related to smoking severity and nicotine addiction [22]. Smoking increases inflammation-related biomarkers such as C-reactive protein and interleukin [23], which provokes higher pain sensitivity [24], and the nicotine in tobacco may directly increase pain sensitivity in the brain [8]. Such mechanisms may explain the association between smoking and pain intensity.

We found both direct (75%) and indirect (25%) paths between smoking and pain-related occupational disability, independently of smoking-related pain intensity. Although the mechanism remains unclear, smoking may reduce workers' motivation to achieve [24]. Occupational disability is related to motivation [25]. Substance addiction, including nicotine addiction, impairs motivation and reward systems in the brain. Nicotine combines to α4β2 nicotinic receptors and secretes endogenous dopamine in the limbic system [26]. Nicotine addiction is developed by the artificial dopamine secretion with prolonged smoking [26]. Learning performance of chronic smokers depends on continuous nicotine intake compared with non-smokers [27]. Substances such as nicotine induce stronger uplifting feelings and motivation than does work achievement [28]. Compared with non-smokers, current smokers are likely to be dissatisfied with their work and may tend to have occupational disability.

One of the strengths of this study was that we controlled various work-related psychosocial factors. After adjusting for these, the association between smoking and pain-related occupational disability was still significant. However, there were some study limitations. First, we did not include individuals who had retired from work following absenteeism. This might have led to underestimation of the association between smoking and absenteeism. Second, we collaborated with employers to conduct the survey. Although the survey was anonymized, participants may have given socially desirable responses to please their employers. Third, we did not include in small business companies in the current study. Work environment is very different between large and small business companies. A further study is needed to examine workers in small business companies. Finally, the cross-sectional design means that temporal causality cannot be assumed. Workers with pain-related occupational disability might smoke as a distraction from their pain.

Conclusions

Smoking and pain were associated with pain-related occupational disability, partially through greater pain intensity, among Japanese workers. This suggests that smoking cessation could decrease pain-related occupational disability.

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to declare.

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