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Association between psychosocial job characteristics and sickness absence due to low back symptoms using combined DCS and ERI models

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Abstract.
OBJECTIVE: To evaluate the combined demand-control-support (DCS) and effort-reward-overcommitment (ERI-OC) stress models in association with sickness absence due to low back symptoms (SA-LBS).
METHODS: A total of 2,737 blue-collar workers recruited from 13 companies in the most populous province (Henan) of China were included in the study. Personal and physical job characteristics, psychosocial scales of the stress models, and SA-LBS data in the preceding year were collected by a self-reported questionnaire and analyzed by a multivariable logistic regression model. Tertile exposure levels (low, medium and high) were constructed to discriminate a risk level. Odds ratios (OR) with 95% confidence intervals (CI) were used as the association with SA-LBS.
RESULTS: A large percentage (84.5%) of the Chinese workers did not take sick leave after reporting low back symptoms during the preceding year. High job demand or medium–high reward was associated with SA-LBS. The association of the combined stress models and SA-LBS was not evident.
CONCLUSIONS: The ERI-OC model appeared to be more predictive of SA-LBS than the DCS model in the study population. The advantage of using combined stress models for predicting SA-LBS is not evident.

Keywords: Demand-control-support, efforts-reward-overcommittment, stress, low back symptoms, sickness absence

1. Introduction

Musculoskeletal disorders (MSDs), especially low back symptoms (LBS), have become a prominent workplace health problem in many western countries [1–3]. Work disability from low back problems has been a growing concern because of associated productivity losses and health costs [4]. Total annual expenditures attributable to LBS including both direct and indirect costs, such as sickness absence due to low back symptoms (SA-LBS), are estimated to be $119 billion in the United States, £12 billion in the United Kingdom, $9 billion in Australia, €6 billion in the Netherlands [5]. To reduce the productivity losses and economic burdens associated with SA-LBS, it is imperative to understand the complex association of SA-LBS and contributing factors.

Sickness absence is not an absolute result of an illness. Personal, social, and workplace factors (such as

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work organization) all play a role in a conscious choice of being absent from work because of sickness [6]. Psychosocial job characteristics, a measure of interaction between the extrinsic job factors and intrinsic personal attributes, have become a popular explanatory model for exploring the mechanisms of sickness absence due to various illnesses [7]. One of the most popular models is the demand-control-support (DCS) model [8,9], which has been used in numerous studies in the domain of job stress and musculoskeletal disorders [10–18]. The other popular model used for assessing different occupational illnesses and resulting absence is the effort-reward imbalance (ERI) model [19–25]. The DCS model primarily measures job-induced psychological demands and decision latitude (i.e., job control), while ERI deals with balance between extrinsic work environment and intrinsic personal nature. Compared with the DCS model, the ERI model is thought to cover a wider range of psychological aspects such as job satisfaction, promotion, and work stability [26]. Constructing scales of the models such as low social support (SS), high job demand, low job control, over-commitment (OC) have been linked to absenteeism in many previous studies [18,27–33].

Some previous studies compared the scales of the DCS and ERI models for predicting health outcomes using the same study population [15,25,28]. However, the two models in the previous studies were constructed separately for comparisons. None of the previous studies addressed the overall effect of the combined models [15,25,28]. In addition, the sickness absence data in the previous studies were generally linked to stress-related symptoms such as insomnia, depression, and myocardial infarction [20,34,35]. None of the previous studies investigated SA-LBS using the combined stress models. Since both models measure different aspects of psychological factors, a combination of both models should provide a more complete explanatory power for predicting health outcomes or sickness absence than one model alone [26].

To our knowledge, only one study used the overall effects of the combined stress models to investigate their association with sickness absence [26]. This previous study suggests that findings based on both models are better predictors of health outcomes or sickness absence than one model alone [26]. However, the study findings were drawn from a nursing population from three hospitals [26]. Generalizability of the combined stress models for predicting sickness absence in other working populations is limited. Another limitation of the previous study is that physical job factors for SA-LBS were not investigated and adjusted for potential confounding effects [26]. Physical job factors have been liked to SA-LBS in the literature [6].

Therefore, the current study was aimed at addressing the above-mentioned study limitations by using a working population from a broad range of occupations. Additionally, adjustment for physical job characteristics was included to investigate the association between SA-LBS and work-related psychosocial stressors determined by the DCS/ERI model.

2. Methods

2.1. Study population

A total of 2,737 blue-collar workers were analyzed for this study. The study population was drawn from 13 large companies in Henan province, the most populated province (population $=\sim$100 million) in China. Workers on the payroll of each participating company were recruited. Of 6,711 recruited workers, 5,909 (88%) agreed to participate in the study. The participating companies encompassed a wide range of occupations and included one public transportation service company ($n = 204$) and a variety of manufacturing companies, including a diamond production plant ($n = 274$), a diesel engine plant of a tractor factory ($n = 771$), an electrolyte aluminum plant ($n = 405$), a chemical fiber production factory ($n = 335$), a battery plant ($n = 264$), a high voltage electric equipment factory ($n = 1{,}772$), an environment protection equipment factory ($n = 209$), an oil equipment factory ($n = 200$), a garment plant ($n = 176$), a mechanical equipment fabrication plant ($n = 329$), a refractory plant ($n = 218$), and a chemical processing plant ($n = 181$). The participants received a standardized questionnaire in their workplaces and completed it in about 45 minutes. To ensure data quality, the participants with three or more missing responses (9.6%) were excluded from the data analysis, resulting in the final questionnaire response rate of 79.6% [36,37]. Of 3,186 participants who reported LBS, 2,737 were blue-collar workers who accounted for about 86% of the study population. Since this study population was comprised of mostly blue-collar workers, they were used for the present study to reduce confounding factors associated with manual material handling activities that were not commonly observed among white-collar workers [38].

2.2. Survey of SA-LBS and risk data

Both survey of SA-LBS and risk data collection were conducted by a standardized questionnaire, which consisted of four parts: (1) demographic and job information (gender, age, weight, height, job tenure, job type, smoking, alcohol consumption, education, work schedule, health status, and medical background), (2) musculoskeletal symptoms in the neck, shoulders, elbows, wrists, low back, hips, knees, ankles and feet, (3) physical job characteristics, and (4) work-related psychosocial factors using job stress models. Reported symptoms were limited to the preceding 12 months at the time of the survey. Data were collected anonymously between November 2008 and June 2009. The study protocol was approved by the Medical Ethics Committee of the Henan Provincial Institute of Occupational Health.

The question for assessing SA-LBS was adapted from the Dutch musculoskeletal questionnaire [39]. The reliability and validity of the adapted questionnaire have been established and demonstrated in our previous study [40]. The surveyed symptoms in this study included pain and discomfort. Discomfort was explained to participants as any unpleasant sensation including numbness, soreness, and/or any limitation of physical activity. Participants who responded positively to the following question were considered to have a musculoskeletal symptom in the low back region: "Did you have pain and discomfort in the low back region lasting more than 24 hours in the past 12 months?" A diagram of a human body depicting the low back region was shown to help indicate the location of the pain. A separate question 'Did you take sick day(s) due to the pain and discomfort in the same body region?' was asked for SA-LBS. The answers to the both questions were dichotomous (yes/no). The participants who answered 'yes' to the both questions were used as the sickness absence group. The participants who answered 'yes' to the first question but 'no' to the second question were classified as the reference group.

2.3. *Evaluation of psychosocial job characteristics*

Psychological demands, job control, and the SS dimensions of the DCS model, based on the Job Content Questionnaire, were used in this study [41]. The reliability and validity of the Chinese version of the DCS model have been established and reported in our previous studies [42]. Psychological demands, job control, and SS were assessed by 9, 10 and 11 items, respectively. Cronbach's α coefficients for the psychological demands, job control, supervisor SS and coworker SS scales in the study population were 0.60, 0.70, 0.62 and 0.65, respectively. The Chinese version of the questionnaire for the ERI model was also used in this study [43]. The reliability and validity of the Chinese version of the questionnaire have been established and reported elsewhere [42]. The questionnaire consisted of the following 3 scales: extrinsic efforts (6 items), occupational rewards (11 items), and OC (6 items). Extrinsic efforts were evaluated by measuring the psychosocial workload, occupational rewards focusing on the worker's financial status (i.e. salary), and self-esteem and career opportunity (e.g. promotion prospects and job security). OC as a personal (intrinsic) component was defined as a set of attitudes, behaviors, and emotions reflecting excessive striving along with a strong desire for approval and esteem. Cronbach's α for the effort, rewards, and over commitment scales were 0.78, 0.58, and 0.64, respectively.

2.4. *Confounding variables*

Personal confounding factors evaluated in the study included 9 items: (1) gender; (2) age (4 categories: $\leqslant$ 25, 26–34, 35–44 and $\geqslant$ 45 years); (3) length of employment (4 categories: $\leqslant$ 4, 5–14, 15–24 and $\geqslant$ 25 years); (4) education level (4 categories: elementary school, junior high school, high school, and college/university); (5) subjective health status (4 categories: very good, general, bad, and very bad); (6) medical history (yes/no: seeking medical attention with a doctor during the past 6 months); (7) cigarette smoking (yes, no); (8) alcohol dinking (yes, no); and (9) body mass index (BMI) (underweight: BMI $<$ 18.5 kg/m^2; normal: 18.5 $\leqslant$ BMI $<$ 24 kg/m^2; overweight: 24 kg/m^2 $\leqslant$ BMI $<$ 28 kg/m^2; and obesity: BMI $\geqslant$ 28 kg/m^2), as recommended by the Ministry of Health of The People's Republic of China in 2009.

Other confounding variables including physical job characteristics were grouped by awkward posture (trunk flexion, trunk twisting, arms above shoulders, prolonged neck bending forward, prolonged bent wrists, holding objects in an uncomfortable position, pinch grip, working without support for body weight, etc.), repetitive motion (of arms/hands and trunk), lifting/pushing/pulling ($>$ 5 kg), maintaining a body posture (standing, sitting, walking, squatting, kneeling, static posture) for long periods of time, insufficient clearance causing increased awkward body posture (neck, trunk or wrist flexion) great force exertions of arms/hands, and using vibrating tools. An example of the questions about awkward postures is "Do you in your work often have to bend your neck forward or hold your neck in a forward posture for long periods of

Table 1
Demographics and health information of study participants (N = 2,737)

Variables	Non-sickness		Sickness		Total	
	n	%	n	%	n	%
Low back symptom	2314	84.5	423	15.5	2737	100
Sex						
Male	1609	84.2	302	15.8	1911	69.8
Female	705	85.4	121	14.6	826	30.2
Educational level*						
Elementary	14	0.6	5	1.2	19	0.7
Junior high school	481	20.8	99	23.4	580	21.2
High school	1449	62.6	265	62.6	1714	62.6
College or university	370	16.0	54	12.8	424	15.5
Age (years)*						
$\leqslant$ 25	496	21.4	64	15.1	560	20.5
26–34	781	33.8	155	36.6	936	34.2
35–44	824	35.6	160	37.8	984	36.0
$\geqslant$ 45	213	9.2	44	10.4	257	9.4
Years of service (years)*						
$\leqslant$ 4	779	33.7	103	24.3	882	32.2
5–14	825	35.7	171	40.4	996	36.4
15–24	590	25.5	124	29.3	714	26.1
$\geqslant$ 25	120	5.2	25	5.9	145	5.3
Cigarette smoking*						
Yes	915	39.5	193	45.6	1108	40.5
No	1399	60.5	230	54.4	1629	59.5
Alcohol drinking						
Yes	958	41.4	184	43.5	1142	41.7
No	1356	58.6	239	56.5	1595	58.3
BMI						
Normal	1416	61.2	241	57.0	1657	60.5
Underweight	124	5.4	23	5.4	147	5.4
Overweight	655	28.3	145	34.3	800	29.2
Obesity	119	5.1	14	3.3	133	4.9
Subjective health status*						
Very good	328	14.2	35	8.3	363	13.3
General	1560	67.4	260	61.5	1820	66.5
Bad	345	14.9	80	18.9	425	15.5
Very Bad	81	3.5	48	11.3	129	4.7
Medical history*						
Yes	956	41.3	276	65.2	1232	45.0
No	1358	58.7	147	34.8	1050	55.0

*: χ^2 test with $p < 0.05$.

time?" An example of the questions about heavy lifting is "Do you in your work often have to lift heavy loads more than 5 kg?" Dichotomous answer (yes or no) to each question item was provided.

2.5. Statistical analysis

Logistic regression analyses were performed to estimate the associations between SA-LBS and psychosocial variables in the stress models. Bivariate and multivariate odds ratios (ORs) and 95% confidence intervals (CIs) were derived from the logistic regression models. The confounding variables for the multivariate models included the significant variables found in the bivariate analysis ($P < 0.1$), including age, educational level, subjective health status, medical history, and some physical job characteristics. The associations between three levels (tertiles) of exposure to the individual scales of the stress models were evaluated first, while adjusting for the confounding variables. The second analysis was followed to evaluate the association of the scale variable of each stress model and sickness absence, while adjusting for the same confounding variables and additional SS and OC for the DC and ERI models, respectively. In the second analysis, the quotient method was used for determining the scale variables – ratio of job demand to job control (i.e. job strain) for the DC model and the ratio of effort to rewards for the ERI model [9,20]. Similar to the first analysis, the scale variables were further characterized

Table 2
Crude and adjusted OR for association between scales of the DC/ERI models and SA-LBS (N = 2,737)

Variables	N(%)	Crude OR (95%CI)	Adj OR (95%CI)*
DC model			
Job demands**			
1st tertile (low)	79 (11.2)	1.0	1.0
2nd tertile (medium)	163 (14.6)	1.36(1.02–1.81)[a]	1.21(0.90–1.63)
3rd tertile (high)	181 (19.8)	1.97(1.48–2.61)[b]	1.42(1.05–1.92)[a]
Job control			
1st tertile (high)	114 (15.3)	1.0	1.0
2nd tertile (medium)	155 (15.2)	0.99(0.76–1.19)	1.00(0.76–1.31)
3rd tertile (low)	154 (15.8)	1.04(0.80–1.35)	0.94(0.71–1.24)
ERI model			
Effort**			
1st tertile (low)	93 (11.1)	1.0	1.0
2nd tertile (medium)	132 (15.1)	1.43(1.07–1.90)[a]	1.25(0.93–1.68)
3rd tertile (high)	198 (19.3)	1.92(1.47–2.50)[b]	1.32(0.99–1.75)
Rewards			
1st tertile (high)	70 (10.5)	1.0	1.0
2nd tertile (medium)	142 (16.2)	1.65(1.21–2.23)[b]	1.41(1.03–1.94)[a]
3rd tertile (low)	210 (17.7)	1.83(1.37–2.44)[b]	1.36(1.00–1.84)[a]

*Adjusted for age, educational level, subjective health status, medical history, physical job characteristics (lifting heavy loads more than 5 kg, insufficient clearance causing increased trunk flexion, awkward posture and working without support for body weight). $^{**}p < 0.01$ for linear-by-linear association in the multivariable analysis. [a]:$P < 0.05$, [b]:$P < 0.01$.

by tertile grouping. In the final analysis, three combinations (DC and SS, ERI and OC, and DC and ERI) of the stress models were evaluated in relation to sickness absence [26]. For each combination, the respondents were divided into four exposure categories on the basis of the exposure tertile data: one group for those exposed to the lowest tertile of both stress models (reference group), two groups for those exposed to the highest tertile (presence) of one stress model but lowest tertile (absence) of the other stress model, and one group for those simultaneously exposed to the highest tertiles of both the stress models [26]. The same confounding variables used previously in the first and second analyses were controlled for in the final analysis for the combined models. The significant level for the risk estimates in the models was 0.05. All significant statements were two-tailed. All the statistical analyses were performed with SPSS for Windows (version 13.0; SPSS Inc., Chicago, IL).

3. Results

3.1. Characteristics of study participants between SA-LBS and non-SA-LBS groups

Table 1 shows the demographics and health information about the study participants with LBS. Among these participants, the 1-year prevalence of SA-LBS was 15.5%. About 70% of the study population were male workers. Although statistically significant, the education levels, age, and years of service of the SA-LBS and non-SA-LBS participants were generally comparable. A larger percentage of the participants with SA-LBS drank alcohol and smoked cigarette than those without SA-LBS. No statistically significant difference was found in the BMI between the SA-LBS and non-SBL-LBS groups. A larger percentage of the participants in the SA-LBS group reported poorer health (bad, very bad) status and sought medical attention during the past 6 months than those in the non-SA-LBS group. The percentage difference was statistically significant ($P < 0.05$).

3.2. Association between job stress and SA-LBS

3.2.1. Job stress analyzed through individual scales of stress models

Table 2 shows the results of bivariate and multivariable logistic regression analyses on the association between scales of the DC/ERI models and SA-LBS. With respect to the DC model, results showed an increased risk of SA-LBS associated with increased levels of job demands in the bivariate analysis. This association remained significant after adjusting for demographics, health status, and physical job characteristics (OR = 1.42; 95%CI = 1.05–1.92). A dose-response relationship seemed to exist between the level of job demands and SA-LBS in both the bivariate and multivariable analyses, although no statistical significance ($P <$

Table 3
Crude and adjusted OR between each individual stress model and SA-LBS (N = 2,737)

Variables	N (%)	Crude OR(95%CI)	Adj OR(95%CI)*	Adj OR(95%CI)**
DC model				
DC model; $P < 0.001^c$				
1st tertile (low)	96(12.1)	1.0	1.0	1.0
2nd tertile (medium)	140(15.9)	1.38(1.04–1.82)[a]	1.28(0.96–1.71)	1.28(0.96–1.72)
3rd tertile (high)	187(17.6)	1.55(1.19–2.02)[b]	1.22(0.92–1.62)	1.21(0.90–1.63)
SS; $P < 0.05^c$				
1st tertile (high)	134(13.8)	1.0	1.0	1.0
2nd tertile (medium)	93(14.4)	1.05(0.79–1.39)	0.94(0.70–1.27)	0.91(0.67–1.23)
3rd tertile (low)	196(17.5)	1.33(1.05–1.69)[a]	1.07(0.83–1.38)	1.02(0.79–1.33)
ERI model				
ERI model; $P < 0.001^c$				
1st tertile (low)	83(10.8)	1.0	1.0	1.0
2nd tertile (medium)	122(14.4)	1.39(1.03–1.87)[a]	1.25(0.92–1.70)	1.20(0.88–1.64)
3rd tertile (high)	218(19.4)	1.98(1.51–2.60)[b]	1.41(1.06–1.89)[a]	1.39(1.02–1.90)[a]
OC; $P < 0.001^c$				
1st tertile (low)	87(10.7)	1.0	1.0	1.0
2nd tertile (medium)	145(17.3)	1.74(1.31–2.32)[b]	1.54(1.15–2.07)[b]	1.47(1.09–1.98)[a]
3rd tertile (high)	191(17.5)	1.77(1.35–2.32)[b]	1.29(0.97–1.72)	1.15(0.85–1.56)

*Adjusted for age, educational level, subjective health status, medical history, physical job characteristics (lifting heavy loads more than 5 kg, insufficient clearance causing increased trunk flexion, awkward posture and working without support for body weight). **The DC model was additionally adjusted for SS; the SS scale was additionally adjusted for the DC model. Similarly, the ERI model was additionally adjusted for OC; the OC scale was additionally adjusted for the ERI model. [a]:$P < 0.05$;[b]:$P < 0.01$; [c]: p value for linear-by-linear association.

0.05) was found for exposure to the medium level in the multivariable analysis. Job control (i.e., decision latitude) was not significantly associated with SA-LBS in both bivariate and multivariable analyses. With regard to the ERI model, both scales of the ERI model were significantly associated with SA-LBS in the bivariate analysis. However, the association remained significant only for the rewards component after adjusting for the confounding variables. Unlike job demands, rewards did not have a dose-response relationship with SA-LBS in the multivariate analysis.

3.2.2. *Job stress analyzed through stress models*

Table 3 shows results concerning associations between the stress constructs of DC/ERI models and SA-LBS. With regard to the job strain (i.e., demands/control ratio) in the DC model, participants classified in the highest and the medium exposure levels of job strain were more likely to report SA-LBS in the bivariate analysis. An analysis of linear-by-linear association revealed a significant dose-response relationship. However, after adjusting for confounding variables and SS at work, such associations became non-significant. With respect to SS, a greater risk of SA-LBS among those classified in the group of lowest level of SS at work was observed in the bivariate analysis. Similar to job strain, such association became non-significant after adjusting for the confounding variables and the DC model. Both medium and high exposure levels of stress in the ERI model were associated with SA-LBS in the bivariate analysis. After adjusting for confounding variables and OC to work, only the highest level of stress in the ERI model was statistically associated with SA-LBS. The median level of OC demonstrated a statistically significant association ($p < 0.05$) with SA-LBS in both bivariable analysis and multivariable analysis.

3.2.3. *Job stress analyzed by means of combined stress models*

Table 4 shows the results for three combined stress models. In model 1 (DC-SS), participants presenting both high job strain and low SS showed a significantly increased risk (crude OR = 1.5; 95%CI = 1.16–1.95) for SA-LBS, but the increased risk was not statistically significant after adjusting for confounding variables, ERI, or OC. In model 2 (ERI-OC), the presence of ERI alone or the combination of presence of ERI and OC was statistically associated (crude OR = 1.76; 95%CI = 1.36–2.27) with SA-LBS. The OR was not statistically significant after adjusting for confounding variables and additional job strain or SS. In model 3 (DC-ERI), the presence of ERI or a combination of the presence of ERI and DC was statistically associated with SA-LBS. Similar to models 1 and 2, the association was not significant after adjusting for confounding variables and additional OC or SS.

Table 4
Crude and adjusted OR between combinations of stress models/scales and SA-LBS (N = 2,737)

Variables	N (%)	Crude OR(95%CI)	Adj OR(95%CI)*	Adj OR(95%CI)**	Adj OR(95%CI)**
Model 1				Adj OC	Adj ERI
DC and low SS absent	158(13.3)	1.0	1.0	1.0	1.0
DC present	187(17.6)	1.24(0.91–1.69)	1.04(0.76–1.44)	1.04(0.75–1.43)	0.96(0.69–1.33)
Low SS present	196(17.5)	1.25(0.93–1.67)	1.09(0.81–1.49)	1.08(0.80–1.47)	1.02(0.74–1.39)
DC and low SS present	118(18.7)	1.50(1.16–1.95)[b]	1.12(0.85–1.48)	1.12(0.85–1.48)	1.00(0.74–1.35)
Model 2				Adj DC	Adj SS
ERI and low OC absent	232(14.1)	1.0	1.0	1.0	1.0
ERI present	218(19.4)	1.61(1.20–2.17)[b]	1.35(0.99–1.83)	1.30(0.95–1.79)	1.35(0.98–1.86)
Low OC present	191(17.5)	1.11(0.80–1.55)	0.99(0.71–1.40)	0.98(0.70–1.38)	1.00(0.71–1.41)
ERI and low OC present	135(19.9)	1.76(1.36–2.27)[b]	1.18(0.89–1.55)	1.15(0.86–1.53)	1.17(0.88–1.56)
Model 3				Adj OC	Adj SS
DC and ERI absent	151(12.4)	1.0	1.0	1.0	1.0
DC present	187(17.6)	1.11(0.79–1.54)	0.94(0.67–1.33)	0.94(0.67–1.33)	0.94(0.66–1.34)
ERI present	218(19.4)	1.60(1.20–2.14)[b]	1.19(0.88–1.62)	1.18(0.86–1.62)	1.19(0.87–1.62)
DC and ERI present	133(20.0)	1.76(1.37–2.27)[b]	1.24(0.94–1.64)	1.25(0.93–1.67)	1.23(0.91–1.67)

*Adjusted for age, educational level, subjective health status, medical history, physical job characteristics (lifting heavy loads more than 5 kg, insufficient clearance causing increased trunk flexion, awkward posture and working without support for body weight). **Multiple logistic regression models were additionally adjusted for OC and ERI in Model 1, for job strain and low SS in Model 2, for OC and low SS in Model 3, respectively. [a]:$P < 0.05$; [b]:$P < 0.01$.

4. Discussion

In this study, we found prevalence of 15.5% for SA-LBS among the workers who reported LBS in the preceding year, implying that a large percentage (84.5%) of the blue-collar Chinese workers in this field survey did not take sick leave for LBS. This SA-LBS prevalence is similar to that (18%) in a blue-collar working population in the Danish Work Environment Cohort Study [44] and that (14%) in Dutch laundry workers [30]. In addition, it is in the range of the prevalence (9–23%) reported in several previous studies in spite of different definitions for sickness absence due to LBS in different working populations [29,32,45–47].

This study resulted in three main findings. First, job control and effort were not significantly associated with SA-LBS after adjusting for confounding factors (Table 2). The results are in accordance with several studies analyzing both physical job factors and psychosocial elements of the DCS model in relation to SA-LBS [30,48,49]. Job demands and rewards, two other psychological elements in the two stress models, were significantly associated with SA-LBS. The finding is not coherent with the findings in the aforementioned studies, but is in line with findings from two studies using combined stress models on overall sickness absence [25,26]. The DCS model on SA-LBS has been used in many studies for comparisons [30,48,49], while the ERI model has not been previously tested for its association with SA-LBS. This study is the first attempt to assess the ERI model in relation to SA-LBS, adjusting for a variety of confounding variables including elements of the DCS model.

Second, job strain of the DC model was not linked to SA-LBS after controlling for confounding variables and low SS, while high exposure level of stress construct in the ERI model remained significantly associated with SA-LBS after adjusting for confounding variables and OC (Table 3), suggesting that the ERI-OC model was more predictive of SA-LBS than the DCS model. These two stress models measure different interactions between psychological factors at work and the working environment. Conceptually, the DC model focuses on job profile, while the ERI model combines structural and personal components of work stress [28, 43]. These differences have been discussed comprehensively elsewhere and hence not reported here in the study [50]. Among the scales of the stress models, our study results showed that the reward component in the ERI model was a strong predictor for SA-LBS, which invariably led to a significant association of an increased effort to reward ratio of the ERI model with SA-LBS. The findings imply that in the Chinese blue-collar working population, reward itself and the effort to reward ratio are two key workplace psychosocial factors for SA-LBS. Most Chinese manufacturing companies (sources of the study population) have been making drastic changes in workstation designs to meet the global manufacturing demands during the past 2 decades. An ample supply of inexpensive Chinese labor may cause job insecurity in such a dynamic working environment. To prevent SA-LBS in Chinese blue-collar workers, offering rewards (money, esteem, job security, and career opportunities) as a psychosocial intervention may be an effective measure. However, caution should be exercised to minimize money-based health and safety policy without considering other effective engineering controls.

Third, the general effect of the combined stress models without adjustment for confounding variables is that increased stress exposure levels, whether by DC-SS, ERI-OC or DC-ERI were significantly associated with SA-LBS (Table 4). However, after adjustment for confounding variables and the other stress model, none of the combined models showed a statistically significant association with SA-LBS. In short, results from this study provided limited evidence to support the hypothesis that combined stress models are more predictive of sickness absence than a single stress model alone [26]. In the previous study by Griep and colleges [26], the combination of high ERI and high DC-low SS were better predictors for sickness absence of short spells than each model/scale separately. In this previous study, overall sickness data were used for their evaluation of the combined stress models, while only SA-LBS data were assessed in the present study. Other main factors associated with the discrepancies in the findings are different study populations (nursing vs. blue-collar workers), definition of spells of sickness absence, physical job characteristics, and confounding variables. To our knowledge, this is the first study to report the effects of combined stress models on SA-LBS. It is, therefore, difficult to relate to previous research evidence.

It should be noted that the effects of personal and physical job characteristics (confounding variables) on the association of the combined DCS and ERI models with SA-LBS indicate a stronger association of these confounding variables with SA-LBS than the model(s) alone. In previous studies showing a significant association of the stress models and sickness absence, personal and health behavior factors were analyzed, but specific physical job factors (e.g. lifting more than 5 kg, awkward working posture, lack of support for body weight, etc.) included in our analysis were not surveyed and included in their analyses [25,28,51]. Therefore the main contribution of the SA-LBS in our study population might have come from the physical job factors, implying that the DCS or combined DCS and ERI-OC models primarily measuring psychological stressors may not be the underlying causes of SA-LBS. Other relevant physical job factors may explain SA-LBS in our study population. This finding corroborates those from several previous studies investigating effects of both physical and psychosocial factors (of the DCS model) on SA-LBS [29,30].

Growing evidence from longitudinal studies shows that physical job factors are more relevant to the development of low back disorders and subsequent sickness absence than psychosocial factors at work [3,27,52]. Insufficient evidence for the association of psychosocial factors and low back disorders from the longitudinal studies may stem from methodological issues of the previous studies [52]. In our previous work, we found a decreased association of the stressors in the DC or ERI models with musculoskeletal symptoms in various body regions when detailed physical job factors were analyzed simultaneously [38]. As a result, it seems reasonable to find a weakened association of the stressors in the stress models with SA-LBS when specific physical job factors were analyzed simultaneously.

Previous studies suggest that the psychosocial stressors are mediating factors for MSDs [38,53,54]. The strength of these stressors manifests itself in association with specific musculoskeletal pain from physical job factors [38,53,54]. In our study, the psychosocial factors seemed not to interact significantly with physical job factors (presumed underlying causes of low back pain and subsequent sickness absence). The effects of the psychosocial factors on SA-LBS was consequently limited. Interactions between physical and psychosocial factors in relation to long-term all-cause sickness absence have been documented in a previous study, but the effects of the interactions with regard to SA-LBS are unclear [55]. It is, however, also plausible that the SA-LBS in our study population was not mediated by the stress-related factors, which, in contrast, have been found in several previous studies for cardiovascular disease and depression [20,34,35]. The controversy over the role work-related psychosocial factors play in the development of low back disorders is likely to continue, as the etiology of most low back disorders are still not well understood. The review paper by Hartvigsen and colleagues highlighted the controversy in great detail [52].

Another theory about different results of the effects of the combined stress models is the application of the stress constructs in workers with different socioeconomic backgrounds [20]. Our study findings using combined stress models provide some empirical evidence to support this theory. Since the questions for the stress constructs entail generic job information about control, creativity, time pressure, hardship of work, psychological workload, self-esteem and so on, interpretation of the questions in different study populations with different cultural and educational backgrounds is likely to vary to some degree. Hence, it seems reasonable to find some discrepancies in the associations between the stress models and occupational illnesses and following sickness absence in different study populations, especially in different nations. Questions arise as to the reliability of the stress models across different cultures. Two comprehensive studies examining the issue showed a comparable reliability across different study populations [9,43]. However, these two studies only used the study populations in the western/developed countries [9,43]. A comparison of the validity of the stress models across a wide range of nations (i.e. cultures), including large emerging countries such as China or India, is recommended to help elucidate the cultural effects.

Several strengths and limitations of the study are warranted for considerations. Physical job factors, mostly ergonomics related, were controlled for in our data analysis. These ergonomic factors, previously demonstrated as significant factors for sickness absence, have not been adjusted for assessing the effects of stress models in most previous studies [27,30]. However, it should be noted that the physical job factors were self-reported and still subject to recall biases. Another strength of the study is that three levels of exposure to the stress models were constructed to provide adequate contrast for estimating the effects of different levels of exposure. In addition, assessments of combined stress models for SA-LBS enabled us to investigate many dimensions of psychosocial work stress in relation to SA-LBS. Furthermore, workers in a wide range of occupations were included in our study to increase the power of generalization of the study results on blue-collar workers.

The first limitation of the study is the binary data for sickness absence. The number of days of absence due to any illnesses including LBS was not collected in this survey, resulting in the inability of our data analysis to distinguish the effects of the combined stress models on short, medium, and long spells of absence as well as multiple episodes of absence in the same worker. The second limitation is a lack of data in pain severity for the LBS. The additional pain information might lead to different responses to the stress models. The third limitation is associated with unknown occurrences or chronology of the LBS. The history of LBS is one of the most significant predictors for occurrences of LBS and subsequent sickness absence [32]. Whether the SA-LBS data collected in the study was biased by the prior occurrences of LBS beyond the study length of one year is unclear. The fourth limitation is that no interaction between variables was examined in this study because of the complex adjustment for the different constructs in the stress models. Interactions between personal and psychosocial factors in relation to long-term sickness absence have been found in previous studies [6,55]. Finally, the present study was cross-sectional in nature, thus any temporal relationship between the study variables cannot be determined. This limitation implies that a reverse relationship between the psychosocial variables and sickness absence may exist.

5. Conclusions

A large percentage (84.5%) of the Chinese blue collar workers in this study did not take sick leave after reporting LBS in the preceding year. The ERI-OC stress model appeared to be more predictive of SA-LBS than the DCS stress model in the study population. After adjusting for personal and physical job characteristics, the association of the combined stress models and SA-LBS was not evident, suggesting that SA-LBS is primarily attributable to personal and physical job characteristics.

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