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ORIGINAL ARTICLE

Job satisfaction and job security as moderators in the relationships among job demands, musculoskeletal symptoms, and work performance

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Abstract

Purpose This study examined whether job satisfaction and job security moderate the path from physical demands and job strain to impaired work performance via musculoskeletal symptoms in the upper extremities (MSUE). Moderation effects on five paths were examined: (1) from job strain to MSUE; (2) from job strain to work performance; (3) from physical demands to MSUE; (4) from physical demands to work performance; (5) from MSUE to work performance.

Methods This was a cross-sectional study of 669 full-time workers from 9 manufacturing and 3 healthcare facilities. Data were collected via health interviews, on-site physical exposure assessments, and computation of the Strain Index by ergonomists, and self-administered questionnaires on psychosocial factors. Structural equation modeling and zero-inflated negative binomial regression analysis were performed to examine the moderation effect on each path.

Results Job satisfaction moderated the relationship between MSUE and impaired work performance (B = − 0.09, 95% CI: − 0.15, − 0.04) and job security moderated the relationship between physical demands and MSUE (B = − 0.64, 95% CI: − 1.17, − 0.11). Interaction between job satisfaction and MSUE was significant on both the occurrence (OR: 0.92, 95% CI: 0.87, 0.97) and the degrees of impaired work performance (mean ratio: 0.99, 95% CI: 0.97, 0.99), while the interaction between job security and physical demands was significant only on the degrees of MSUE (mean ratio: 0.94, 95% CI: 0.89, 0.99).

Conclusion Job satisfaction and job security can, respectively, mitigate the adverse impacts of working with MSUE and physical demands on work performance. Workplace interventions to improve workers' job satisfaction and job security can contribute to their musculoskeletal health and work performance.

Keywords Occupational stress · Work performance · Musculoskeletal pain · Job satisfaction · Job insecurity · Presenteeism

Introduction

Musculoskeletal symptoms in the upper extremities (MSUE) are common health problems. A recent study estimated that 31% of the general population had MSUE in the past 3 months (Lucas et al. 2021). Many workers continue working despite experiencing MSUE (Walker-Bone et al. 2004; Herr et al. 2015), and these workers may not be fully functioning at work due to the condition. Musculoskeletal symptoms can hamper an employee's ability to work, which may result in lost productivity and necessitate work accommodations or sick leave (Gardner et al. 2014). Previous research indicates a range of risk factors that lead to musculoskeletal disorders (MSDs) while also suggesting that the differential impacts of MSDs depend on their stage and severity (Evanoff et al. 2014). For example, while physical demands

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are a critical risk factor for the onset of MSDs, psychosocial factors may be more important for the progression of MSDs or work disability (Evanoff et al. 2014). Hence, disentangling the role of contributing factors at each stage of work-related MSD—specifically, the development of MSUE and work disability due to MSUE—is essential to inform the design of MSD prevention strategies and interventions. However, little is known about what kinds of occupational factors influence the path from MSUE to work performance.

According to the biopsychosocial model, disability is not just a consequence of a health condition but occurs as a consequence of the interaction between health, environmental, and personal factors (Gatchel et al. 2007). Within a given illness, different levels of disability may occur depending on the surrounding environment. Based on the biopsychosocial model, the World Health Organization (2001) proposed the International Classification of Functioning, Disability, and Health (ICF) framework, which illustrates not only the three components of disability (i.e., bodily impairment, activity limitation, and decreased social participation), but also how the relationships among these components can be moderated by personal or environmental factors. Based on the ICF framework, a French longitudinal study by Rouquette et al. (2015) reported that environmental factors such as family relationships and the use of mobility devices modified the relationship between bodily impairment (pain) and activity limitation (physical function) among patients with knee osteoarthritis. However, little is known as to whether occupational environments can modify the effect of MSUE on work performance. While people can have the same degree of MSUE, their work performance due to MSUE may differ depending on what kinds of jobs they perform and what kinds of resources are available to them for coping with MSUE at work.

Both physical and psychosocial factors have been recognized as main occupational risk factors for the occurrence of MSDs (Bernard et al. 1997; National Research Council and Institute of Medicine 2001; Da Costa and Vieira 2010). Based on laboratory studies, physical job factors, such as work posture, force exertion, and repetition, are considered to be plausible biological causes of MSDs. However, their effects, as observed in epidemiologic studies, are modest or less conclusive (National Research Council and Institute of Medicine, 2001; Burton et al. 2008; Da Costa and Vieira 2010). The psychosocial job factors most commonly investigated in MSD studies include psychological job demands, job control, job security, and job satisfaction. While high psychological job demands, low job control, and high job strain have been consistently shown to be associated with increased risk of MSDs (Cantley et al. 2016; Eatough et al. 2012; Bugjska et al. 2013; Hauke et al. 2011; IJzelenberg et al. 2004; Da Costa and Vieira 2010), the influences of other psychosocial factors such as job satisfaction and job security have been less supported (Bernard et al. 1997; Lang et al. 2012; Zare et al. 2021).

A possible reason that job satisfaction and job security have shown inconsistent evidence regarding their relationships with MSDs may be because they operate as moderators rather than as independent risk factors. Prior studies that observed significant associations of job security (Kivimäki et al. 2001; Lipscomb et al. 2008; Bugjska et al. 2013; Wami et al. 2019) and job satisfaction (Tegenu et al. 2021; Baek et al. 2018; Lachowski et al. 2017; Christensen et al. 2017) with MSDs did not account for other major factors such as physical demands, psychological job demands, job control, and job strain in their analyses. The impact of job security on MSD symptoms was not supported after accounting for the influence of physical demands (Lourenço et al. 2015). Meanwhile, a study showed that job security moderated the relationship between job demands and job performance (Lu et al. 2017). Another study examined a mediating role of job satisfaction for MSDs among hospital nurses but failed to find it after controlling for job strain (Mehralizadeh et al. 2017).

To further contemplate the moderating influence of job satisfaction and job security on the effect of major occupational factors on MSDs, the Job Demand Resource (JDR) model (Demerouti et al. 2001) offers a helpful framework. The JDR entails physical, social, and organizational factors of the work environment and purports that job resources buffer job demands (Bakker et al. 2005). Job demands are factors that require physical and psychological effort and are associated with certain physical and psychological costs, which lead to depleted energy and predict job strain and health impairment (Bakker et al. 2003). Job resources are factors that help to achieve work goals, reducing job demands, and increasing personal growth and motivation (Bakker et al. 2003). Several empirical studies have shown the moderating effect of job resources on MSDs (Joling et al. 2008; Pekkarinen et al. 2013; Mai and Kim 2022). Previous studies have tested the moderating effect of job resources such as social support and fair reward systems on MSDs (Joling et al. 2008; Pekkarinen et al. 2013; Mai and Kim 2022), but investigations have been relatively limited. For example, the moderating effect of job resources on the pathway from MSDs to work performance has never been examined. In addition, factors such as job security and job satisfaction have not been examined as job resources.

MSUE at work is also germane to a phenomenon of presenteeism, and whether it depends on the presence of MSUE (bodily impairment) or work performance (activity limitation) needs to be considered. McGregor et al. (2018) argued that the previous operationalized definitions of presenteeism such as "attending work while ill" or "the productivity loss that stems from attending work while ill" were not valid to workers with chronic health conditions

and suggested for future studies a new definition as "attending work while feeling impaired." This assertion prompts the examination of different kinds of presenteeism among people with MSUE: positive presenteeism (having MSUE but no impaired work performance) and negative presenteeism (having both MSUE and impaired work performance). Psychosocial factors such as job satisfaction and job security may play a role in workers' decision whether to attend work despite feeling impaired work performance due to MSUE, as well as whether to attend work despite feeling MSUE but no impaired work performance. High job satisfaction may reflect a resourceful work environment for preventing impaired work performance, as well as MSUE. Company benefits and perks such as competitive health insurance coverage, paid leave, wellness program, and flexible work schedule were associated with job satisfaction as well as employees' health (Tessema, Ready and Embaye 2013; Ledikwe et al. 2018; Ray and Pana-Cryan 2021). Therefore, people with high job satisfaction may have more resources to cope with MSUE. On the other hand, job insecurity may be associated with the negative presenteeism. While taking rest or sick leave when desired for reducing MSUE (Park and Kim 2020), workers with low job security may tend to delay taking sick leave, especially when their work is busy.

The purpose of the present study is to examine whether job resources of job satisfaction and job security moderate the path from physical demands and job strain to impaired work performance via MSUE. This study hypothesized that job satisfaction and job security would have moderating effects on the following three paths: (i) from job strain to MSUE; (ii) from physical demands to MSUE; (iii) from MSUE to impaired work performance; (iv) from job strain to impaired work performance; and (v) from physical demands to impaired work performance. The proposed conceptual model of this study is provided in Fig. 1.

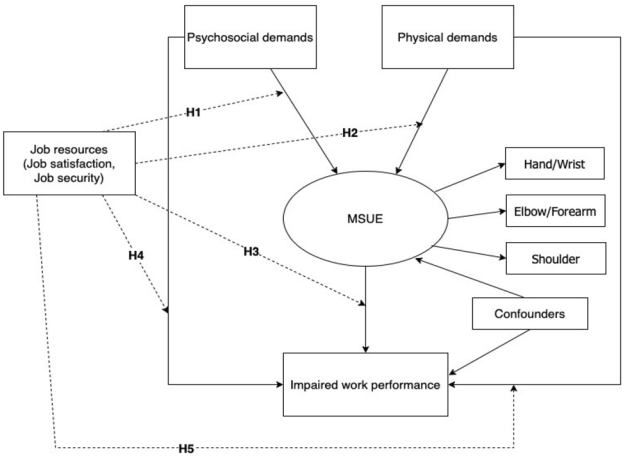

Fig. 1 Conceptual framework and hypotheses, *H* hypothesis, *MSUE* musculoskeletal symptoms in upper extremities. All exogenous variables such as job strain, physical demands, job resources, and confounders were allowed to covary each other if there was no direct path between them

Methods

Setting and design

This cross-sectional study utilized the baseline data from a prior prospective cohort study, conducted by the Washington State Department of Labor and Industries, Safety and Health Assessment and Research for Prevention (SHARP) program. The SHARP study recruited 733 full-time employees in 9 manufacturing sites and 3 healthcare facilities in the state of Washington (USA) from 2001 to 2004. The study included: (1) individual quantifications of physical factors by certified professional ergonomists; (2) a health interview (health history, job history, MSUE) by trained interviewers; and (3) a self-administered questionnaire of psychosocial factors. Among 733 employees recruited at baseline, 266 participants (36%) were terminated or laid off during the following period due to the economic recession. In addition, the attrition rate was 56% among the participants who reported low job satisfaction and 90% among those who reported low job security at baseline. Given the high attrition rates and possible selection bias from the lost to follow-up, we considered that using the longitudinal data would not be appropriate to examine the moderating effects of job satisfaction and job security. Therefore, this study conducted the examination using the cross-sectional baseline data. The SHARP study was approved by the Washington State Institutional Review Board.

Participants

Details of the methods for the SHARP study were previously reported (Bao et al. 2006a, b). Briefly, SHARP contacted manufacturing or healthcare facilities with more than 200 employees that were anticipated to have a variety of physical occupational exposures. The study included sites that had a department where at least 30 full-time workers were exposed to jobs with ≥ 3 of 6 varied hand force (high/low) and repetition (high/medium/low) exposures. Due to limited resources to measure physical factors, workers who had more than four tasks or mobile jobs, such as forklift driving, were excluded. In addition, workers involving direct patient care in healthcare facilities were excluded because of patient privacy concerns that restricted videotaping job tasks which was needed for assessing physical exposures. The SHARP study enrolled workers who were willing to participate (65%, 733 out of 1123) within the selected facilities. Most participants (86%) were from manufacturing industries such

as sawmills and plywood mills; electronics assembly; and window, machine, and furniture manufacturing. Among the 733 participants of the original SHARP study, those who had a sudden injury to the upper extremities from slip, fall, or a car accident in the last year ($n = 29$) and those whose data had been lost for all psychosocial variables ($n = 35$) were excluded. As a result, 669 workers were included in the analysis of the present study.

Measures

Physical demand exposure

In the original study, certified professional ergonomists, who were blinded to workers' health status, directly observed and videotaped workers while they were performing their usual jobs and then documented physical job exposure parameters from the right and left sides of the upper body. The dominant side was determined by the question of which hand they write with. A Strain Index, which was developed as a distal upper extremity physical exposure assessment, was calculated to assess the level of physical job exposure for each side. The Strain Index (Moore and Garg 1995) is the product of the multipliers of six domains (intensity of exertion, duration of exertion per cycle, efforts per minute, wrist posture, speed of exertion, and duration of task per day) for each side of the body. A higher score of the Strain Index indicates more strenuous physical exposure. To account for workers with multiple tasks, a time-weighted average was used for calculating the Strain Index (Bao et al. 2009). Log-transformed Strain Index in the dominant side was used for this analysis due to its skewness.

Job strain exposure

A modified version of the Job Content Questionnaire (JCQ) (Karasek 1985; Silverstein et al. 2006) was used to assess psychological job demands (five items, Cronbach alpha = 0.65) and job control (nine items, Cronbach alpha = 0.67). A job strain variable was created by computing the ratio of psychological job demands (score range: 12–48) to job control (24–98); in the ratio calculation, the job demand score was doubled considering the difference in scale scores (Landsbergis et al. 1994). Job strain ranged from 0.25 to 4.

Moderators

Job satisfaction (three items, Cronbach alpha = 0.81) and job security (two items, Cronbach alpha = 0.64) were measured by the adapted version of JCQ (Karasek 1985; Silverstein et al. 2006; Cullen et al. 2008). All responses were recorded using a four-point Likert scale (strongly disagree-1, disagree-2, agree-3, strongly agree-4). Total scores for job satisfaction and job security ranged from 3 to 12 and 2–8, respectively.

Mediator

A body map was used to measure MSUE in the right/left shoulder, right/left elbow/forearm, and right/left hand/wrist (Silverstein et al. 2006, 2010; Smith et al. 2009). The study defined MSUE as pain, aching, stiffness, burning, numbness, or tingling that occurred at least three times, or lasting a week or longer, in the past year. For those with MSUE, trained interviewers asked them about symptom intensity within the last 7 days using a five-point Likert scale rating (none, mild, moderate, severe, very severe) for each body part. The categories of severe and very severe were combined because few participants had very severe symptoms.

Since MSUE commonly involves symmetrical and clustered adjacent body parts (Walker-Bone et al. 2004), examining the effects of occupational factors on MSUE solely in a specific body region, such as the hand/wrist or shoulder, may not capture the overall impact. Therefore, a latent variable of MSUE (Cronbach alpha = 0.67) was constructed using symptom intensity from three body parts in the dominant side: shoulder, elbow/forearm, and hand/wrist.

Outcome variable

Information on work performance was collected only from workers with MSUE. Workers rated their ability to perform work tasks in the prior week using the four-item work module of the Disabilities of the Arm, Shoulder, and Hand (DASH) (Beaton et al. 2001). Each item was rated on a five-point Likert scale (No difficulty-0, Unable-4). Total scores were computed by multiplying the average of the item scores by 25; the score range was from 0 to 100, where higher scores indicated more impaired work performance. For workers who did not report MSUE that occurred at least three times or lasted a week or longer in the last year, zero was assigned to the variable score, assuming no lost work performance. Because the score was highly skewed and contained zeros, we added 1 and used a log-transformed score [ln(DASH work score + 1)] for the analysis.

Confounders

Gender, age, smoking status (never smoked, used to smoke, and current smoker), and comorbidities (a previous diagnosis of thyroid disease, diabetes mellitus, or rheumatoid arthritis) were included.

Statistical analysis

The analysis consisted of three steps: (1) confirmatory factor analysis and measurement invariance test for MSUE, (2) structural equation modeling (SEM) for the proposed model in Fig. 1, (3) moderation tests of job resources (i.e., job satisfaction and job security), and (4) sensitivity analysis using zero-inflated negative binomial regression. Missing data were found in multi-item measures assessing job strain ($n=40$), job satisfaction ($n=15$), job security ($n=16$), and MSUE ($n=3$). To prevent the loss of observed information from participants who answered some, but not all items within a scale, multiple imputation was conducted at the item level (Azur et al. 2011). The imputation was conducted by the R package *MICE* (van Buuren and Groothuis-Oudshoorn 2011), using predictive mean matching with the number of imputations being 5. A total summary score for each scale was computed after the missing values were replaced with the imputed values in the one of the five datasets.

Due to the skewness and kurtosis of MSUE variables, multivariate normal distribution did not hold. Therefore, MSUE from three body parts were treated as ordinal outcomes and the weighted least squares means and variance adjusted (WLSMV) estimator were used. The fitness of each model was examined based on the comparative fit index (CFI) ≥ 0.95, Tucker–Lewis Index (TLI) ≥ 0.95, and root mean square error of approximation (RMSEA) ≤ 0.05 (Kline 2015). Since females generally reported higher MSUE than males in other prior studies (Walker-Bone et al. 2004; Burton et al. 2008), there were concerns about differential response to measuring MSUE by gender. To ensure there was no measurement difference between males and females, the measurement invariance test for MSUE by gender was conducted by configural (equivalence of pattern of loadings), metric (equivalence of factor loadings), and scalar invariance (equivalence of item intercepts or thresholds). A difference Chi-square test with a scaled and shifted test statistic (Satorra 2000) was applied in this study because it was more robust than changes in approximate fit indices with WLSMV (Sass et al. 2014). Theses analyses were conducted using the open source R software version 4.2.1 (R Core Team, 2022) with *Lavaan* (Rosseel 2012) and *semTool*s (Jorgensen et al. 2020) packages.

SEM was constructed to examine the main effects of physical demands and job strain on MSUE and impaired work performance, regardless of the levels of job satisfaction and job security and the model adjusted for age, gender, smoking, and comorbidity status (Fig. 1). The fitness of the model was examined, and coefficients and their 95% confidence intervals (CI) were computed. To test for the moderation effect of job satisfaction, job satisfaction and three interaction terms (Job strain × Job satisfaction, physical demands × Job satisfaction, and the latent variable of MSUE × Job satisfaction) were included in the path analysis (Model 1). The same procedure was applied when testing the moderating effect of job security (Model 2). All analyses were conducted using *Mplus 8.8* (Muthén and Muthén, 2017).

There were many zero scores for MSUE (42% of participants) and impaired work performance (65% of participants), which may reflect two different processes from the count and the zero values. To better understand the moderating effect, we conducted zero-inflated negative binomial regression where there was a significant moderating effect, using only observed variables. Zero-inflated regression is appropriate when treating excessive zeros in the outcome by examining the relationship between the occurrence of the outcome and the degree of the outcome at the same time (He et al. 2014). Based on likelihood ratio test, zero-inflated negative binomial regression was selected over zero-inflated Poisson regression because of overdispersion. Instead of physical demands and the latent variables of MSUE in dominant side, we used the log-transformed sum of both sides of the Strain Index scores and the sum of the intensity of six body parts (range: 0–16), respectively. To make the continuous score of the DASH Work Module into an integer, the sum of the DASH Work Module score was used in this analysis (total DASH work scores/25 × 4), which ranged from 0 to 16. Odds ratios (OR) for zero-inflated part, mean ratios (MR) for count part, and bootstrapped 95% CI were reported. This analysis was performed using R software version 4.2.1 (R Core Team, 2022) with *pscl* (Jackman 2020) packages.

Results

Table 1 shows characteristics of participants. The mean age was 39 years, and most participants were male (52%), White (59%), high school graduates (48%), and never had been smokers (51%). Among the participants, 9% reported comorbidities such as thyroid disease, diabetes mellitus, and rheumatoid arthritis. The prevalence of MSUE in the last 7 days was 58% and the most common MSUE area was the right hand/wrist (34%), followed by the left hand/wrist (27%), the right shoulder (20%), and the left shoulder (14%). Information on the correlation matrix used in this study is available in Supplementary Table S1.

Measurement model of MSUE

For the latent variable of MSUE constructed by symptom severity in shoulders, elbows/forearms, and hands/wrists, the confirmatory factor model was saturated ($x^2(0)=0.00$). Table S2 displays the fit indices for the models that tested measurement invariance by gender. The initial model assessing configural invariance was saturated

Table 1 Characteristics of study participants ($n = 669$)[a]

Characteristics	*N* (%)	Mean (SD)
Gender		
Male	348 (52%)	
Female	321 (48%)	
Age (years)		39.4 (10.8)
Race/Ethnicity		
White	402 (60%)	
Asian	121 (18%)	
Hispanic	84 (13%)	
Others	62 (9%)	
Education		
Some high school or less	113 (17%)	
High school graduate	319 (48%)	
Some college or higher	237 (35%)	
Smoking status		
Non-smoker	330 (49%)	
Ex-smoker	140 (21%)	
Current smoker	199 (30%)	
Comorbidity (yes)[b]	60 (9%)	
Strain Index (range: 0.06–1053)		
Right		13.6 (26.1)
Left		11.6 (25.6)
Dominant side		13.9 (26.4)
Job strain (range: 0.25–4)		1.1 (0.3)
Job satisfaction (range: 3–12)		9.1 (2.1)
Job security (range: 2–8)		5.8 (1.2)
Region of MSUE in the last 7 days[c]		
None	284 (42%)	
Shoulder, right	136 (20%)	
Shoulder, left	94 (14%)	
Shoulder, dominant side	141 (21%)	
Elbow/forearm, right	71 (11%)	
Elbow/forearm, left	93 (14%)	
Elbow/forearm, dominant side	101 (15%)	
Hand/wrist, right	228 (34%)	
Hand/wrist, left	182 (27%)	
Hand/wrist, dominant side	232 (35%)	
DASH work module (range: 0–100)[d]		8.2 (14.9)
Zero score of DASH work module	438 (65%)	

[a]Missing data were found in job strain ($n = 40$, 6%), job satisfaction ($n = 15$, 2%), job security ($n = 16$, 2%), and MSUE ($n = 3$, 0.4%). This table displays the results after imputing for missing data using predictive mean matching

[b]Previous diagnosis of diabetes mellitus, rheumatoid arthritis, or thyroid disease

[c]MSUE: musculoskeletal symptoms in upper extremities. Symptom must be equal to or greater than a mild level. These categories are not mutually exclusive

[d]DASH: Disabilities of the Arm, Shoulder and Hand

($x^2(0) = 0.00$). Testing the metric invariance yielded a good fit, and the Chi-square increase was not significant compared to the configural model ($\Delta x^2(3) = 3.28$, $p = 0.35$). Similarly, the scalar invariance model produced an acceptable fit, and there was no significant Chi-square increase ($\Delta x^2(2) = 0.32$, $p = 0.85$) when compared to the metric invariance model.

The effect of job demands on MSUE and work performance

The model fit for this SEM was satisfactory with CFI = 0.99 (criterion: ≥ 0.95), TLI = 0.98 (criterion: ≥ 0.95), and RMSEA = 0.02 (criterion: ≤ 0.05) (Table 2). Higher job strain was associated with more severe MSUE (B [standardized coefficient] = 0.14, 95% CI: 0.03–0.25) and more impaired work performance (B = 0.10, 95% CI: 0.03–0.18) after adjusting for gender, age, smoking status, and comorbidity. Increasing MSUE was associated with greater impairment in work performance (B = 0.65, 95% CI: 0.53–0.76) after controlling for job strain, physical demands, gender, age, smoking status, and comorbidity. However, the effect of physical demands on MSUE and work performance was not significant ($p > 0.05$).

Moderating effect of job satisfaction and job security

A statistically significant moderating effect of job satisfaction was shown on the path between MSUE and impairment in work performance. As shown in Model 1 of Table 3, higher MSUE was associated with greater impairment in work performance (B = 1.14, 95% CI: 0.85, 1.44) while the effect (slope) of MSUE on impaired work performance was lower (less steep) as job satisfaction becomes higher (B = − 0.09, 95% CI: − 0.15, − 0.04). However, no significant group difference was found in the other paths: from job strain to MSUE, from physical demands to MSUE, from job strain to work performance, and from physical demands to work performance. In this model, higher job satisfaction was associated with lower MSUE (B = − 0.62, 95% CI: − 1.05, − 0.19) but the effect of job strain on MSUE (B = − 0.38, 95% CI: − 0.81, 0.05) and impaired work performance (B = 0.22, 95% CI: − 0.12, 0.56) was not statistically significant.

A moderating effect of job security was observed on the path between physical demands and MSUE (Model 2 of Table 3). Higher physical demands were associated with severe MSUE (B = 0.70, 95% CI: 0.19, 1.21) while the effect (slope) of physical demands on MSUE was weaker (less steep) among those with high job security (B = − 0.64, 95% CI: − 1.17, − 0.11). However, no significant group

Table 2 Effects of physical demands and job strain on musculoskeletal symptoms in upper extremities (MSUE) and work performance ($N=669$)[a]

Exposure	Mediator: MSUE		Outcome: impaired work performance[b]	
	β (95% CI)	B (95% CI)	β (95% CI)	B (95% CI)
Job strain	0.37 (0.08, 0.67)	0.14 (0.03, 0.25)	0.58 (0.15, 1.00)	0.10 (0.03, 0.18)
Physical demands	0.04 (− 0.02, 0.10)	0.08 (− 0.04, 0.19)	− 0.04 (− 0.12, 0.05)	− 0.04 (− 0.11, 0.04)
MSUE	–	–	1.37 (0.74, 0.95)	0.65 (0.53, 0.76)
Female (ref: male)	0.34 (0.18, 0.50)	0.27 (0.14, 0.35)	0.93 (− 0.21, 0.30)	0.02 (− 0.07, 0.10)
Age	0.02 (0.01, 0.03)	0.24 (0.17, 0.38)	− 0.01 (− 0.02, 0.01)	− 0.05 (− 0.13, 0.03)
Comorbidity (yes)[c]	0.03 (− 0.22, 0.29)	0.01 (− 0.09, 0.12)	0.05 (− 0.30, 0.40)	0.01 (− 0.06, 0.08)
Smoking status (ref: non-smoker)				
Ex-smoker	0.32 (0.13, 0.51)	0.19 (0.08, 0.29)	0.43 (− 0.74, − 0.13)	− 0.12 (− 0.20,− 0.04)
Current smoker	0.34 (0.16, 0.52)	0.22 (0.11, 0.33)	− 0.32 (− 0.60, − 0.03)	− 0.10 (− 0.19, − 0.01)
R-square	0.225		0.417	
Model fit indices	Chi-square = 18.79, degree of freedom = 16, *P*-value = 0.28 CFI = 0.99, TLI = 0.98, RMSEA = 0.02 (90% CI: 0.00–0.04)			

[a]*Ref* reference, *CFI* comparative fit index, *TLI* Tucker–Lewis Index, *RMSEA* root mean square error of approximation, β = unstandardized coefficient, *CI* = confidence intervals, *B* standardized coefficient

[b]This is log transformed of Disabilities of the Arm, Shoulder, and Hand (DASH) work score adding 1 [Ln (DASH work score + 1)]

[c]Previous diagnosis of diabetes mellitus, rheumatoid arthritis, or thyroid disease

Table 3 The moderating effect of job satisfaction and job security on the relationship of job factors, musculoskeletal symptoms in upper extremities (MSUE), and impaired work performance ($N=669$)[a]

M	Predictor	Mediator: MSUE		Outcome: impaired work performance[b]	
		β(95%CI)	B (95%CI)	β(95%CI)	B (95%CI)
1	Job strain	− 2.23 (− 4.73, 0.27)	− 0.38 (− 0.81, 0.05)	1.21 (− 0.67, 3.08)	0.22 (− 0.12, 0.56)
	Physical demands	0.51 (− 0.08, 1.10)	0.45 (− 0.06, 0.96)	− 0.14 (− 0.56, 0.29)	− 0.13 (− 0.53, 0.27)
	Job satisfaction	− 0.47 (− 0.80, − 0.14)	− 0.62 (− 1.05. − 0.19)	0.06 (− 0.17, 0.28)	0.08 (− 0.23, 0.39)
	MSUE	–	–	1.07 (0.66, 1.47)	1.14 (0.85, 1.44)
	Job strain × Job satisfaction	0.26 (− 0.02, 0.54)	0.41 (− 0.04, 0.85)	− 0.06 (− 0.26, 0.15)	− 0.09 (− 0.44, 0.25)
	Physical demands × Job satisfaction	− 0.05 (− 0.11, 0.02)	− 0.39 (− 0.93, 0.15)	0.01 (− 0.03, 0.05)	0.09 (− 0.30, 0.47)
	MSUE × Job satisfaction	–	–	− 0.04 (− 0.07, − 0.01)	− 0.09 (− 0.15, − 0.04)
	R-square	0.333		0.486	
2	Job strain	− 1.05 (− 3.86, 1.76)	− 0.17(− 0.62, 0.28)	0.58 (− 1.22, 2.37)	0.10 (− 0.22, 0.43)
	Physical demands	0.83 (0.19, 1.48)	0.70 (0.19, 1.21)	− 0.19 (− 0.61, 0.23)	− 0.18 (− 0.57, 0.21)
	Job security	− 0.20 (− 0.74, 0.35)	− 0.14 (− 0.53, 0.25)	0.01 (− 0.30, 0.33)	0.01 (− 0.25, 0.27)
	MSUE	–	–	0.74 (0.34, 1.14)	0.83 (0.48, 1.18)
	Job strain × Job security	0.35 (− 1.16, 0.85)	0.37 (− 0.16, 0.89)	− 0.01 (− 0.32, 0.30)	− 0.01 (− 0.38. 0.36)
	Physical demands × Job security	− 0.13 (− 0.24, − 0.02)	− 0.64 (− 1.17, − 0.11)	0.02 (− 0.05, 0.09)	0.14 (− 0.25, 0.52)
	MSUE × Job security	–	–	− 0.02 (− 0.06, 0.03)	− 0.03 (− 0.09, 0.03)
	R-square	0.251		0.471	

[a]Analyses adjusted for confounders (age, gender, smoking status, comorbidity), β unstandardized coefficient, CI confidence intervals, *B* standardized coefficient, *M* model

[b]This is log transformed of DASH (Disabilities of the Arm, Shoulder, and Hand) work score adding 1 [Ln (DASH work score + 1)]

difference was found in the other paths: from job strain to MSUE and from MSUE to impaired work performance. In addition, both job security and job strain did not show statistically significant association with MSUE and impaired work performance in Model 2.

Sensitivity analysis: the process of the moderating effect of job satisfaction and job security

Similar results were observed when conducting zero-inflated negative binomial regression using only observed variables (Table 4). As shown in Model 3, job satisfaction moderated the effect of MSUE on the occurrence of impaired work performance (OR: 0.92, 95% CI: 0.87–0.97) and on the degree of impaired work performance (mean ratio: 0.99, 95% CI: 0.97–0.99). Statistically significant interaction effects were found between physical demands and job security on the severity of MSUE (mean ratio: 0.94, 95% CI: 0.89–0.99) but not the occurrence of MSUE (OR: 0.95, 95% CI: 0.81–1.12) (Model 4).

Discussion

The purpose of this study was to examine whether job resources such as job satisfaction and job security moderate the impact of physical demands and job strain on MSUE and work performance. Job satisfaction and job security showed a moderating effect on MSUE and impaired work performance. Job satisfaction showed a moderation effect on the path from MSUE to work performance, and people with higher job satisfaction were less likely to experience impaired work performance compared to those with low job satisfaction. In addition, job satisfaction showed a significant effect on MSUE while job satisfaction did not moderate the effect of job strain or physical demands on MSUE. Meanwhile, job security showed a significant moderation effect on the path from physical demands to MSUE and workers with low job security experienced more harmful effect of physical demands on MSUE. Sensitivity analyses further explains these results. Job satisfaction moderated the effect of MSUE on both the occurrence and the degree of impaired work performance. Job security moderated the effect of physical demands on the severity of MSUE but not on the occurrence of MSUE.

Interestingly, the effect of physical demands did not show a statistically significant effect on MSUE and work performance in the SEM model. This may be because of the healthy worker effect. Participants reported that during the past 12 months, they moved to their current jobs to avoid more MSUE ($n=29$, 4%), missed work due to MSUE ($n=46$, 7%), had light or restricted work because of MSUE

Table 4 Sensitivity analysis of the moderating effect of job satisfaction and job security using zero-inflated negative binomial regression ($N=669$)[a]

Model	Predictors	Outcome: impaired work performance (IWP)[b]	
		Having IWP	The degrees of IWP
		OR (95% CI)	MR (95% CI)
3	Job strain	0.01 (0.00, 1.44)	0.32 (0.09, 1.20)
	Physical demands[c]	1.56 (0.75, 3.25)	1.24 (0.92, 1.67)
	MSUE[d]	1.18 (0.77, 1.79)	1.22 (1.08, 1.37)
	Job satisfaction	0.91(0.51, 1.61)	0.89 (0.74, 1.08)
	Job strain × Job satisfaction	1.46 (0.85, 2.52)	1.16 (0.99, 1.35)
	Physical demands[c] × Job satisfaction	0.95 (0.87, 1.02)	0.97 (0.94, 1.01)
	MSUE[d] × Job satisfaction	0.92 (0.87, 0.97)	0.99 (0.97, 0.99)
Model	Predictors	Outcome: MSUE[d]	
		Having MSUE	The severity of MSUE
		OR (95% CI)	MR (95% CI)
4	Job strain	0.38 (0.00, 58.30)	0.36 (0.07, 1.90)
	Physical demands[c]	1.15 (0.47, 2.85)	1.40 (1.00, 1.95)
	Job security	1.05 (0.45, 2.44)	0.83 (0.60, 1.14)
	Job strain × Job security	0.98 (0.44, 2.18)	1.27 (0.96, 1.69)
	Physical demands[c] × Job security	0.95 (0.81, 1.12)	0.94 (0.89, 0.99)

[a]This result was adjusted for age, gender, smoking status, and comorbidity. *MR* mean ratio, *OR* odds ratio, *CI* confidence intervals

[b]This is log transformed of DASH (Disabilities of the Arm, Shoulder, and Hand) work score adding 1 [Ln (DASH work score+1)]

[c]Physical demands are log transformation of the sum of the right and left job strain indices

[d]MSUE (musculoskeletal symptoms in upper extremities) was calculated as the sum of intensities in the six body parts including right/left shoulder, right/left elbow/forearm, and right/left hand/wrist

($n = 60$, 9%). While other studies showing the significant effect of physical demands on MSDs conducted a survival analysis to account for days exposed to physical demands (Garg et al. 2012; Harris-Adamson et al. 2015, 2022), this study did not. In addition, outcomes such as MSUE and work performance are more fluctuating and easily reversible (Gardner et al. 2014) than the diagnosis of MSDs and its disability. When workers had fully recovered from MSUE and its work limitation, the effect of physical demands on MSUE and work performance could be reduced. Conversely, the reason why the effect of physical demands on MSUE was significant in the model with job security may reflect that workers with low job security may delay taking sick leave or rest when they need to.

To our knowledge, no previous study has examined the role of job satisfaction as a moderator on the relationship between MSUE and work performance. Previous studies have shown that job satisfaction is significantly related to presenteeism (Rodríguez-Cifuentes et al. 2020), productivity loss due to health (Pereira et al. 2017), and intention to return to work after non-traumatic upper limb surgery (Peters et al. 2017). On the other hand, job satisfaction has also been investigated as an outcome in occupational stress research, indicating that high job strain and high physical demands decrease job satisfaction (Faucett 2005). The biopsychosocial model purports that the work environment plays a critical role in the relationship between MSUE and work disability. In addition, resourceful work environments aid workers in maintaining work performance despite impaired health, which enables workers to have positive presenteeism (Bergström et al. 2020; Karanika-Murray and Biron 2020). Since job satisfaction can reflect the employee's perception of the overall work environment, including both physical and psychosocial work factors, high job satisfaction may be indicative of a favorable work environment, which in turn can moderate the impact of MSUE on impaired work performance. For example, those with high job satisfaction may have more freedom to adjust their working conditions and job tasks to manage their symptoms. Previous qualitative studies (Bosma et al. 2020, 2019; Oakman et al. 2017) showed that workers with chronic disease experience difficulties ranging from disclosing their conditions to employers to getting job accommodations. Recently, flexible work arrangements such as taking time off and allowing changes in work schedule (Ray and Pana-Cryan 2021) were related to high job satisfaction and low work limitations. If workplaces have policies or practices that allow flexibility for workers to adjust their work schedules and make arrangements for them to carry out their job duties/tasks, workers with MSUE may be less compelled to disclose their work limitations to employers. Furthermore, they can continue working without loss of work performance and potentially have higher job satisfaction.

This study found that the negative impact of physical demands on MSUE was stronger among those who reported low job security. A similar relationship was observed in previous studies. In a study of female employees in poultry processing, job insecurity at the baseline was associated with increased risk of MSDs in the upper extremities at the follow-up (Lipscomb et al. 2008). High job insecurity was associated with frequent musculoskeletal symptoms among hospital workers (Nella et al. 2015) and with a higher prevalence of neck pain among U.S. workers in a national health interview survey study (Yang et al. 2016). A higher prevalence of low back pain was observed among temporary workers compared to full-time workers (Wami et al. 2019). In addition, this finding is consistent with studies indicating that workers with high job insecurity are more likely to go to work even when they have health conditions requiring sick leave (Heponiemi et al. 2010; Schmidt and Pförtner 2020). The uncertainty of job security may prevent workers from managing their MSUE because they may be reluctant to either take sick leave or ask for work accommodations or even request to change their job, especially during the busy season. Job insecurity is common among people with low socioeconomic status (Landsbergis et al. 2014), and it becomes more critical among manual workers, especially when they have limited specialized skills or live paycheck to paycheck (Sverke et al. 2002). Work conditions such as job insecurity, individual financial difficulties, and high job demands make people substitute absenteeism with presenteeism (Miraglia and Johns 2016; Kim et al. 2020; Aronsson et al. 2021). In this study, education level was not associated with job strain, but a difference was found for physical demands. Participants with less education were exposed to higher physical demands. Workers with a low education level may represent a low socioeconomic group that is more vulnerable to job insecurity and financial difficulties. This connection was supported by a study which found that low socioeconomic status was associated with work disability due to MSDs as well as a higher incidence of MSDs (van der Molen et al. 2018).

The findings of this study need to be interpreted with the following limitations. First, given that cross-sectional data were used, the temporality of variables does not hold and the exact directional association cannot be demonstrated. Second, this study used SEM, which requires strong assumptions. While this study waived multivariate normality because of the use of the WLMSL estimator, unmeasured confounders can incur bias and lead to biased conclusions. Third, the Strain Index measures physical impact on distal upper extremities but does not measure impact on shoulders. The present study utilized a 1995 version of the Strain Index that was subsequently corrected to account for a combination of long duration and low-frequency tasks, which may pose greater risk than a

combination of short duration and high-frequency tasks (Garg et al. 2017). Fourth, no record about testing the psychometric properties of the adapted JCQ (job demands, job control, job security, and job satisfaction) was found, which may compromise the validity and reliability of our results. Fifth, MSUE and work performance might have been underestimated in this study. The intensity of MSUE and level of work performance were collected only from workers who had symptoms at least three times or lasting a week or longer in the prior 12 months. Workers with MSUE who did not meet the case definition were regarded as symptom-free and as having no lost work performance. Due to this possible misclassification bias, the effect of physical demands and job strain on MSUE and impaired work performance might have been underestimated. Because of this limitation, the examination of the mediating effect of MSUE was not included in this study.

Nevertheless, this study has important strengths. First, physical demands were measured individually by experienced ergonomists unlike in many other studies in which physical demands were measured at a group level. Therefore, the physical demands measured in this study are closer to true physical demand exposures. Second, this study showed a high participation rate of 65%, where a selection bias may be of little concern. This may be because the facilities where the participants worked agreed to let them participate at the beginning of the study during normal work hours with no loss of pay or privileges.

In conclusion, this study demonstrated that job resources such as job satisfaction and job security may modify the effect of MSUE as well as the subsequent path leading to impaired work performance. MSUE is common and recurrent, and working with MSUE without appropriate accommodations or management of symptoms can lead to impaired work performance. Employers need to create favorable work environments for workers with MSUE by considering the beneficial effects of job security and job satisfaction on employees' health and work performance. Also, health care professionals should consider occupational factors when assessing patients with musculoskeletal symptoms and provide early intervention to those exposed to high physical and psychosocial job hazards. Furthermore, future studies need to call attention to populations with low job security and low job satisfaction.

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Author contributions All authors contributed to the conceptualization, design, and interpretation of findings for this secondary data analysis study. Material preparation and data collection were performed by SK and SB; SK conducted the statistical analyses and delineation of results, as well as drafted the initial version of the manuscript. JRH supervised the statistical analysis. All authors contributed critical revisions to the manuscript.

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Data availability The data are held at Safety and Health Assessment and Research for Prevention (SHARP) Program, Washington State Department of Labor and Industries. Procedures to access data from this study are available through contacting SHARP.

Declarations

Conflict of interest The authors declare no conflict of interest.

Ethical approval SHARP in the Washington State Department of Labor and Industries approved access to and use of the data. As de-identified data were used for this secondary analysis, this study was not subject to human subjects review by the University of Washington Human Subjects Division (Institutional Review Board).

Consent to participate Informed consent was obtained from all individual participants in the original study.

References

Aronsson G, Hagberg J, Björklund C et al (2021) Health and motivation as mediators of the effects of job demands, job control, job support, and role conflicts at work and home on sickness presenteeism and absenteeism. Int Arch Occup Environ Health 94(3):409–418. https://doi.org/10.1007/s00420-020-01591-w

Azur MJ, Stuart EA, Frangakis C, Leaf PJ (2011) Multiple imputation by chained equations: what is it and how does it work? Int J Methods Psychiatr Res 20:40–49. https://doi.org/10.1002/mpr.329

Baek K, Yang S, Lee M, Chung I (2018) The association of workplace psychosocial factors and musculoskeletal pain among Korean emotional laborers. Saf Health Work 9:216–223. https://doi.org/10.1016/j.shaw.2017.09.004

Bakker A, Demerouti E, Schaufeli W (2003) Dual processes at work in a call centre: an application of the job demands – resources model. Eur J Work Organ Psychol 12(4):393–417. https://doi.org/10.1080/13594320344000165

Bakker AB, Demerouti E, Euwema MC (2005) Job resources buffer the impact of job demands on burnout. J Occup Health Psychol 10:170–180. https://doi.org/10.1037/1076-8998.10.2.170

Bao S, Spielholz P, Howard N, Silverstein B (2006a) Quantifying repetitive hand activity for epidemiological research on musculoskeletal disorders - Part I: Individual exposure assessment. Ergonomics 49:361–380. https://doi.org/10.1080/00140130500520214

Bao S, Howard N, Spielholz P, Silverstein B (2006b) Quantifying repetitive hand activity for epidemiological research on musculoskeletal disorders - Part II: comparison of different methods of measuring force level and repetitiveness. Ergonomics 49:381–392. https://doi.org/10.1080/00140130600555938

Bao S, Spielholz P, Howard N, Silverstein B (2009) Application of the strain index in multiple task jobs. Appl Ergon 40:56–68. https://doi.org/10.1016/j.apergo.2008.01.013

Beaton DE, Davis AM, Hudak P, Mcconnell S (2001) The dash (disabilities of the arm, shoulder and hand) outcome measure: what do we know about it now? Br J Hand Ther 6:109–118. https://doi.org/10.1177/175899830100600401

Bergström G, Gustafsson K, Aboagye E et al (2020) A resourceful work environment moderates the relationship between presenteeism and

health a study using repeated measures in the Swedish working population. Int J Environ Res Public Health 17(13):1–14. https://doi.org/10.3390/ijerph17134711

Bernard BP, Putz-Anderson V, Burt S, Cole L, Fairfield-Estill C, Fine L et al (1997) Musculoskeletal disorders and workplace factors : A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back. US Dept of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Cincinnati (OH)

Bosma AR, Boot CRL, De Maaker M, Boeije HR, Schoonmade LJ, Anema JR et al (2019) Exploring self-control of workers with a chronic condition: a qualitative synthesis. Eur J Work Organ Psychol 28:653–668. https://doi.org/10.1080/1359432X.2019.1631801

Bosma AR, Boot CRL, Schaafsma FG, Anema JR (2020) Facilitators, barriers and support needs for staying at work with a chronic condition: a focus group study. BMC Public Health 20:1–11. https://doi.org/10.1186/s12889-020-8320-x

Bugjska J, Żołnierczyk-Zreda D, Jędryka-Góral A, Gasik R, Hildt-Ciupińska K, Malińska M et al (2013) Psychological factors at work and musculoskeletal disorders: a one year prospective study. Rheumatol Int 33:2975–2983. https://doi.org/10.1007/s00296-013-2843-8

Burton AK, Kendall NAS, Pearce BG, Birrell LN, Bainbridge LC (2008) Management of work-relevant upper limb disorders and the biopsychosocial model. Report No: RR596 Health and Safety Executive (UK) London

Cantley LF, Tessier-Sherman B, Slade MD, Galusha D, Cullen MR (2016) Expert ratings of job demand and job control as predictors of injury and musculoskeletal disorder risk in a manufacturing cohort. Occup Environ Med 73:229–236. https://doi.org/10.1136/oemed-2015-102831

Christensen JO, Johansen S, Knardahl S (2017) Psychological predictors of change in the number of musculoskeletal pain sites among norwegian employees: a prospective study. BMC Musculoskelet Disord 18:1–13. https://doi.org/10.1186/s12891-017-1503-7

Cullen JC, Silverstein BA, Foley MP (2008) Linking biomechanical workload and organizational practices to burnout and satisfaction. J Bus Psychol 23:63–71. https://doi.org/10.1007/s10869-008-9079-8

Da Costa BR, Vieira ER (2010) Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. Am J Ind Med 53:285–323. https://doi.org/10.1002/ajim.20750

Demerouti E, Bakker AB, Nachreiner F, Schaufeli WB (2001) The job demands-resources model of burnout. J Appl Psychol 86:499–512. https://doi.org/10.1037/0021-9010.86.3.499

Eatough EM, Way JD, Chang C-H (2012) Understanding the link between psychosocial work stressors and work-related musculoskeletal complaints. Appl Ergon 43:554–563. https://doi.org/10.1016/j.apergo.2011.08.009

Evanoff B, Dale AM, Descatha A (2014) A conceptual model of musculoskeletal disorders for occupational health practitioners. Int J Occup Med Environ Health 27:145–148. https://doi.org/10.2478/s13382-014-0232-5

Faucett J (2005) Integrating psychosocial factors into a theoretical model for work-related musculoskeltal disorders. Theor Issues Ergon Sci 6:531–550

Gardner B, Dale AM, Descatha A, Evanoff B (2014) Natural history of upper extremity musculoskeletal symptoms and resulting work limitations over 3 years in a newly hired working population. J Occup Environ Med 56:588–594. https://doi.org/10.1097/JOM.0000000000000179

Garg A, Kapellusch J, Hegmann K, Wertsch J, Merryweather A, Deckow-Schaefer G et al (2012) The strain index (SI) and threshold limit value (TLV) for hand activity level (HAL): risk of carpal tunnel syndrome (CTS) in a prospective cohort. Ergonomics 55:396–414. https://doi.org/10.1080/00140139.2011.644328

Garg A, Moore JS, Kapellusch JM (2017) The revised strain index: an improved upper extremity exposure assessment model. Ergonomics 60:912–922. https://doi.org/10.1080/00140139.2016.1237678

Gatchel RJ, Peng YB, Peters ML, Fuchs PN, Turk DC (2007) The Biopsychosocial approach to chronic pain: scientific advances and future directions. Psychol Bull 133(4):581–624. https://doi.org/10.1037/0033-2909.133.4.581

Harris-Adamson C, Eisen EA, Kapellusch J, Garg A, Hegmann KT, Thiese MS et al (2015) Biomechanical risk factors for carpal tunnel syndrome: a pooled study of 2474 workers. Occup Environ Med 72:33–41. https://doi.org/10.1136/oemed-2014-102378

Harris-Adamson C, Eisen EA, Kapellusch J, Hegmann KT, Thiese MS, Dale AM et al (2022) Occupational risk factors for work disability following carpal tunnel syndrome: a pooled prospective study. Occup Environ Med. https://doi.org/10.1136/oemed-2021-107771

Hauke A, Flintrop J, Brun E, Rugulies R (2011) The impact of work-related psychosocial stressors on the onset of musculoskeletal disorders in specific body regions: a review and meta-analysis of 54 longitudinal studies. Work Stress 25:243–256. https://doi.org/10.1080/02678373.2011.614069

He H, Tang W, Wang W, Crits-Christoph P (2014) Structural zeroes and zero-inflated models. Shanghai Arch Psychiatry 26(4):236–242. https://doi.org/10.3969/j.issn.1002-0829.2014.04.008

Herr RM, Bosch JA, Loerbroks A, van Vianen AE, Jarczok MN, Fischer JE et al (2015) Three job stress models and their relationship with musculoskeletal pain in blue- and white-collar workers. J Psychosom Res 79:340–347. https://doi.org/10.1016/j.jpsychores.2015.08.001

IJzelenberg W, Molenaar D, Burdorf A, (2004) Different risk factors for musculoskeletal complaints and musculoskeletal sickness absence. Scand J Work Environ Heal 30:56–63. https://doi.org/10.5271/sjweh.765

Jackman S. (2020) pscl: Classes and methods for R developed in the political science computational laboratory. United States Studies Centre, University of Sydney. https://github.com/atahk/pscl/

Joling CI, Blatter BM, Ybema JF, Bongers PM (2008) Can favorable psychosocial work conditions and high work dedication protect against the occurrence of work-related musculoskeletal disorders? Scand J Work Environ Heal 34:345–355. https://doi.org/10.5271/sjweh.1274

Jorgensen TD, Pornprasertmanit S, Schoemann AM, Rosseel Y (2020) semTools: Useful tools for structural equation modeling. R package version 0.5–3

Karanika-Murray M, Biron C (2020) The health-performance framework of presenteeism: Towards understanding an adaptive behaviour. Hum Relations 73(2):242–261. https://doi.org/10.1177/0018726719827081

Karasek R (1985) Job content questionnaire and user's guide. University of Massachusetts, Lowell (MA)

Kim J, Yoon J, Bahk J, Kim S (2020) Job insecurity is associated with presenteeism, but not with absenteeism: a study of 19 720 full-time waged workers in South Korea. J Occup Health 62(1):1–11. https://doi.org/10.1002/1348-9585.12143

Kivimäki M, Vahtera J, Ferrie JE, Hemingway H, Pentti J (2001) Organisational downsizing and musculoskeletal problems in employees: a prospective study. Occup Environ Med 58:811–817. https://doi.org/10.1136/oem.58.12.811

Kline RB (2015) Principles and practice of structural equation modeling. The Guilford Press, New York

Lachowski S, Choina P, Florek-Łuszczki M, Goździewska M, Jezior J (2017) Dissatisfaction with work as a risk factor of musculoskeletal complaints among foresters in Poland. Ann Agric Environ Med. https://doi.org/10.26444/aaem/80985

Landsbergis PA, Schnall PL, Warren K, Pickering TG, Schwartz JE (1994) Association between ambulatory blood pressure and alternative formulations of job strain. Scand J Work Environ Heal 20:349–363. https://doi.org/10.5271/sjweh.1386

Landsbergis PA, Grzywacz JG, Lamontagne AD (2014) Work organization, job insecurity, and occupational health disparities. Am J Ind Med 57:495–515. https://doi.org/10.1002/ajim.22126

Lang J, Ochsmann E, Kraus T, Lang J (2012) Psychosocial work stressors as antecedents of musculoskeletal problems: a systematic review and meta-analysis of stability-adjusted longitudinal studies. Soc Sci Med 75(7):1163–1174. https://doi.org/10.1016/j.socscimed.2012.04.015

Ledikwe JH, Kleinman NJ, Mpho M, Mothibedi H, Mawandia S, Semo B et al (2018) Associations between healthcare worker participation in workplace wellness activities and job satisfaction, occupational stress and burnout: a cross-sectional study in Botswana. BMJ Open. https://doi.org/10.1136/bmjopen-2017-018492

Lipscomb H, Kucera K, Epling C, Dement J (2008) Upper extremity musculoskeletal symptoms and disorders among a cohort of women employed in poultry processing. Am J Ind Med 51:24–36. https://doi.org/10.1002/ajim.20527

Lourenço S, Carnide F, Benavides FG, Lucas R (2015) Psychosocial work environment and musculoskeletal symptoms among 21-year-old workers: a population-based investigation (2011–2013). PLoS ONE 10:1–15. https://doi.org/10.1371/journal.pone.0130010

Lu CQ, Du DY, Xu XM, Zhang RF (2017) Revisiting the relationship between job demands and job performance: the effects of job security and traditionality. J Occup Organ Psychol 90:28–50. https://doi.org/10.1111/joop.12158

Lucas JW, Connor EM, Bose J (2021) Back, lower limb, and upper limb pain among U.S. adults, 2019, NCHS data brief

Mai HB, Kim J (2022) The role of job resources in the relationship between job demands and work-related musculoskeletal disorders among hospital nurses in Thua Thien Hue province Vietnam. Int J Environ Res Public Health. https://doi.org/10.3390/ijerph19084774

McGregor A, Sharma R, Magee C, Caputi P, Iverson D (2018) Explaining variations in the findings of presenteeism research: A meta-analytic investigation into the moderating effects of construct operationalizations and chronic health. J Occup Health Psychol 23(4):584–601. https://doi.org/10.1037/ocp0000099

Mehralizadeh S, Dehdashti A, Motalebi Kashani M (2017) Structural equation model of interactions between risk factors and work-related musculoskeletal complaints among Iranian hospital nurses. Work 57:137–146. https://doi.org/10.3233/WOR-172534

Miraglia M, Johns G (2016) Going to work ill: a meta-analysis of the correlates of presenteeism and a dual-path model. J Occup Health Psychol 21(3):261–283. https://doi.org/10.1037/ocp0000015

Moore JS, Garg A (1995) The strain index: a proposed method to analyze jobs for risk of distal upper extremity disorders. Am Ind Hyg Assoc J 5:443–458. https://doi.org/10.1080/15428119591016863

Muthén LK, Muthén BO (2017) Mplus: statistical analysis with latent variables: user's guide (Version 8) Los Angeles, CA

National Research Council, Institute of Medicine (2001) Musculoskeletal disorders and the workplace: low back and upper extremities. National Academies Press (US) Washington DC

Nella D, Panagopoulou E, Galanis N, Montgomery A, Benos A (2015) Consequences of job insecurity on the psychological and physical health of Greek civil servants. Biomed Res Int 2015:673623. https://doi.org/10.1155/2015/673623

Oakman J, Kinsman N, Briggs AM (2017) Working with persistent pain: an exploration of strategies utilised to stay productive at work. J Occup Rehabil 27:4–14. https://doi.org/10.1007/s10926-016-9626-5

Park J, Kim Y (2020) Association of exposure to a combination of ergonomic risk factors with musculoskeletal symptoms in Korean workers. Int J Environ Res Public Health 17:1–10. https://doi.org/10.3390/ijerph17249456

Pekkarinen L, Elovainio M, Sinervo T et al (2013) Job demands and musculoskeletal symptoms among female geriatric nurses: the moderating role of psychosocial resources. J Occup Health Psychol 18(2):211–219. https://doi.org/10.1037/a0031801

Pereira MJ, Johnston V, Straker LM, Sjøgaard G, Melloh M, O'Leary SP et al (2017) An investigation of self-reported health-related productivity loss in office workers and associations with individual and work-related factors using an employer's perspective. J Occup Environ Med 59:e138–e144. https://doi.org/10.1097/JOM.0000000000001043

Peters SE, Johnston V, Ross M, Coppieters MW (2017) Expert consensus on facilitators and barriers to return-to-work following surgery for non-traumatic upper extremity conditions: a Delphi study. J Hand Surg 42:127–136. https://doi.org/10.1177/1753193416669263

Ray TK, Pana-Cryan R (2021) Work flexibility and work-related well-being. Int J Environ Res Public Health 18(6):1–17. https://doi.org/10.3390/ijerph18063254

R Core Team (2022) R: A language and environment for statistical computing. R foundation for statistical computing, Vinnea, Austria

Rodríguez-Cifuentes F, Topa G, Fernández-Salinero S, Moriano JA (2020) Presenteeism, overcommitment, workplace bullying, and job satisfaction: a moderated mediation relationship. Int J Environ Res Public Health 17:1–13. https://doi.org/10.3390/ijerph17228616

Rosseel Y (2012) lavaan : An R package for structural equation modeling. J Stat Softw. https://doi.org/10.1837/jss.v048.i02

Rouquette A, Badley EM, Falissard B, Dub T, Leplege A, Coste J (2015) Moderators, mediators, and bidirectional relationships in the international classification of functioning, disability and health (ICF) framework: An empirical investigation using a longitudinal design and structural equation modeling (SEM). Soc Sci Med 135:133–142. https://doi.org/10.1016/j.socscimed.2015.05.007

Sass DA, Schmitt TA, Marsh HW (2014) Evaluating model fit with ordered categorical data within a measurement invariance framework: a comparison of estimators. Struct Equ Model 21:167–180. https://doi.org/10.1080/10705511.2014.882658

Satorra A (2000) Scaled and adjusted restricted tests in multi-sample analysis of moment structures. In: Heijmans RDH, Pollock DSG, Satorra A (eds) Innovations in multivariate statistical analysis. Kluwer Academic Publishers, London, pp 233–247

Schmidt K, Pförtner TK (2020) Job insecurity, sickness presenteeism and the moderating effect of workplace health promotion. J Occup Environ Med 62:937–942. https://doi.org/10.1097/JOM.0000000000001997

Silverstein BA, Viikari-Juntura E, Fan ZJ, Bonauto DK, Bao S, Smith C (2006) Natural course of nontraumatic rotator cuff tendinitis and shoulder symptoms in a working population. Scand J Work Environ Heal 32:99–108. https://doi.org/10.5271/sjweh.985

Silverstein BA, Fan ZJ, Bonauto DK et al (2010) The natural course of carpal tunnel syndrome in a working population. Scand J Work Environ Heal 36(5):384–393. https://doi.org/10.5271/sjweh.2912

Smith CK, Silverstein BA, Fan ZJ, Bao S, Johnson PW (2009) Psychosocial factors and shoulder symptom development among workers. Am J Ind Med 52(1):57–68. https://doi.org/10.1002/ajim.20644

Sverke M, Hellgren J, Näswall K (2002) No security: a meta-analysis and review of job insecurity and its consequences. J Occup Health Psychol 7:242–264. https://doi.org/10.1037/1076-8998.7.3.242

Tegenu H, Gebrehiwot M, Azanaw J, Akalu TY (2021) Self-reported work-related musculoskeletal disorders and associated factors among restaurant workers in gondar City, Northwest Ethiopia,

2020. J Environ Public Health 2021:1–9. https://doi.org/10.1155/2021/6082506
Tessema MT, Ready KJ, Embaye AB (2013) The effects of employee recognition, pay, and benefits on job satisfaction : Cross country evidence. J Bus Econ 4.
van Buuren S, Groothuis-Oudshoorn K (2011) Mice: multivariate imputation by chained equations in R. J Stat Softw 45(3):1–67
van der Molen HF, de Vries S, Sluiter JK (2018) Occupational diseases among workers in lower and higher socioeconomic positions. Int J Environ Res Public Health 15(12):11–16. https://doi.org/10.3390/ijerph15122849
Walker-Bone K, Reading I, Coggon D, Cooper C, Palmer KT (2004) The anatomical pattern and determinants of pain in the neck and upper limbs: an epidemiologic study. Pain 109:45–51. https://doi.org/10.1016/j.pain.2004.01.008
Wami SD, Abere G, Dessie A, Getachew D (2019) Work-related risk factors and the prevalence of low back pain among low wage workers: results from a cross-sectional study. BMC Public Health 19:1–9. https://doi.org/10.1186/s12889-019-7430-9
World Health Organization (2001) International classification of functioning, disability and health : ICF. World Health Organization, Geneva
Yang H, Hitchcock E, Haldeman S, Swanson N, Lu ML, Choi BK et al (2016) Workplace psychosocial and organizational factors for neck pain in workers in the United States. Am J Ind Med 59:549–560. https://doi.org/10.1002/ajim.22602
Zare A, Choobineh A, Hassanipour S, Malakoutikhah M (2021) Investigation of psychosocial factors on upper limb musculoskeletal disorders and the prevalence of its musculoskeletal disorders among nurses: a systematic review and meta-analysis. Int Arch Occup Environ Health 94(5):1113–1136. https://doi.org/10.1007/s00420-021-0165