Applied Ergonomics 43 (2012) 554–563

Contents lists available at SciVerse ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Understanding the link between psychosocial work stressors and work-related musculoskeletal complaints

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ARTICLE INFO

Article history:
Received 14 May 2010
Accepted 22 August 2011

Keywords:
Work-related musculoskeletal disorders
Occupational stress
Strain

ABSTRACT

It is well established that psychosocial work stressors relate to employees' work-related musculoskeletal disorder (WRMSD) symptoms. Using a model investigating psychological strain as a mediator between work stressors and WRMSD complaints, this study demonstrated that high levels role conflict, low job control, and low safety-specific leadership are associated with increased employee strain. Strain, in turn, was related to higher levels of WRMSD symptoms of the wrist/hand, shoulders, and lower back. Partial mediation of some relationships was also found, suggesting that additional meditational mechanisms for the relationships between stressors and musculoskeletal symptoms are plausible. This work supports the notion that psychosocial stressors in the work environment have important links to employee health, especially WRMSDs.

1. Introduction

Work-related musculoskeletal disorders (WRMSDs) affect tendons, tendons sheaths, muscles, nerves, bursae, and blood vessels in the body. Every year, more than 70 million physician office visits can be attributed to WRMSD-related complaints (Sobeih et al., 2006). Moreover, a conservative estimate puts the economic burden resulting from symptoms related to WRMSDs (including costs associated with workers' compensation, lost wages, and productivity) at $50 billion annually (Research Council and Institute of Medicine, 2001). Work-related musculoskeletal problems therefore represent a significant threat to employees' health and well-being across a wide range of industries and occupations.

One line of work in this area has focused on the physical demands of work that employees must perform. For example, in the healthcare sector, patient lifting, positioning, and transferring are physical tasks that are particularly demanding, and have been associated with nurses' WRMSDs and disability (e.g., Engels et al., 1996; Simon et al., 2008; Yassi et al., 1995). Similarly, for construction workers, physical job demands such as manual handling of heavy materials, awkward positions, and use of vibrating tools have been associated with high risk of WRMSDs (e.g., Latza et al., 2000; Sobeih et al., 2006). Retail and transportation workers often suffer from back injuries due to lifting and moving merchandise (Wassell et al., 2000). Taken together, biomechanical strain generated from physically strenuous tasks, awkward positions, and repetitive motions contribute to WRMSD complaints.

Lower back, hands, wrist, and shoulder WRMSDs are dominant in magnitude. Trunk and upper extremities have the highest prevalence of all WRMSDs (Bureau of Labor Statistics, BLS, 2007). Lower back injuries in particular comprise the most prevalent cause of absence from work out of the array of back/trunk problems (BLS, 2007). Furthermore, upper-extremity WRMSDs such as hand, wrist, and shoulder problems have become more prevalent over the past two decades, possibly due to increases in the widespread use of computer-based technology (Gerr et al., 1991). Thus, lower back, hands, wrist, and shoulder WRMSDs are of particular importance.

More recently, the psychosocial work stressors at work have been recognized as additional risk factors for WRMSDs (e.g., Lacey et al., 2007; Simon et al., 2008; Sobeih et al., 2006). For example, factors such as job dissatisfaction, lack of autonomy and social support, and high workload have been related to increased risk for WRMSDs (NIOSH, 1997; Sobeih et al., 2006). Similarly, high mental demands or pressure increased the risk for WRMSDs (Smith et al., 2004; Elovainio and Sinervo, 1997), especially when paired with low rewards (Simon et al., 2008). Additionally, lack of social support has also been shown to have negative impacts on risk for WRMSDs (Smith et al., 2004; Kaergaard and Andersen, 2000), as well as safety climate perceptions (Hofmann and Mark, 2006; Stone et al., 2007). Interestingly, Hollmann et al. (2001) found a three-way interaction between physical workload, mental job demand, and

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doi:10.1016/j.apergo.2011.08.009

control in predicting nursing home staff members' musculoskeletal symptoms. In particular, while control attenuated the association between job demand and symptoms when physical workload was low, it had little effect on the relationship between job demand and WRMSD symptoms when physical workload was high. Thus, psychosocial work stressors may have complex effects on WRMSDs beyond the simple bivariate relationships.

Unfortunately, although multiple theoretical models (e.g., Bonger et al., 1993; Faucett, 2005; Sauter and Swanson, 1996) exist in speculating the mechanisms underlying the associations between psychological factors and WRMSDs, research remains inconsistent in supporting hypotheses generated by different models (e.g., Swanson and Sauter, 2006; Wademan and Kjellberg, 2007). These conflicting research findings may be partly due to the lack of precision in the definition and measurement of the psychosocial aspects of jobs. Although most of the studies were couched on a job stress framework (e.g., Simon et al., 2008; Hollmann et al., 2001), very few directly tested the hypothesized pathway implied by the framework. Instead, effects of psychosocial work stressors (e.g., job demands, role conflict, lack of control, low levels of safety leadership) and strain (e.g., job dissatisfaction, negative mood, physical stress symptoms) were often lumped together (e.g., Smith et al., 2004; Yip, 2002), making it difficult to evaluate their relative impact on musculoskeletal symptoms. Additionally, few studies used established measures to assess psychosocial work stressors or strain, and instead opted for using single-item measures written specifically for the study (e.g., Smith et al., 2004; Swanson and Sauter, 2006). While these single-item measures may fit the purpose of a particular study, they can suffer from low reliability, imprecision, and narrowness of scope (Spector, 1992). Moreover, these studies typically examined only the bivariate relationships between psychosocial work stressors and musculoskeletal symptoms, rather than considering these variables within a more complex, stress process-based framework. Taken together, a direct test of a stress-based model that integrates established measures of psychosocial stressors, strain, and WRMSD symptoms can contribute to the literature by providing better understanding of the mechanisms linking psychosocial work stressors with musculoskeletal complaints.

The goal of the current study is to test a stress-based model that links psychosocial work stressors, strain, and WRMSD symptoms. We will first introduce the occupational stress model and explain how psychosocial work stressors are related to musculoskeletal complaints through psychological strain. Specific hypotheses based on the model will be presented. Results from structural equation modeling will be used test the proposed hypotheses.

This study contributes to the existing literature by approaching specific stressors and specific components of strain to better to evaluate their relative impact on particular musculoskeletal symptoms. Furthermore, this study examines relationships in a process-based framework, a fairly novel approach in this body of literature.

1.1. Occupational stress model

Occupational stress refers to the process through which employees perceive, appraise, and respond to adverse or challenging job demands at work (Frese and Zapf, 1988). The transactional approach suggests that the work environment and its stressors are assumed to cause strain responses by or in the person, and these strain responses have implications for workers' subsequent attitudes and behaviors (Lazarus, 1991). Two specific elements of the stress process are distinguished. The first element is the stressors, which are situational stimuli that evoke responses from employees. Responses may be adaptive (i.e., increased motivation; LePine et al., 2004) or maladaptive (i.e., psychological strain, Jex, 1998). Strain refers to individuals' maladaptive responses to environmental demands or stressors and may have emotional components (Beehr et al., 2000; Jex, 1998). When encountered with work stressors, employees may experience anxiety, tension, and feel overwhelmed by the amount of demands that they must fulfill. In other words, these emotional responses are representations of psychological strain. It should be noted that strain can also include physiological components such as hormonal or cardiovascular responses. However, the framework of the current study is focused on the psychological or emotional aspects of strain, from hence fourth referenced as "strain".

There are a variety of occupational stressors that have been reported to have associations with strain. These range from job characteristics, social relationships at work, job insecurity, and even acute events at work such as homicides. Based on a recent taxonomy of occupational stressors (Rosen et al., 2010) three main categories of psychosocial work stressors will be discussed and a selection of stressors incorporated into our model: work role stressors, job control, and social characteristics. These categories are selected as they represent relatively stable characteristics in the work environment. As a result, employees may have prolonged exposure to these psychosocial work stressors. Chronic exposure to stressors can make the development of WRMSDs more likely as they are often developed via repetitive motion or over exertion across a period of time.

Work roles refer to the set of responsibilities and authorities associated with a particular position (Jackson and Schuler, 1985). Role conflict is one stressor which falls into this category and refers to employees receiving incompatible role expectations from different members of the organization (e.g., supervisor, coworker; Rosen et al., 2010). Job control, or autonomy, refers to employees' ability to decide how and when to perform tasks and involvement in decision-making processes. Lack of control may elicit strain (Jex, 1998). Social characteristics are a set of stressors derived from interpersonal interactions, such as interpersonal conflicts, organizational politics, leadership styles, and abusive supervision.

One social characteristic stressor that may have direct ties to WRMSDs in particular is safety-specific leadership. Safety-specific leadership involves leaders' emphasizing the value of safe performance, setting goals for injury prevention, and rewarding safety-related compliance (Kelloway et al., 2006). Lack of safety-specific leadership can be conceptualized as a psychosocial work stressor for several reasons. First, poor safety-specific leadership may signal to employees a general environmental context that is unconcerned with employee safety and well-being. Furthermore, poor safety leadership is likely associated with scarce support for employees to help them cope with safety hazards and injuries. Poor safety policies and procedures can affect WRMSD risk through the design of jobs, work pace (i.e., work pressure), and the level of employee safety training. Employees who perceive poor safety leadership may also feel that they are under pressure to disregard formal policies and procedures designed to protect their safety and well-being. In fact, safety-specific leadership may have ties to both strain and WRMSDs as it have been previously shown to relate to severe muscle and back pain (Barling et al., 2002; Kelloway et al., 2006).

Existing literature supports that these psychosocial work stressors have significant relationships to employee strain responses (e.g., Jackson and Schuler, 1985; Spector and Jex, 1998). For example, empirical studies have demonstrated that role conflict, job control and leadership are associated with strain (e.g., Jex and Beehr, 1991; Siu et al., 2004; Spector, 1986; Spector and Jex, 1998). Role conflict has been shown to relate to employee strain responses (e.g., Jackson and Schuler, 1985; Spector and Jex, 1998). Similarly, control has been shown to relate to strain (Spector and Jex, 1998). Effective leadership

has been found to contribute to employees' well-being (Nielsen et al., 2008) and has been reported to have a relationship to emotional exhaustion and burnout (Cole and Bedeian, 2007; Hetland et al., 2007). However, safety-specific leadership in particular has not been widely studied in relation to strain, although is expected to have a negative relationship to strain. Furthermore, this type of leadership may be of particular relevance to WRMSDs. Recent studies have found that safety-specific leadership behaviors, such as emphasizing the value of safe performance, setting goals for injury prevention, and rewarding safety-related compliance, contributed positively to the reduction of accidents and various occupational injuries, including severe muscle and back pain, for workers in heterogeneous industries (Barling et al., 2002; Kelloway et al., 2006).

1.2. Psychosocial work stressors, strain, and WRMSDs

As described earlier, psychosocial work stressors relate to employees' WRMSD symptoms (NIOSH, 1997; Sobeih et al., 2006). One proposed model by Sauter and Swanson (1996), an ecological model of musculoskeletal disorders, is based on the notion that both physical and psychological factors in the work environment contribute to the experience of WRMSDs. Many parallels between this model and those in the psychosocial work stress literature exist. First, Sauter and Swanson suggest that work organization is directly associated with psychological strain which, in turn, influences musculoskeletal outcomes. Factors in the environment will elicit strain and this strain may have a direct impact on physical health. This idea is similar to the transactional stress model (Lazarus, 1991) as strain is one of the primary pathways by which the environment plays a role in health. Additionally, Sauter and Swanson discuss the experience of strain as an interpretive process which may be influenced by a variety of contextual and experiential factors. The transactional stress model also emphasizes the individual's appraisal in leading to the experience of strain. Furthermore, the ecological model suggests that the outcome of strain (WRMSDs) may interact with the environment to increase environmental stressors. WRMSDs can also then feed back to influence the amount of stress felt at work. Similar to this theoretical proposition, the transactional stress model (Lazarus, 1991) emphasizes the importance person-environment transactions. Thus, both the ecological model and the transactional model provide a similar foundation from which to empirically explore the role of strain as a mediator between psychosocial work stressors and WRMSDs.

One way by which Sauter and Swanson (1996) posit the mediation to occur is through physiological consequences of experiencing strain. There are several physiological explanations for why strain may play a mediating role between psychosocial work stressors and WRMSDs. First, strain may mediate the effect of stressors on WRMSDs due to increases in muscular tension when employees experience strain. The muscle tension and other autonomic effects in the body may then compound the biomechanical strain employees are under when performing task-related physical efforts. In fact, previous research has suggested that strain may have a direct effect on muscular tension. For example, in experiments where participants were subject to stress-inducing tasks, psychological strain responses such as anxiety have been linked with muscular tension (e.g., Krantz et al., 2004; Lundberg et al., 1994). Researchers have suggested that prolonged experiences of muscular tension may explain why psychosocial work stressors and strain are linked to WRMSDs (Krantz et al., 2004; Lundberg et al., 1999). In addition, strain may lead to an increased physiological susceptibility to WRMSDs by affecting hormonal, circulatory, and respiratory responses that exacerbate the impact of physical risk factors (Blair, 1996; Landsbergis et al., 1994; Schleifer and Ley, 1994). It is possible that strain mediates the relationship between psychosocial work stressors and WRMSDs because the biophysiological reactions associated with strain can add to the effects of physical demands by limiting the ability of the body to repair tissue after microtrauma (Carayon et al., 1999). Strain could also result in reduced blood flow to the extremities and to the muscles, increased blood pressure, increased corticosteroids, such as cortisol, fluid retention in body tissues, increases in peripheral neurotransmitters, such as norepinephrine, and reduced effectiveness of immune system responses which all contribute to risk for WRMSDs (Carayon et al., 1999). A final possibility is that strain reactions such as frustration and anger could lead to risky behavior (i.e., over exertion) that increases WRMSD risk (Smith and Carayon, 1996). Thus, strain may theoretically be a mediator between psychosocial work stressors and WRMSDs.

While there are many possible mediating mechanisms between strain and WRMSDs as described above, we did not test them directly in the current study. Rather, the current study will test a theoretical model that links stressors to work-based musculoskeletal complaints via psychological strain. The stress-based model is presented in Fig. 1, which is consistent with the transactional stress model (Lazarus, 1991) and the ecological model of musculoskeletal disorders (Sauter and Swanson, 1996) described earlier. Based on the theoretical mechanisms by which stressors relate to WRMSD symptoms, role conflict, control, and safety-specific leadership were selected for the model. Indicators of frustration, anger, anxiety, and depression were used to create a latent variable of strain similar to prior work using a latent variable of psychological strain (Korunka and Vitouch, 1999). These strain responses, in turn, are expected to lead to increased WRMSD complaints. As mentioned earlier, biomechanical demands such as physically strenuous tasks, awkward positions, and repetitive motions contribute to WRMSD complaints. In order to best isolate how psychological strain may mediate the relationship between psychological work stressors and WRMSDs, biomechanical demands must be accounted for. Because physical demands placed on employees are expected to impact reports of WRMSD symptoms, it is included as a control variable in our model.

1.3. Hypotheses

Hypothesis 1. (a) There will be a positive relationship between role conflict and work-related musculoskeletal complaints and (b) this relationship will be mediated by psychological strain.

Hypothesis 2. (a) There will be a negative relationship between job control and work-related musculoskeletal complaints and (b) this relationship will be mediated by psychological strain.

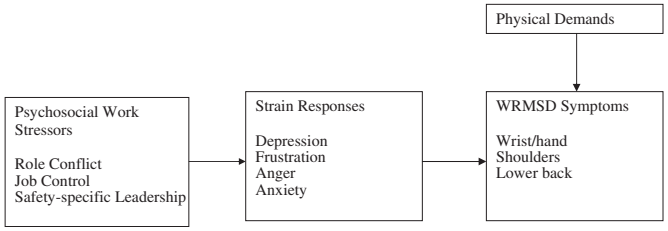

Fig. 1. Theoretical model linking psychosocial work stressors to WRMSDs through strain responses.

Hypothesis 3. (a) There will be a negative relationship between safety-specific leadership and work-related musculoskeletal complaints and (b) this relationship will be mediated by psychological strain.

2. Method

2.1. Participants and procedure

Data were obtained from 277 full-time employees. The majority of the participants were females (79%) and Caucasian (69%), or African American (10%). The average age of the participants was 24 years old ($SD = 6.6$). Participants had an average tenure of 3 years ($SD = 3.5$) in their present job and worked a minimum of 20 h per week. The majority of participants worked in retail/service (41%; e.g., customer service representative) and professional (14%; e.g., nurse) industries. A small percentage of participants worked in education (6%; e.g., teacher) or in a technical job (3%; e.g., computer programmer). Participants were recruited from working adults taking classes in a large university in southeastern US. Participants completed a web-based survey and received a $5 gift card for their participation. Institutional review board approval was obtained prior to conducting this study.

2.2. Measures

2.2.1. Demographic variables

Participants reported their sex, age, race, industry of employment, and job tenure.

2.2.2. Physical job demands

Participants' physical job demands were measured by the physical job demands of the Job Content Questionnaire (Karasek et al., 1998). The 7-item scale assesses the extent of physical exertion and awkward positioning required by the job. Participants responded to items on a 5-point Likert scale by rating whether they agreed or disagreed with the statement (1 = Strongly disagree; 5 = Strongly agree). An example item is "My job requires lots of physical efforts". The total physical job demands score was calculated by summing participants' responses on all items ($\alpha = .91$).

2.2.3. Safety-specific leadership

Participants rated their supervisor's safety-specific leadership using the 10-item safety-specific transformational leadership scale developed by Barling et al. (2002). The scale assesses the extent to which the supervisors set safety-specific goals for the followers, reward safety-related behaviors, and coach employees to perform job tasks safety. Participants responded to items on a 5-point Likert scale by rating whether they agreed or disagreed with the statement (1 = Strongly disagree; 5 = Strongly agree). An example item is "My supervisor behaves in a way that displays a commitment to a safe workplace". The scale score was calculated by summing the responses on these items ($\alpha = .94$).

2.2.4. Autonomy/control

Job autonomy and control were assessed using a scale adopted from the job diagnostic survey (Hackman and Oldham, 1974) and job decision latitude scale (Karasek, 1979). The 5-item scale assessed the extent to which participants feel they have control over how they perform their jobs, and whether they have opportunities to make decisions relevant to their job. Participants responded to the scale on a 7-point Likert scale (1 = Very inaccurate; 7 = Very accurate), and the scale score was calculated by summing the responses on these items ($\alpha = .89$). An example item is "This job allows me to make a lot of my own decisions".

2.2.5. Role conflict

Role conflict was assessed using scales developed by Rizzo et al. (1970). This scale has 8 items. Participants rated the extent to which they feel that the roles prescribed by their supervisors and other members of the organization are incompatible (role conflict) using the 5-point Likert scale (1 = Strongly disagree; 5 = Strongly agree). An example item is "I receive incompatible requests from two or more people". Scale scores were created by summing participants' rating on the items ($\alpha = .84$).

2.2.6. Anger, anxiety, and depression

Participants' anger (3 items), anxiety (4 items) and depression (6 items) were assessed by three subscales from the Brief Symptom Inventory 18 (Derogatis, 2003). Response choices ranged from 1 (never or a little) to 4 (most of the time). Participants' anger, anxiety, and depression scores were calculated by summing responses to the corresponding items ($\alpha = .87, .71, .82$, respectively). The stem question is "In the past three months, how did you feel in general at work?" and example items are "I get angry"; "I feel nervous"; and "I feel depressed", respectively.

2.2.7. Frustration

Participants' frustration at work was assessed by the Frustration with Work scale (Peters et al., 1980). The 3-item scale asks participants to rate their frustration at work using a 5-point Likert scale (1 = Strongly disagree; 5 = Strongly agree). An example item is "Trying to get this job done was a very frustrating experience". The score was calculated by summing participants' responses on the items. Of all the scales, the frustration scale was found to have a relatively low reliability ($\alpha = .41$). This could have effects on the results relating frustration to the other study variables.

2.2.8. Musculoskeletal complaints

Participants' musculoskeletal complaints for lower back, hands/wrists, and shoulders were measured by the standardized Nordic Musculoskeletal Questionnaire. Participants indicated whether they have had trouble with a particular area in their body in the past three months (yes and no). No responses were scored as 0 and no further questions were asked. If the respondent answered yes then participants were asked to answer a follow-up question. The follow-up question asked about whether the discomfort has prevented them from engaging in normal activities using a 4-point Likert scale (1 = Almost never; 4 = Almost always). Using this method, each participant was given a score from 0 (they had no trouble with this body part in the last three months) to 4 (1–4 was assigned depending on response to the follow-up question). The measure has been widely used for assessing musculoskeletal complaints (Kuorinka et al., 1987).

2.3. Data analysis

To test the proposed model, we formed latent constructs using the scale items or scale scores as indicators (Hall et al., 1999). Latent constructs are theoretical constructs in a structural equation model and are represented by circles in our path diagram illustrated in Fig. 2. For the exogenous variables (i.e., role conflict, control, and safety leadership), scale items were used as indicators for the latent factors. For psychological strain, the scale scores of anger, anxiety, depression, and frustration were used as indicators. WRMSD symptoms were modeled as observed, or manifest, variables and are represented by squares in our path diagram. One item was used

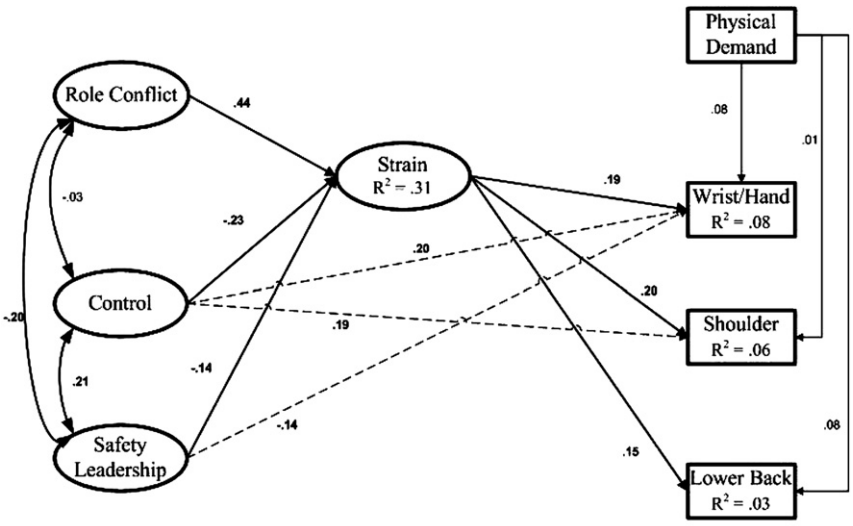

Fig. 2. Path diagram of final structural model. Note. Parameter estimates in bold are significant at $p < .05$. Item level indicators were used to create the latent stressor variables. Scale level indicators were used to create the latent variable of Strain. Loadings of indicators were omitted from the figure.

to measure the WRMSD symptoms at each area and this item was treated as the manifested score for each body area. These item and scale scores were used to evaluate measurement and structural models of relationships among focal constructs (Anderson and Gerbing, 1988). The structural equation model was tested using the TCALIS procedure in SAS 9.2 (Statistical Analysis Software) using maximum likelihood estimation. Model fit was assessed using Hu and Bentler's (1999) strategy, with the following cutoff values: values greater than .90 for the Comparative Fit (CFI) and Goodness of Fit (GFI) indices, .06 or below for the root mean squared error of approximation (RMSEA), and .08 or below for the standardized root mean square residual (SRMR).

3. Results

Table 1 reports the means, standard deviations, internal consistencies, and correlations among the focal variables. Each psychosocial work stressor was significantly related to at least one of the WRMSD symptoms. Consistent with our hypotheses, safety leadership was significantly related to wrist/hand ($r = -.14$) and lower back symptoms ($r = -.13$), and role conflict was significantly related to lower back symptoms ($r = .16$), thus providing partial support for Hypotheses 1a and 3a. Interestingly, control had positive, significant relationships with shoulder ($r = .14$) and wrist/hand symptoms ($r = .12$), which was opposite from our expectation. Thus, Hypothesis 2a was not supported.

3.1. Model testing

The first step in the analysis was to examine a confirmatory factor analysis model to test if the proposed factor structure was a good fit to the data. The results showed that the factor structure is a good representation of the latent factors in the data ($\chi^2_{(410)} = 855.97$, $p < .05$, SRMR = .07, GFI = .83, RMSEA = .06, CFI = .90). A test for common method variance was also conducted in order to rule out the possibility that the relationships among the variables in the study were solely due to self-report biases across all measures. Common method variance can result in artificial inflation of the relationships among variables. This test involved creating a single "method" factor, and loading all of the measured variables onto it at once. The resulting model showed very poor fit ($\chi^2_{(434)} = 2629.33$, $p < .05$, SRMR = .16, GFI = .51, RMSEA = .14, CFI = .49)., indicating that common method variance does not account for all of the relationships among the variables, although it cannot be ruled out completely as a contributor (Williams et al., 1989).

We next tested the proposed fully mediated model with employee perceptions of psychosocial stressors at work relating to strain, which in turn relates to WRMSD symptoms after controlling for reports of physical job demands. The hypothesized structural model (i.e., Full Mediation Model in Table 2) had reasonable fit (see Table 2). All focal variable path coefficients were significant. Furthermore, the control variable of self-reported physical

Table 1
Descriptive statistics and correlations among study variables.

Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1. Safety Leadership	35.08	8.37	(.94)										
2. Control	25.27	6.13	.19**	(.89)									
3. Role Conflict	22.93	6.21	−.20**	.00	(.84)								
4. Physical Demands	18.09	6.97	.14*	−.01	.29**	(.91)							
5. Depression	9.99	2.88	−.28**	−.26**	.29**	.09	(.82)						
6. Anxiety	7.06	2.15	−.08	−.09	.29**	.19**	.54**	(.71)					
7. Anger	5.45	1.78	−.13*	−.16**	.28**	.13*	.54**	.40**	(.87)				
8. Frustration	7.68	2.34	−.19**	−.03	.41**	.13*	.33**	.28**	.40**	(.41)			
9. Shoulder	.60	.84	−.09	.14*	.09	.03	.07	.05	.13*	.13*			
10. Wrist/Hand	.39	.8	−.14*	.12*	.09	.09	.15*	.14*	.04	.13*	.18**		
11. Lower Back	.84	1.03	−.13*	.03	.16**	.11	.07	.05	.09	.22**	.23**	.23**	

Note. ($N = 277$). *$p < .05$, **$p < .01$. Values in parentheses along diagonal are reliabilities for the scale.

Table 2
Model fit statistics.

	χ^2	df	$\Delta\chi^2$, df	SRMR	GFI	RMSEA	CFI
Full Mediation Model	910.26*	423		.07	.82	.06	.89
Partial Mediation Test of WH	897.36*	420	12.9*, 3	.07	.82	.06	.89
Partial Mediation Test of SHD	899.63*	420	10.7*, 3	.07	.82	.06	.89
Partial Mediation Test of LB	903.69*	420	6.6, 3	.07	.82	.06	.89
Final Model	888.94*	420	21.4*, 3	.07	.83	.06	.89

Note. $N = 277$, $^*p < .05$. SRMR = Standardized Root-Mean-Square Residual, GFI = Goodness of Fit Statistic, RMSEA = Root-Mean-Square Error of Approximation, CFI = Comparative Fit Index, WH = Wrist/Hand Symptoms, SHD = Shoulder Symptoms, LB = Lower Back Symptoms.

demands did not have significant path coefficients to any of the WRMSD symptom reports.

In order to assess whether any of the psychosocial work stressors were having direct effects on the WRMSD symptoms, a series of partial mediation models were tested. These partial mediation tests allowed us to examine whether strain fully accounted for the association between stressors and WRMSD complaints. The first partial mediation model tested whether the stressors had direct paths to reports of wrist/hand symptoms. This model showed a significant improvement in model fit compared to the fully mediated model ($\Delta\chi^2_{(3)} = 12.90$, $p < .05$). However, only the direct paths from control and safety leadership significantly predicted reports of wrist/hand symptoms, indicating that strain partially mediated the relationship between those psychosocial work stressors and reports of wrist/hand symptoms. The second partial mediation model tested whether the stressors had direct effects on reports of shoulder symptoms, and showed a significant improvement in model fit compared to the fully mediated model ($\Delta\chi^2_{(3)} = 10.70$, $p < .05$). Only the direct path from control significantly predicted reports of shoulder symptoms, indicating that strain partially mediated the relationship between control and reports of shoulder symptoms. Finally, the third model tested whether the psychosocial work stressors had direct effects on reports of lower back symptoms. This model did not show a significant improvement in model fit compared to the fully mediated model ($\Delta\chi^2_{(3)} = 6.60$, $p > .05$), nor was any of the direct paths from the stressors to reports of lower back symptoms significant. This suggested that strain fully mediated the relationships between the stressors and reports of lower back symptoms.

Taking the partial mediation results into account, a final model was tested that included the proposed mediation effects via strain, as well as all the significant direct paths emerged at the three partial mediation model tests. This model showed a significant improvement in fit compared to the fully mediated model ($\Delta\chi^2_{(3)} = 21.40$, $p < .05$), and all the direct paths from stressors to the symptoms remained significant.. Fit statistics for this model can be found in Table 2.

3.2. Model parameter estimates

Specifically, low safety leadership ($\beta = -.14$, $p < .05$) was associated with increased employees strain. Low job autonomy/job control ($\beta = -.23$, $p < .05$) was associated with increased employees strain. Role conflict ($\beta = .44$, $p < .05$) was associated with increased employees strain. Higher strain, in turn, were associated with an increase in wrist/hand ($\beta = .19$, $p < .05$) and shoulder symptoms ($\beta = .20$, $p < .05$) as well as lower back symptoms ($\beta = .15$, $p < .05$). Furthermore, control had direct, positive effects on wrist/hand symptoms ($\beta = .20$, $p < .05$) and shoulder symptoms ($\beta = .19$, $p < .05$). Safety leadership had a direct effect on wrist/hand symptoms ($\beta = -.14$, $p < .05$; see Fig. 2). As in the fully mediated model that was initially tested, the control variable of self-reported physical demands did not have a significant association with any of the reported WRMSD symptoms. Thus, we found full support for Hypothesis 1b, such that the relationship between role conflict and WRMSD symptoms was fully mediated by strain. In addition, partial support was found for Hypotheses 2b and 3b, such that effects of safety leadership and control were partially mediated by psychological strain.

4. Discussion

The purpose of the current study was to understand the link between psychosocial work stressors, strain, and the musculoskeletal symptoms in a stress processed-based model. By cleanly separating stressors from strains, relying on improved measures, and using sophisticated methodology to test the theoretical model, the current work provides a significant added value to the current literature in this area. Our methodology included mediation analyses using structural equation modeling while ensuring common method variance alone was not responsible for construct covariance. Our results suggested that high levels of various psychosocial work stressors (namely low safety leadership, low job control, and high role conflict) were associated with increased strain. Strain, in turn, was related to higher levels of WRMSD symptoms of the wrist/hand, shoulders, and lower back. These results were consistent when controlling for the physical demands of the job. The fact that self-reports of physical demands were not related to any of the physical symptom reports suggests that it may not be any physical demands of the job causing the symptoms, but rather the psychological work stressors and their resulting emotional strain. Furthermore, evidence of a partial mediation by strain between control and both wrist/hand symptoms and shoulder symptoms was found as well as a partial mediation between safety leadership and wrist/hand symptoms. These partial mediation effects suggest that there may be additional explanations regarding the mechanisms linking control and safety leadership to WRMSD symptoms. The results of the SEM model demonstrate that psychosocial stressors in the work environment can have meaningful links to employee health on both psychological and physical levels.

4.1. Theoretical and practical implications

Role conflict, job control and safety-specific leadership all had significant path coefficients to strain. In line with previous literature, role conflict was associated with increased levels of psychological strain. This supports the notion that inconsistent demands from multiple sources (i.e., multiple supervisors) can have a significant impact on employee psychological well-being. Furthermore, in line with previous work, job control was significantly related to strain such that lower levels of control were associated with higher levels of strain (Karasek, 1979). Finally, safety-specific leadership had a significant association with strain. This finding underscores a lack of safety-specific leadership as an occupational stressor that may elicit psychological distress in employees.

Further, strain fully mediated the association of role conflict with WRMSD symptoms, suggesting that the psychological states arising from role conflict are related to increases in WRMSD complaints. Our results suggest that low levels of role conflict may be associated with reduced levels of strain which in turn leads to fewer WRMSD complaints. This is in line Sauter and Swanson's (1996) ecological model of musculoskeletal disorders, suggesting that psychosocial work stressors contribute to higher reports of WRMSDs through their effects on psychological strain. This finding is also consistent with previous work demonstrating strain as an important precursor of musculoskeletal symptoms (Lim and

Carayon, 1993) and emphasizes the role of psychological distress in understanding how role conflict in one's job may contribute to poorer physical health.

Similarly, strain fully mediated the relationship between job control and lower back symptoms, and partially mediated the relationship between control and wrist/hand and shoulder symptoms. Higher levels of job control may protect employees from developing lower back pain by reducing the amount of strain employees are experiencing. It is possible the job control is related to reduced strain and subsequently, reduced muscle tension or other physiological reactions that put individuals at a greater risk for developing WRMSDs. Employees with higher job control are able to have more autonomy and thus take more breaks, providing relief to their muscles and reducing risk of developing WRMSDs. However, there were positive, direct linkages between control and wrist/hand and shoulder symptoms. This finding is consistent with previous research in that employees with high levels of job control are more likely to work in white-collar jobs in which computer work and typing is a primary and consistent task. In this case, employees are likely to develop WRMSD symptoms for their wrist/hand and shoulder areas (Sauter and Swanson, 1996). Thus, job control may function as a double-edged sword when it comes to WRMSD symptoms. While it may alleviate the discomfort associated with WRMSD through its relationship with lower psychological strain, control may have exacerbate musculoskeletal symptoms for certain areas. Thus, future research should focus more on exploring the role of job control and its relationship with WRMSDs.

Lastly, the relationships between safety-specific leadership and lower back and shoulder symptoms were fully mediated by strain, as expected. Greater levels of safety leadership may be associated with reducing employees' experience of strain thereby reducing risk of WRMSDs in these areas. However, evidence of a partial mediation of strain was found between safety leadership and wrist/hand symptoms, prompting the consideration of other mechanisms by which safety leadership is associated with wrist/hand symptoms. For example, safety-specific leadership may improve safety climate, safety consciousness, and reduce safety-related events (Barling et al., 2002). Leaders exhibiting more safety-specific leadership behaviors may help protect employees from productivity pressure (Barling et al., 2002) that may put employees at risk for developing WRMSDs, especially in the wrist and hand area by encouraging breaks from typing or using appropriate wrist supports. Additionally, low safety-specific leadership may be associated with generally poor physical ergonomic conditions, such as poor workstation design or tool design. Thus, there may be alternative mechanisms by which safety leadership is related to WRMSDs.

Our study demonstrates how WRMSDs are related to stressors and strains. However, in addition to psychosocial stressors and emotional strains, the interaction between psychosocial factors, technology, and job and work design should also be considered as significant contributor to WRMSDs. As such, apart from psychologists, WRMSD symptoms are of particularly important concerns for ergonomists, safety researchers, and human factors researchers. WRMSDs can be critical indicators of high underlying safety risks that could lead to more severe injury or future development of health issues. Therefore, WRMSDs reports could be used to inform the need for intervention.

In this case, we believe that it is of value to integrate our findings, which focuses on psychosocial stressors, with other relevant ergonomic interventions in order to generate a more comprehensive framework that improves WRMSDs from multiple angles. First, we suggest that our findings may be pertinent to participatory ergonomics (PE) approach. PE is a system that emphasizes the active involvement of employees in implementing ergonomic procedures, provides supervisor training on feedback seeking, and encourages employees to voice concerns. PE has been shown to reduce WRMSDs (Rivilis et al., 2008) and general physical symptoms (Nagamachi, 1995), perhaps by simultaneously improving ergonomic conditions and increasing an overall sense of control through its employee-centered system. Our results suggest that supervisory training may be a particularly effective method for reducing the prevalence of WRMSDs if the training focuses on two elements. First, supervisor training for safety-specific leadership can help supervisors to raise employee awareness of ergonomic standards, appropriate accommodations, and prevention of WRMSDs (i.e., Shaw et al., 2006). Second, supervisor training that promotes a supportive environment and fosters open communication regarding ergonomics and safety issues has been shown to reduce WRMSD disability (McLellan et al., 2001). Training specific to communication may improve how supervisors and employees work together to solve ergonomic issues.

Another key element of many effective interventions is job design (Nagamachi, 1995), either through a microergonomic approach (i.e., reducing workload), or through a macroergonomic approach (i.e., job redesign and organizational change). As noted in the balance model of stress reduction (Smith and Carayon-Sainfort, 1989), both job design and environmental stressors are important factors contributing to employee health. The organization can help maintain a balance (thereby keeping stress to a minimum) by regulating the number of demands that it places on the employees, both in terms workload and redesigning jobs to remove unnecessary or repetitive physical requirements. Our findings suggest that job or work system design efforts could potentially be maximized by seeking the input and feedback of incumbents. By including employees in the job design process, a reduction in work overload and role conflict could result through better information exchange. Also, employees may experience an enhanced sense of control when they were included in job design and other ergonomic interventions.

Thus, we encourage ergonomists, human factors specialists, and psychologists alike to treat WRMSDs as an important outcome in research. Future studies should explore these additional intervention strategies. In particular, our data suggest that supervisory training, direct reduction in psychosocial work stressors, and interventions that simultaneously improve upon psychosocial *and* ergonomic aspects of the job (i.e., participatory ergonomics or work system design interventions) have high potential for success in reducing WRMSDs in the workforce.

In sum, our findings support the idea that employee psychological strain can have important implications for employee health. Researchers should consider WRMSDs as additional outcomes when investigating stress at work. Furthermore, it is via the experience of psychological strain that some psychosocial work stressors are related to WRMSDs. This study demonstrates the profound effects that strain can have on employee well-being. Strain responses to environmental stimuli should be considered when investigating antecedents of WRMSDs. Future research in musculoskeletal disorders should include the study of workplace stressors as well as general psychological strain as potential contributors to severity and prevalence of symptoms. Organizations should be particularly aware of psychosocial stressors such as low safety leadership, low job control, and high role conflict because these stressors are related to employee strain which in turn may increase WRMSD symptoms. Simultaneous concern for job design and ergonomic conditions may be the most effective strategy. Organizations should work to reduce psychosocial work stressors and also reduce overall employee strain by seeking feedback from employees about work conditions, encouraging open communication between employees and the management,

and fostering a positive work environment. Creating a feedback rich environment at work (see Steelman et al., 2004) or implementing participatory ergonomics programs may be effective because adequate communication may improve the exchange of safety-related information. In addition, feedback opportunities, providing sufficient job autonomy, and organizational support to employees may increase control perceptions (Thompson and Prottas, 2006). Furthermore, effective training may be a practical way to reduce role conflict (House, 1982) and well as the implementation of quality of work life programs (Sirgy et al., 2008). Efforts to reduce work stressors may be particularly effective when combined with improvements to physical ergonomic conditions such as participatory ergonomics (Rivilis et al., 2008) and the reorganization of work environments to prevent WRMSDs (e.g., Wahlstedt et al., 1997).

4.2. Limitations and future research

One limitation of this study was the cross-sectional nature of the design, which makes causal interpretations of our current finding only speculative. Future studies should adopt a longitudinal design to better delineate the causal links between stressors, strain, and WRMSD symptoms. Also, the size of our sample may not have been large enough to reflect the true model fit given the number of variables included. Additionally, our sample consisted primarily of younger adults. Previous work has found stronger relationships between computer use and upper-extremity MSD symptoms in young adults compared with the general population (e.g., Katz et al., 2000; Noack-Cooper et al., 2009), therefore our sample may represent higher levels of upper-extremity symptoms than the general population. Additionally, our sample mostly consisted of workers from the retail and service industries. Thus, the overall prevalence rate and severity of their WRMSD symptoms may be lower than workers in other settings, such as manufacturing or healthcare. However, even with the low prevalence rate and severity of their injuries, we still found support for our hypothesized relationships among stressors, strain, and WRMSD symptoms in the current sample. As such, we believe that the relationship patterns demonstrated in the current study are likely to be lower bound estimates. We encourage future researchers to replicate the finding in a larger sample including older employees from industries that are highly susceptible to WRMSD injuries. Related to this, future work should consider focusing on vulnerable occupational groups that encounter the same physical demand, job design, and environmental conditions. Selecting one occupation of interest, such as nursing or customer service, is important for validating the model and its robustness within particular occupations. Finally, role conflict and physical demands had an unanticipated significant bivariate correlation. One explanation is that an unmeasured variable such as job level produced this spurious correlation. For example, lower level employees may perform more manual labor tasks and may also have more competing demands from multiple supervisors or managers. Future work should investigate how job level may play a role in the experience of physical demands and job stressors.

Next, we are unable to draw specific conclusions about the mechanisms underlying the observed relationships between strain and WRMSDs. Several explanations may account for the observed relationship such as physiological mechanisms (Sauter and Swanson, 1996), behavioral mechanisms (i.e., strain leading to maladaptive physical behavior; Smith and Carayon, 1996), or spurious factors (i.e., strain leading to exaggerated symptom reports; Sauter and Swanson, 1996). While the current study was able to establish the link between psychosocial work stressors, strain, and WRMSDS, future studies should explore the specific pathways by which strain may impact WRMSDs.

Some consideration should be given to the possibility of common method bias influencing our results due to the sole reliance on self-report measures. However, a structural model of the data using a single latent variable indicated that common method variance was not the main driving force behind the findings. While it should still be considered as a potential contributor to the correlations, we are convinced that common method variance alone is not explaining the relationships. Also, the frustration scale used had low internal consistency in this sample, but because of the statistical nature of structural equation modeling, this unreliability would only serve to attenuate the strength of the relationships.

Also, in order to expand upon the model, future studies should explore how individual differences variables, such as psychological hardiness and conscientiousness personality dimensions, may moderate the relationship between psychosocial work stressors and strain, possibly by buffering stressful experiences or increasing a person's attention to appropriate ergonomic posture or standards. In addition, expansion of this model could include organizational interventions aimed at increasing employee awareness of healthy computing and work habits or including supervisor training initiatives aimed at supporting their employees' efforts to avoid long-term repetitive stress injuries. Finally, additional psychosocial work stressors and susceptible areas of the body to WRMSDs should also be integrated in the model in order to expand upon the current findings.

4.3. Conclusion

In conclusion, this study demonstrates that high levels of psychosocial work stressors (high role conflict, low job control, and low safety-specific leadership) are associated with increased employee strain. Strain, in turn, related to higher levels of WRMSD symptoms of the wrist/hand, shoulders, and lower back. Partial mediation of some relationships was also found suggesting other explanations for the relationships are plausible. This work supports the notion that the psychosocial components of the work environment have important links to employee health, as assessed by WRMSDs. To maintain a healthy and productive workplace, organizations should work to reduce psychosocial work stressors which could result in high levels of strain and in turn, physical complaints in employees.

Acknowledgments

This work was partially funded by the National Institute for Occupational Safety and Health (NIOSH Training Grant No. T42 OH 008438) and conducted as a part of the Sunshine Education and Research Center at the University of South Florida. An earlier version of the paper has been presented at the 2010 Annual Meeting of the Academy of Management, Montreal, Canada. We would like to kindly thank Danesh Jaiprashad and Tom Bernard for their contributions to this project.

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