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Occupational safety: Application of the job demand–control-support model

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ABSTRACT

The utility of the job demand–control-support (JDCS) model for explaining psychological and physical well-being has been documented in a variety of settings. The current study's purpose was to assess the effectiveness of the JDCS model for predicting occupational safety well-being criteria (i.e., workplace injuries) based on two studies that employed samples of union blue-collar workers from two different regions of the United States. The JDCS model's buffer hypotheses were evaluated using hierarchical linear modeling. Both studies showed significant interactions between situational constraints and safety control to predict workplace injuries such that safety control buffered the negative effects of situational constraints. No significant three-way interaction between situational constraints, safety control, and safety climate on workplace injuries was found for either study. The implications of the present findings for both the JDCS model and occupational safety research are discussed.

1. Introduction

The prediction and prevention of workplace injuries are the seminal foci of research in the area of occupational safety (Smith et al., 2003). While earlier occupational safety research consisted mainly of the evaluation of safety intervention programs, more recent efforts have begun to apply other concepts well-established in the organizational psychology domain (e.g., perceived organizational support: Hofmann and Morgeson, 1999; transformational leadership: Barling et al., 2002) to the safety context. Given that efforts to use these organizational constructs and theories to predict occupational safety criteria (e.g., safety behaviors, workplace injuries) have yielded fruitful results, it seems worthwhile to investigate the applicability of other established psychological models to the safety domain.

The area of occupational stress is rich with theories and frameworks used to explain the process by which the characteristics of the work environment (e.g., job demands) interact with employee characteristics (e.g., skills) to affect psychological and physical well-being (Spielberger et al., 2003). Although the research area of occupational stress is subsumed along with occupational safety under the discipline of occupational health psychology, minimal work has actually been conducted to integrate the stress and safety areas. Those researchers that have incorporated the seminal work stressors (i.e., role ambiguity, role conflict, interpersonal conflict, time pressure, and workload) into occupational safety studies (e.g., Barling et al., 2002; Frone, 1998; Hofmann and Stetzer, 1996) have included them tangentially instead of focusing specifically on their effects. Furthermore, these studies that have examined the role of stressors in safety have largely produced either null or conflicting results.

By means of the two studies presented below, an attempt is made to apply a well-established occupational stress model to the examination of occupational safety phenomena. Specifically, the purpose of the current research is to examine the utility of the job demand–control-support (JDCS) model (Karasek, 1979; Johnson and Hall, 1988) and its corresponding buffer hypotheses for predicting the experience of workplace injuries.

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1.1. Overview of the JDCS model

The job demand–control (JDC) model put forth by Karasek (1979) coupled with the expanded JDCS model (Johnson and Hall, 1988) represent one of the fundamental and most cited theories in the research area of occupational stress (Spielberger et al., 2003). The models have been used to predict standard occupational stress criteria (e.g., burnout: Rafferty et al., 2001) as well as both work-related criteria (e.g., job dissatisfaction: Rodriguez et al., 2001) and criteria beyond the work context (e.g., cardiovascular disease: Kristensen, 1996).

Although the JDC model has been conceptualized and applied in many different ways, central to the model is the inclusion of three components, namely job demand, job control, and job strain (Karasek, 1979). While job demand refers to an independent variable that is a source of stress present in the work environment (e.g., workload), job control, or job decision latitude, represents an individual's opportunity to affect work activities, the work process, and the work environment (Karasek, 1979). Finally, job strain is defined as symptoms of mental strain that result in poor psychological and physiological well-being.

Using these three components of the model, a buffer hypothesis was proposed and has been the source of a considerable amount of research (Karasek, 1979; van der Doef and Maes, 1999). Specifically, the buffer hypothesis refers to an interaction between job demand and job control such that high levels of job control will buffer the negative effects of job demands on well-being, which result in job strain. Support has been found for the buffering effect of positive job control perceptions on the negative consequences of stressors on psychological and physical health (e.g., Ganster and Fusilier, 1989; Schaubroeck et al., 2001).

While discussing the JDC model, Karasek (1979) acknowledged that the model did not take into consideration "the impact of social relations at the group and organizational level" (p. 303). Johnson and Hall (1988) thus expanded the model to include a support component, labeled "work-related social support" and measured by assessing the extent to which participants interacted with coworkers (e.g., while working, while on break, outside of the workplace). Johnson and Hall (1988) also stipulated that along with control, support should also buffer the negative effects of job demand on well-being. Specifically, the buffer hypothesis for the JDCS model states that an interaction exists between job demand, job control and support such that support buffers the negative effect of high strain (i.e., high demand–low control) on well-being (van der Doef and Maes, 1999).

In 1985, Cohen and Wills reviewed the research that had examined whether work-related social support buffers the negative effects of stressors on strains. They found that evidence did exist that work-related social support served as a buffer. Since this review, other studies have also found that when under high levels of stressors, participants reported greater levels of well-being when work-related support is high compared to when it is low (Terry et al., 1994; Viswesvaran et al., 1999).

After reviewing the studies that examined the buffering effect of control specifically within the JDC framework, van der Doef and Maes (1999) concluded that mixed results existed with respect to the job-related well-being indices (i.e., job satisfaction, job-related psychological well-being, burnout) and suggested that the discrepancy in results was due to the fact that supportive studies were more likely to use more specific and better aligned measures of demand and control than studies achieving null results. Furthermore, van der Doef and Maes found that while several studies included all three components in the JDCS model (i.e., job demand, job control, and support), they did not test the interaction between all three variables. As a result, the authors called it premature to reach conclusions about the JDCS model's buffer hypothesis.

1.2. The JDCS model components in the safety context

1.2.1. Demand

In his original specification of the model, Karasek (1979) stated that job demands referred to "psychological stressors involved in accomplishing the work load, stressors related to unexpected tasks, and stressors of job-related personal conflict" (p. 291). For the most part, job demands have been measured by scales such as workload, time pressure, or role conflict (Karasek and Theorell, 1990; van der Doef and Maes, 1999); however, the predictive validity of these job demands (stressors) for occupational safety criteria has been mediocre at best. The problem is likely attributed to the fact that when used in occupational safety research, the job demand measures have often remained in the general work context (e.g., Hofmann and Stetzer, 1996) rather than achieving consistency in both the context (e.g., safety) and specificity of the model components as suggested by van der Doef and Maes (1999) to maximize the potential of the predictors to explain the criteria.

In their study of the JDCS model, Andries et al. (1996) specifically investigated the ability of "blue collar" stressors (e.g., physical work environment) to serve as the job demand component of the model instead of the psychosocial job characteristics typically examined. The authors found that physical demands were a better predictor of participants' health and safety risk when compared with psychological demands. Following this positive result with respect to the physical work environment, we contend that one of the most pertinent job demands within the occupational safety context is situational constraints.

Situational constraints represent job circumstances such as faulty equipment, incomplete or poor information, and interruptions by others that prevent employees from performing their work. Situational constraints are commonly identified job stressors (Spector and Jex, 1998) and have been shown to function similarly to other job stressors by being related to job performance, job dissatisfaction, and intention to quit (Spector and Jex, 1998; Villanova and Roman, 1993).

Situational constraints could have important implications for job safety and injury prevention, since a necessary circumstance to working safely is the presence of appropriate training, instructions, equipment, and other resources. As of yet, the role of situational constraints in predicting safety-related outcomes has not been investigated.

1.2.2. Control

Control (i.e., decision latitude) refers to one's perceived ability to control the work environment, work activities, and the outcomes of the work activities (Karasek, 1979; Karasek and Theorell, 1990). The job control dimension of the JDCS model has been assessed differently dependent upon the job demand or occupational context of interest (e.g., control over tasks, decisions, physical environment, resources; McLaney and Hurrell, 1988). Coinciding with the recent development of a safety control measure conducted by Anderson et al. (2004) and for the purposes of this study, safety control is defined as individual perceptions that employees possess influence over (1) the development of organizational safety practices and procedures, (2) the engagement in safety behaviors, and (3) the occurrence of workplace injuries in the current job.

Though Karasek (1979) and Johnson and Hall (1988) focused mainly on the buffering effects of control in the JDC and JDCS models, substantial evidence exists that high levels of control offer positive direct benefits for psychological and physical health (Ganster and Fusilier, 1989). Specifically, research has shown that high levels of control are related to less anxiety, burnout, and illness (Elsass and Veiga, 1997) as well as physical symptoms, emotional distress, and turnover (Spector, 1988). In fact, in his original work, Karasek (1979) observed that decision latitude possessed direct relationships with the strain indicators (e.g., exhaustion, depression, sick days) such that greater decision latitude was associated with less strain.

Coupled with the research investigating how control is related to stress outcomes, its associations with safety criteria have been examined in a few studies (Barling et al., 2003a,b; Geller, 2001), though limited effort has been made to fully develop a safety-specific control construct or offer theoretical mechanisms that explain why control perceptions may be related to safety criteria (for an exception, see Anderson et al., 2004). Given the substantial evidence of control's main effect on psychological and physical health as well as the preliminary evidence for its relationships with safety outcomes, it is likely that in the current study, safety control will not only serve as a moderator of the relationship between situational constraints and workplace injuries but also possess a significant direct relationship with workplace injuries.

1.2.3. Support

Within the occupational stress research area, support is most commonly conceptualized as social support provided by one's coworkers, supervisors, and subordinates (Spielberger et al., 2003; Viswesvaran et al., 1999). Several support variables, such as organizational support and general supervisory practices, have been previously investigated in occupational safety research (Andries et al., 1996; Hofmann and Morgeson, 1999).

In addition to the above individual-level support variables, safety climate can be conceptualized as a higher-level support construct and the subject of considerable occupational safety research. Safety climate is defined as employees' perceptions pertaining to safety practices, policies, and procedures as well as the relative importance of safe conduct at work when compared to other priorities such as productivity (Zohar, 1980, 2003). A positive safety climate suggests that the organization values employees on a personal level, supports their health and wellness, and chooses their safety over productivity when the two are at odds. Safety climate has been directly associated with an increase in safety behaviors (Hofmann and Stetzer, 1996; Hofmann et al., 2003), and a decrease in workplace injuries (Hofmann and Stetzer, 1996; Zohar, 2002).

1.2.4. Well-being

Although it appears that the bulk of studies examining the JDC and JDCS models use cognitive or affective well-being measures that are aligned with Karasek's (1979) original conceptualization of job strains (e.g., van der Doef and Maes, 1999), some research has utilized physical outcomes such as susceptibility to infectious disease (Schaubroeck et al., 2001) and cardiovascular disease (Johnson and Hall, 1988) when applying the models. In fact, Karasek (1979) did investigate the effects of job demands and job control on the more "objective" strain variables of pill consumption and sick-day absences with the purposes of demonstrating the general validity of the JDC model.

Since the purpose of occupational safety programs is to prevent employees from experiencing physical harm during the completion of their work tasks, the well-being criterion for the JDCS model in the safety context should be physical in nature, namely workplace injuries. Furthermore, the use of workplace injuries as the outcome of the JDCS model fortifies two of the methodological problems tainting the research on the model, as identified by van der Doef and Maes (1999). First, by using situational constraints as the job demand of interest and workplace injuries as the well-being criterion, there will be limited conceptual overlap between the job demand and well-being measures. Second, the use of workplace injuries allows for less likelihood of common method bias because of the physical nature of injuries (Spector, 1992), therefore, a standard concern for JDCS studies that employ affective outcome measures will be minimized.

1.3. Specification of hypotheses

Taken together, situational constraints, safety control, safety climate, and workplace injuries represent the work demand, control, support, and well-being constructs of the JDCS model in the safety context, respectively. First, the following relationships between situational constraints, safety control, and workplace injuries were hypothesized:

H1. A positive relationship will exist between situational constraints and workplace injuries.

H2. A negative relationship will exist between safety control and workplace injuries.

Second, based on the buffer hypothesis of the JDC model, it is hypothesized that safety control will interact with situational constraints to predict workplace injuries. Specifically,

H3. The strength of the positive relationship between situational constraints and workplace injuries will be weaker when safety control is high compared to when safety control is low.

Third, based on the buffer hypothesis of the JDCS model, it is hypothesized that safety climate will interact with situational constraints and safety control to predict workplace injuries.

H4. Safety climate will moderate the relationship between situational constraints and safety control in predicting workplace injuries. Specifically, the strength of the positive relationship of the high strain situation (i.e., high demand–low control) with workplace injuries will be weaker when safety climate is high compared to when safety climate is low.

1.4. Levels of analysis

Based on the definition of safety climate (i.e., shared perceptions), the targeted level of analysis for safety climate is higher than the individual level. Because of the contrasting nature of work conducted by the participants in Studies one and two, we focused on two different levels of analysis in Studies one and two. Specifically, the level of analysis for safety climate for Study one was the work unit. Zohar (2000) showed that safety climate perceptions could be successfully targeted at the group level instead of at the higher level of the organization. Additionally, the contractor, which is equivalent to the organizational level, served as the level of analysis for Study two. The organization has served as the level of analysis for safety climate as well as for other climate constructs (Reichers and Schneider, 1990). Since group-level (safety climate) and individual-level variables (situational constraints, safety control, workplace injuries) are both included in these studies, a cross-level model was specified. A cross-level model is one in which variables at one level of analysis are predicted to be related to variables at another level of analysis (Mossholder and Bedeian, 1983). In the case of these studies, the interactive effect of the group-level variable (safety climate) with individual-level variables (situational constraints, safety control) in predicting the individual-level criterion, workplace injuries, was the focus of the investigation.

2. Study one

2.1. Method

2.1.1. Participants

Assessment of the four variables of interest (i.e., situational constraints, safety control, safety climate, workplace injuries) was part of a larger survey administered during working hours to employees of the Facilities Department at a state university in the Midwest. Though a total of 424 employees completed the survey, certain criteria were used to determine whether a respondent would be included in the sample for this study. Specifically, to obtain as uniform a sample as possible with regard to experience of safety issues, only those respondents that belonged to a union were retained. This decision rule eliminated all participants that held administrative positions. Also, only those participants that provided complete data for the four variables of the study were included. Finally, respondents were retained if they belonged to a work unit that had a sufficient number of participants to provide a reliable estimate of safety climate at the unit level ($n = 3$; Hofmann et al., 2003). Collectively, using these decision rules resulted in a final sample of 253 participants. The respondents belonged to five different work units (i.e., food services, maintenance, distribution, moving, catering), and the numbers of respondents within each work unit ranged from 5 in catering to 176 in maintenance.

Of these, 61% were male, and their average age was 43 years old. With regard to ethnicity, 90% were Caucasian, 5% were Native American, 3% were African American, and the remaining 2% were Hispanic and Asian-Pacific Islander. Participants had worked at the university for an average of 10.27 years, possessed their current job for an average of 5.36 years, and worked with their current supervisor for an average of 2.64 years.

2.1.2. Measures

2.1.2.1. Situational constraints. Situational constraints were measured by using a modified version of the Organizational Constraints Scale developed by Spector and Jex (1998). One item was deleted from the original scale (i.e., inadequate help from others), and five additional items were generated based on safety critical incidents supplied by focus group participants, resulting in a total of 15 items. Sample items from the original scale and added scale portions are “incorrect instructions” and “improper work layout,” respectively. To place the demand measure in the safety context, traditional instructions were altered to read, “How often do you find it difficult to do your job *safely* because of the following situations?” Participants responded on the following six-point Likert scale: 1 = never to 6 = several times per day. Internal consistency reliability was .94, and this figure is consistent with the .85 estimate obtained by Spector and Jex (1998).

2.1.2.2. Safety control. The safety control measure was recently developed by Anderson et al. (2004). It contained seven items, and responses were made on a six-point Likert scale using the following options: 1 = strongly disagree to 6 = strongly agree. Respondents were instructed to consider their experience with safety in their current job. An example item is “I am able to modify work conditions in order to make them safer.” The internal consistency reliability was .74, and Anderson et al. reported an internal consistency reliability estimate of .77.

2.1.2.3. Safety climate. Safety climate was measured by using items developed by Mueller et al. (1999) and Gershon et al. (1995). Seventeen items were selected to represent five subscales, which focused on required work pace, social consequences of safe behavior, management’s attitude toward safety, incentives to behave safely, and the extent to which equipment and tools are readily available within the unit. The five subscales were combined to form one measure. Participants responded to each safety climate statement by using the following six-point Likert scale: 1 = not at all descriptive to 6 = completely descriptive. Internal consistency reliability was .91.

For this study, the targeted level of safety climate was the work unit, which has been used as the level of safety climate in prior studies (Hofmann and Stetzer, 1996; Hofmann et al., 2003; Zohar, 2000). Therefore, the safety climate items were written to focus on perceptions of the work unit and behaviors of the unit’s supervisor. Analyses were conducted to ensure that the necessary conditions were met to aggregate participants’ responses to the level of work unit. Specifically, within-group agreement was investigated to ensure that participants within the same unit shared similar perceptions of the unit’s safety climate. Analyses of within-group agreement based on the r_{wg} statistic resulted in acceptable levels of agreement (average $r_{wg} = .78$; James et al., 1993). In addition, a one-way analysis of variance (ANOVA) was conducted to determine whether significant between-group variance in safety climate existed, which would indicate that participants’ perceptions of safety climate differ between units within the same organization. This test also yielded a significant result, $F(4, 258) = 6.12$, $p < .05$. Taken together, the results suggested that participants’ responses could be aggregated to form a single climate score for each work unit.

2.1.2.4. Workplace injuries. Eleven items assessed the respondent’s experience of various injuries. The injuries included on the measure were extracted from scales used by Frone (1998) and Zohar (2000), and example items are “burn” and “dislocated joint.” Additional items were created based on information about common “consequences” (e.g., electrical shock) provided on safety critical incidents from the focus groups.

Respondents indicated whether they had experienced each injury since 1 January, which represented an approximate time span of 9 months. The timeframe of 9 months has been used in previous research (e.g., Frone, 1998), and providing a specific date may aid in the recall of injury experiences. Adapted from Spector and Jex’s (1998) response format for their symptoms scale, the injuries were assessed with the following five response categories: (1) No, I have not experienced this injury; (2) I have experienced the injury. However, I did not seek medical attention and did not miss work; (3) I sought medical attention but I did not miss work; (4) I had to miss work but I did not seek medical attention; and (5) I sought medical attention and also had to miss work. These response options in varying severity were used to capture all injury experiences instead of focusing on injuries resulting in a certain consequence (e.g., medical attention), which are characterized by extremely low base rates and limit the prediction of the model to a specific consequence. As such, a workplace injury score was created for each participant by summing all injuries that he had experienced during the past 9 months across all of the injury consequences. These items are considered causal indicators of workplace injury, because they are indicators of separate, albeit related, constructs. As a result, internal consistency is not a meaningful measure of scale reliability (Bollen and Lennox, 1991; Frone, 1998).

2.1.3. Procedure

2.1.3.1. Focus group. Three focus groups, which included representatives of the work units, totaling 27 participants (15 females and 12 males) were conducted to revise the measures of situational constraints and workplace injuries. Focus group participants completed a safety critical incident task where the participant described a negative safety experience by citing the context of the event, the

Table 1
Descriptive statistics and intercorrelations among Study one variables

Variable	Possible range	Obtained range	*M*	S.D.	1	2	3	4
1. Situational constraints	15.00–90.00	15.00–86.00	33.13	14.69	(.94)			
2. Safety control	7.00–42.00	14.00–42.00	28.88	5.32	−.27*	(.74)		
3. Safety climate	17.00–102.00	28.00–102.00	65.41	16.87	−.54*	.32*	(.91)	
4. Workplace injuries	0.00–11.00	0.00–9.00	1.60	2.23	.24*	−.06	−.08	[a]

Note: N = 253. All correlations are at the individual level. Internal consistency reliabilities appear in parentheses along the diagonal.

* $p < .05$.

[a] Reliability is not calculated for the workplace injury measure, as each type of injury represents a cause indicator and internal consistency is an inappropriate measure of reliability for a scale of this type (Bollen and Lennox, 1991).

job characteristic that caused the safety problem, and the consequence of the event. For example, an individual might report that he was installing a new electrical outlet (context) and a short deadline (job characteristic) caused him to rush when finishing the task. As a result, he suffered from an electrical shock (consequence). Information supplied as job characteristics (e.g., short deadlines) in the critical incidents was used to create additional items for the situational constraints measure. Also, recurring consequences, which mostly represented injuries, were incorporated into the measure of workplace injuries as described above.

2.1.3.2. Survey administration. The survey was administered during working hours, either while attending a regularly scheduled staff meeting or during a special meeting held specifically to complete the survey. Within the Facilities Department, there were a total of 720 employees considered to be potential participants. Of these, 424 employees served as participants by completing the survey. Of the remaining 296 employees, 16 individuals refused to complete the survey, and 280 individuals were not available during the survey administration for various reasons (e.g., absent, could not leave work). This resulted in an overall response rate of 59%.

2.1.4. Analytical approach

The variables and their corresponding data in the current study were multilevel in nature, with safety climate at the group level (level two) and situational constraints, safety control, and workplace injuries at the individual level of analysis (level one). As a result, hierarchical linear modeling (HLM; Raudenbush and Bryk, 2002) was used as the primary analytical technique. In particular, HLM is well equipped to evaluate cross-level interactions, such as hypothesis four in the current study. All analyses were conducted using HLM for Windows 5.02 (Raudenbush et al., 2000).

A random coefficient model with two levels was estimated for the dependent variable workplace injuries. At the first level, the main effects of situational constraints and safety control were estimated. The first level also estimated the interactive effect of situational constraints and safety control on workplace injuries (hypothesis three). At the second level, the main effect of safety climate, the two-way interactions between safety climate and the level-one variables (i.e., situational constraints, safety control) were included along with the three-way interaction between safety climate, situational constraints, and safety control (hypothesis four). When all of the variables, interactions, and errors are included, the following equation is estimated:

$$Y_{ij} = \gamma_{00} + \gamma_{01}W_j + \gamma_{10}X_{ij} + \gamma_{20}Z_{ij} + \gamma_{30}X_{ij}Z_{ij} + \gamma_{11}W_jX_{ij} + \gamma_{21}W_jZ_{ij} + \gamma_{31}W_jX_{ij}X_{ij} + u_{0j} + u_{1j}X_{ij} + u_{2j}Z_{ij} + u_{3j}X_{ij}Z_{ij} + r_{ij}$$

where Y represents workplace injuries, W represents safety climate, X represents situational constraints, and Z represents safety control. The level-one variables (situational constraints, safety control, product of situational constraints and safety control) were group-mean centered, and the level-two variable (safety climate) was grand-mean centered. This centering approach is recommended when a cross-level interaction is investigated (Hofmann and Gavin, 1998).

2.2. Results

Means, standard deviations, internal consistency estimates, and individual-level correlations for all of the study's variables are shown in Table 1. All variables possessed adequate reliability for subsequent analyses. Support for hypothesis one is found in Table 1, as a significant positive correlation was found between situational constraints and workplace injuries (r = .24), suggesting that greater amounts of situational constraints related to safety were associated with greater experiences of workplace injuries. As shown in Table 2, hypothesis two was not supported, since safety control was not significantly related to workplace injuries (r = −.06, $p > .05$). Additionally, logical relationships between safety climate, situational constraints, and safety control were obtained, although they were not specifically hypothesized. For instance, situational constraints related to safety possessed significant negative relationships with both safety climate and safety control (r = −.54 and r = −.27, respectively). Finally, safety climate and safety control were positively related (r = .32), suggesting that those individuals who perceived

Table 2
Random coefficients model predicting workplace injuries for Study one

Variable	γ	S.E. γ	*T*-ratio	*p*-Value
Level 1				
Intercept	1.957	0.293	6.680	.000
Situational constraints	0.213	0.126	1.686	.188
Safety control	−0.364	0.211	−1.721	.181
Situational constraints × safety control	0.004	0.002	2.336	.020
Level 2				
Safety climate	0.027	0.039	0.690	.540
Situational constraints × safety climate	−0.003	0.018	−0.176	.872
Safety control × safety climate	0.002	0.030	0.073	.947
Situational constraints × safety control × safety climate	0.000	0.001	0.349	.750

Note: N = 253.

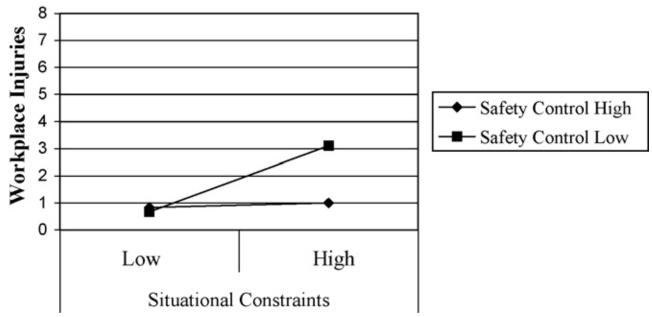

Fig. 1. Safety control as the moderator of the relationship between situational constraints and workplace injuries for Study one.

that their work units emphasized and prioritized safety were also likely to think that they could control whether they experienced injuries at work.

Table 2 shows a summary of the model and results used to test hypotheses three and four. Hypothesis three predicted a significant interactive effect between situational constraints and safety control to predict workplace injuries. The results presented in Table 2 support this hypothesis, with safety control significantly moderating the relationship between situational constraints and workplace injuries ($t = 2.34$, $p < .05$). The form of the interaction is presented in Fig. 1, with the points representing low and high levels of the variables referring to the values observed at one standard deviation below and above the mean for that variable, respectively.

Hypothesis three stated that the relationship between situational constraints related to safety and workplace injuries would vary dependent upon the level of safety control. This pattern is evident in Fig. 1, by examining the different slopes of the lines that represent low and high safety control. When compared to the relationship between situational constraints and workplace injuries for those who possessed low safety control perceptions, the relationship between situational constraints and workplace injuries was weaker for those participants with high safety control. Further analyses showed that the beta coefficient when regressing workplace injuries on situational constraints for those low in safety control was positive and significant ($\beta = .37$, $p < .05$), suggesting a relatively strong relationship between situational constraints and workplace injuries such that greater situational constraints were associated with more experiences of workplace injuries. On the other hand, situational constraints were not a significant predictor of workplace injuries when only those with high safety control perceptions were considered ($\beta = .10$, $p > .05$). These results provide support for hypothesis three and the prediction that high safety control may buffer the negative effects of situational constraints on workplace injuries.

Finally, hypothesis four predicted a significant three-way interaction effect between situational constraints, safety control, and safety climate to predict workplace injuries. The results presented in Table 2 show that the interaction was not significant, which fails to support hypothesis four.

3. Study two

3.1. Method

3.1.1. Participants

Participants in the second study were pipefitters in the construction industry that belonged to a local division of a trade union in a western state. Information about the study's variables was collected as part of a larger occupational safety survey. The local division's mailing list totaling 1056 active (not retired) full-status (journeymen, not apprentices) pipefitters was used for survey administration purposes. Returned mailings and telephone calls explaining that the recipients were no longer involved in the construction trade reduced the number of individuals to 1028. One hundred and fifty-one individuals returned usable surveys, resulting in a response rate of about 14.5%.

Consistent with the first study, only those participants that (1) provided complete data for the four variables of the study and (2) worked for a contractor that had a sufficient number of participants to provide a reliable estimate of safety climate at the contractor level ($n = 3$) were included. Collectively, using the decision rules resulted in 73 respondents being retained for this study's sample. Across these respondents, there were 10 contractor groups, and the numbers of participants in each contractor group ranged from 3 to 15. Of these respondents, 92% were Caucasian, 7% were Hispanic, and 1% were Native American. The average age of the respondents was 47 years, and the average amount of time working as a pipefitter, belonging to the union, and working for their current contractors were 21, 18, and 7 years, respectively.

3.1.2. Measures

3.1.2.1. Situational constraints. Situational constraints were measured with the same 15 items as well as the same instructions and response categories used in Study one. Internal consistency reliability was .93.

3.1.2.2. Safety control. The same seven-item safety control measure used in Study one was used with the same response scale. Participants were asked to consider their experience with safety in their job with their current contractor. The internal consistency reliability was .82.

3.1.2.3. Safety climate. Safety climate was measured with Mueller et al.'s (1999) safety climate subscale "management's attitude toward safety," based on the original scale construction efforts of Zohar (1980). The subscale includes twelve items (e.g., "contractor management is well informed about safety problems"), and participants responded to each item using the following six-point Likert scale: 1 = strongly disagree to 6 = strongly agree. Internal consistency reliability was .96. Using the same subscale of Mueller et al.'s (1999) measure, Hofmann et al. (2003) reported an internal consistency reliability of .94.

For this study, the targeted level of safety climate was the contractor, which is consistent with the level of organization in traditional climate studies (Zohar, 2003). The participants are pipefitters who belong to the trade union and are employed by commercial construction contractors. The union deploys a pipefitter to work for a specific construction contractor on a project-basis. Given the nature of commercial construction projects, the type and length of the project may vary considerably. As all of the participants are pipefitters working within the construction industry, a unique opportunity is present to examine the perceptions of individuals performing virtually identical jobs (pipefitter) at different organizations (contractors) within the same industry (construction). Additionally, focus group results (described in detail below) clearly showed that individuals perceived the various contractor employers to possess strikingly different safety policies and to engage in varying actions related to safety.

The safety climate items were written to focus on perceptions of the contractor and behaviors of contractor management. Note that the participants belonged to a trade union and subsequently worked as pipefitters for different contractors over the course of their careers. Though this is the case, the average amount of time that participants reported working for their current contractor (i.e., 7 years) suggests it is reasonable to conclude that each participant

Table 3
Descriptive statistics and intercorrelations among Study two variables

Variable	Possible range	Obtained range	*M*	S.D.	1	2	3	4
1. Situational constraints	15.00–90.00	15.00–61.00	33.48	10.80	(.93)			
2. Safety control	7.00–42.00	21.00–42.00	33.51	4.91	−.48*	(.82)		
3. Safety climate	21.00–126.00	59.00–125.00	102.32	16.15	−.49*	.59*	(.96)	
4. Workplace injuries	0.00–21.00	0.00–13.00	4.78	4.04	.38*	−.22	.34*	[a]

Note: $N = 73$. All correlations are at the individual level. Internal consistency reliabilities appear in parentheses along the diagonal.
* $p < .05$.
[a] Reliability is not calculated for the workplace injury measure, as each type of injury represents a cause indicator and internal consistency is an inappropriate measure of reliability for a scale of this type (Bollen and Lennox, 1991).

possessed ample time to develop contractor-specific safety climate perceptions. Similar to Study one, analyses were conducted to ensure that the necessary conditions were met to aggregate participants' responses to the level of contractor. The analyses of within-group agreement based on the r_{wg} statistic resulted in acceptable levels of agreement (average $r_{wg} = .98$; James et al., 1993), and the one-way ANOVA demonstrated significant between-group variation in safety climate perceptions, $F(9, 63) = 2.12$, $p < .05$. Therefore, the results of the analyses suggested that participants' responses could be aggregated to form a single climate score for each contractor.

3.1.2.4. Workplace injuries. In the case of Study two, the workplace injury measure included 21 items of various injuries. The first 11 items of the measure were identical to those used in Study one and based on the same sources as specified above. The additional 10 items were developed based on information provided during a focus group and represent frequent injuries experienced by individuals engaged in the job tasks of pipefitting in the construction industry (e.g., welding flash, carpal tunnel).

Respondents indicated whether they had experienced each injury since 4 July, which represented an approximate time span of 1 year. This timeframe has been used in previous research (e.g., Barling et al., 2002). The response options used in Study one were also used here in Study two. Also, the same summation methodology was used to determine the overall number of workplace injuries experienced by each participant that encompassed all levels of severity.

3.1.3. Procedure

3.1.3.1. Focus group. A focus group of pipefitter apprentices that did not participate in the survey provided information to revise the measures of situational constraints and workplace injuries. Specifically, nine apprentices in their fourth or fifth year of the 5-year apprentice program participated in a 2-h focus group. To finalize the measure of situational constraints, focus group participants reviewed the 15 items used in Study one and deemed them all pertinent and exhaustive as potential situational impediments in the work environment. Focus group participants were also provided with the workplace injury measure used in Study one and rated the relevance of each injury for the position of pipefitter using five response categories, ranging from definitely irrelevant (1) to definitely relevant (5). All of the original injuries included on the measure were retained, because the focus group participants found them all to be at least relevant (4). Additional injuries were also included on the finalized measure, which were suggested by the focus group participants as prevalent for a pipefitter. Examples of these additional injuries include welding flash and hearing loss.

3.1.3.2. Survey administration. A letter announcing the survey and expressing support for the survey by the union was mailed to all journeymen members. The study was also announced by the local safety officer at a monthly union meeting (about 100 member attendance) and on the local's job-line prior to the survey administration. One week after the announcement letter administration, survey packets were mailed to all active journeymen members. Two weeks after the survey packet administration, reminder postcards were mailed to all active journeymen members. Additional survey packets were mailed to those participants that called to request new surveys.

3.1.4. Analytical approach

The same analytical approach as that described above for Study one was utilized to test the hypotheses for Study two.

3.2. Results

Means, standard deviations, internal consistency estimates, and individual-level correlations for variables included in Study two are shown in Table 3. All variables possessed adequate reliability for subsequent analyses. Consistent with the results obtained for Study one, hypothesis one was supported with a significant positive correlation found between situational constraints and workplace injuries ($r = .38$). These results provide further evidence that greater amounts of situational constraints related to safety are associated with greater experiences of workplace injuries. Once again,

Table 4
Random coefficients model predicting workplace injuries for Study two

Variable	γ	S.E. γ	*T*-ratio	*p*-Value
Level 1				
Intercept	4.804	0.367	13.072	.000
Situational constraints	0.939	0.110	8.510	.000
Safety control	−1.126	0.104	−10.822	.000
Situational constraints × safety control	0.035	0.004	8.372	.000
Level 2				
Safety climate	−0.018	0.031	−0.570	.584
Situational constraints × safety climate	−0.036	0.010	−3.585	.008
Safety control × safety climate	−0.039	0.016	−2.507	.037
Situational constraints × safety control × safety climate	0.001	0.000	2.015	.078

Note: $N = 73$.

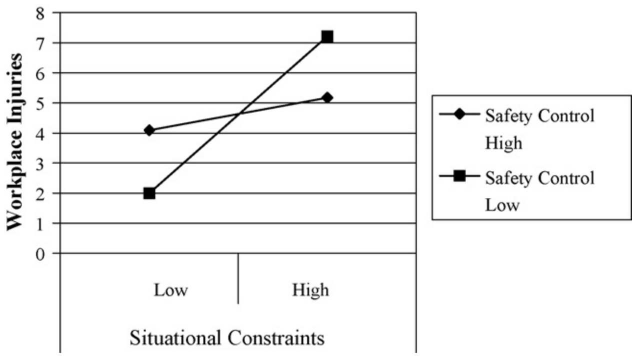

Fig. 2. Safety control as the moderator of the relationship between situational constraints and workplace injuries for Study two.

the results did not show support for hypothesis two, given the nonsignificant relationship between safety control and workplace injuries ($r = -.22$, $p > .05$). Similar logical relationships between the predictors (i.e., safety climate, situational constraints, and safety control) as those found in Study one were also obtained in Study two. Specifically, greater amounts of situational constraints related to safety were associated with poorer perceptions of safety climate and safety control ($r = -.49$ and $r = -.48$, respectively). Likewise, safety climate and safety control were again positively related ($r = .59$).

Table 4 shows a summary of the model and results used to test hypotheses three and four. Evidence to support hypothesis three is shown by the significant interaction effect of situational constraints and safety control on workplace injuries ($t = 8.37$, $p < .05$). The form of the interaction is presented in Fig. 2, with the points representing low and high levels of the variables referring to the values observed at one standard deviation below and above the mean for that variable, respectively. Once again, hypothesis three predicted that the relationship between situational constraints and workplace injuries would differ dependent upon the level of safety control. Specifically, the effect of situational constraints on workplace injuries is weakened when safety control increases, as shown in Fig. 2. Subsequent analyses showed that for the group labeled as low safety control, the relationship between situational constraints and workplace injuries was positive and significant ($\beta = .58$, $p < .05$). The analyses also showed that the same relationship for those with high safety control perceptions was nonsignificant ($\beta = .05$, $p > .05$).

Finally, the three-way interaction between situational constraints, safety control, and safety climate predicted by hypothesis four was nonsignificant, as shown in Table 4.

4. General discussion

The goal of the present research was to examine the applicability of the JDCS model to the occupational safety context by using safety-oriented components of the model to examine the model's buffer hypotheses. A strength of this research was the use of two independent samples and somewhat different measures (i.e., safety climate and workplace injuries) to examine the same phenomenon. Therefore, it is important to examine the results that were consistent between the two studies as well as those aspects that were different.

With respect to the safety-specific components of the JDCS model, an important contribution of this research, the levels and variation in the constructs across the two studies were relatively similar. For instance, the mean and standard deviation for situational constraints in Study one were 33.13 and 14.69 respectively, with Study two's statistics being 33.48 and 10.80, respectively. Indeed, an independent samples *t*-test revealed that the two samples did not differ in situational constraints ($t = -.23$, $p > .05$). Though the second sample did possess greater perceptions of safety control compared to the first sample ($t = -6.96$, $p < .05$), the construct was reliably measured and possessed adequate variation (S.D. = 5.32 and 4.91 for samples one and two, respectively) in both studies. These results are promising given that these studies represented the first adaptation of the situational constraints measure to the safety context, the safety control measure has received minimal exposure, and the two studies' samples were considerably distinct in the nature of their jobs (e.g., dining staff at a university in the Midwest vs. construction pipefitters in a trade union in the Rocky Mountain region).

More variation was observed in the experience of workplace injuries across the two studies, with a participant averaging 1.60 workplace injuries in Study one and 4.78 workplace injuries in Study two ($t = -6.46$, $p < .05$). These differences can be explained by the measure used in Study two containing 10 more items than the measure used in Study one (i.e., 11 items in Study one compared to 21 items in Study two). It should also be noted that the time reference used for the workplace injury measure in Study one was equivalent to roughly 9 months, while the time reference for Study two was about 1 year. Although a comparison about the quantity of workplace injuries experienced across the two studies is difficult to make given the differences in the measures, it is important to always consider the nature of the participants' job tasks and work environment when conducting occupational safety research and examining the experience or lack thereof of workplace injuries.

Regarding the actual research hypotheses, both studies found a strong positive relationship between situational constraints and workplace injuries, providing support for hypothesis one. This suggests that situational constraints do play an important role in the experience of workplace injuries. Additionally, both studies failed to find support for hypothesis two, which predicted a significant negative relationship between safety control and workplace injuries. In the case of hypothesis three, both studies found a significant interaction between situational constraints and safety control to predict workplace injuries. Based on the buffer hypothesis of the JDC model, hypothesis three specifically stated that safety control would moderate the relationship between situational constraints and workplace injuries by the relationship being weaker when safety control was high compared to when safety control was low.

Evidence of the moderating effects of safety control was presented both in Figs. 1 and 2 and in the comparison of the beta coefficients when the high and low safety control groups were isolated and workplace injuries were regressed on situational constraints. It is worthy to note that from looking at the two figures, it seems that safety control does a better job of buffering the negative effects of situational constraints on workplace injuries in Study one compared to Study two. The minor difference across the two studies in the buffering effect of safety control can be explained by the overall higher levels of safety control as well as the larger range and quantity of workplace injuries observed in Study two, as described above.

Additional information displayed in the two figures is worthy of comparison. For instance, both figures show that the group possessing high situational constraints related to safety and perceiving low safety control experienced the most workplace injuries (i.e., 3.10 and 7.21 for Studies one and two, respectively). Though not the focus of this research, this finding is consistent with another hypothesis put forth by Karasek (1979) during his specification of the JDC model. Namely, Karasek stipulated the strain hypothesis that predicted an increase in strain as job demands increase and job control correspondingly decreases, with the "high strain" job represented as the combination of high job demands and low job control. This hypothesis has been the subject of considerable research (e.g., de Lange et al., 2003; van der Doef and Maes, 1999), and the results of these two studies are supportive of the prediction.

Finally, both studies failed to find support for hypothesis four, namely a significant three-way interaction between situational constraints, safety control, and safety climate to predict workplace injuries. This prediction was based on the buffer hypothesis of the JDCS model such that safety climate should moderate the relationship between situational constraints and safety control in predicting workplace injuries. Specifically, the strength of the positive relationship between the high strain group (high situational constraints and low safety control) and workplace injuries should be weaker when safety climate is high compared to when safety climate is low. As stated above, participants experiencing high situational constraints and low safety control (the high strain group) did report the highest amount of injuries, but safety climate did not serve as a buffer in this situation. As reviewed above, minimal studies have appropriately tested the buffer hypothesis for the JDCS model with the three-way interaction, so little evidence exists for hypothesis four in the general work context much less in the safety context. While the two current studies did not find support for the three-way interaction, the value of the JDCS model in the safety context should continue to be examined, potentially with other support variables elaborated upon below. Until further studies more clearly determine the value of the support component of the model, the present research provided evidence for the JDC model in the safety context more so than the JDCS model.

4.1. Theoretical and practical implications

The findings of these studies have theoretical implications for both the JDC model and occupational safety research. The premiere theoretical implication for the JDC model is the applicability of the model to the safety context. The original hypotheses put forth for the JDC and JDCS models by Karasek (1979) and Johnson and Hall (1988), respectively, have been inspected in myriad settings, elaborated upon to include additional components, and examined with varying research designs over the course of the past 25 years. The present research contributed to the examination of the JDC and JDCS models by including the occupational safety context but also ensured that the model's components were "true" to its intended specifications and properly tested the model's hypotheses, two procedures that have not always been successfully accomplished in previous JDC and JDCS research (van der Doef and Maes, 1999).

With respect to the area of occupational safety, two major theoretical implications can be gleaned from the findings of this research. First, the discovery that situational constraints possess a role in occupational safety is worthy of recognition. This information is valuable, as no occupational safety study to date has examined the effects of situational constraints on safety outcomes to our knowledge. Given the strength of the relationships between situational constraints and workplace injuries observed in the two studies, the next step of understanding the mechanism by which situational constraints relate to workplace injuries (e.g., physically inhibiting safe behavior, psychologically affecting work motivation or concentration) would have additional theoretical value.

Second, the addition of a safety control construct is another theoretical contribution to the occupational safety literature. The current findings demonstrated that safety control can be reliably measured and is logically related to other occupational safety constructs. Also, the results of these two studies suggest that belief in the ability to control one's safety may offer benefits to individuals who are plagued by situational constraints. Further theoretical contributions can be made as research continues to examine how safety control relates to other occupational safety variables (e.g., safety-specific transformational leadership) and safety criteria (e.g., safety behaviors).

Additionally, some practical implications can be drawn based on the results of these studies. First, the relevance of situational constraints for occupational safety should be communicated to the management of organizations whose employees engage in dangerous job tasks. Management should set a priority to limit the extent to which situational constraints (e.g., faulty equipment) hinder employees. The type of constraint will likely dictate the intervention needed to minimize it (e.g., clearer communication channels to limit conflicting job demands). A component of situational constraints that should not be neglected is the role of perception. Organizational management should not only engage in overt actions to reduce situational constraints in the workplace but should also incorporate a discussion of employees' perceptions of situational constraints into regular planning and project meetings, to highlight the efforts the organization makes to limit situational constraints and ascertain what aspects of the work environment employees perceive as the most hindering.

Second, the finding that safety control may buffer the negative effects of situational constraints on workplace injuries can be targeted as another opportunity for practical suggestions. For instance, in the case when situational constraints are an inherent part of an employee's work environment or cannot be reduced substantially, as an alternative, efforts can be made to increase safety control perceptions. Since the construct of safety control as described in these studies focuses on perceptions about one's current job rather than stable perceptions across all work experiences, it can be postulated that first, safety control perceptions may be malleable and second, corresponding methods may be developed to alter safety control perceptions. These methods include but are not limited to a training program specifically designed to increase employees' own safety control perceptions, an on-the-job intervention where safety meetings are implemented that allow employees to suggest ways to change work practices or safety policies, and a supervisory training program where supervisors are taught how to increase employees' autonomy in their method during and decisions surrounding the completion of job tasks. The training program centering on control over workplace safety previously developed by Geller (2001) could serve as a resource when developing and delivering either the employee or supervisor focused safety control training program.

4.2. Limitations

These studies did possess some limitations, particularly as a result of response rate, using a single data source, and a cross-sectional design. While the response rate in Study one was quite high (59%), the rate in Study two was much lower (14.5%). This may be attributable to the fact that Study one was administered on-site whereas Study two was conducted via mail. In addition, participant responses were only included in the analyses if they met specific requirements, including returning complete data and being part of a unit that returned sufficient data to aggregate safety climate. Responses for both studies may thus favor employees who work in larger departments or contractor groups. In addition, responses in Study two may be representative of individuals who are particularly interested in or concerned about safety, as the survey in Study two was safety-specific, while the survey in Study one was more general.

We were unable to access union data that would allow comparison of the respondents from Study two to the entire population. However, the similarity in results across the two studies implies that any unique qualities of the sample did not substantially affect the findings.

In terms of using a single data source, participants provided all the information for the four constructs of interest (i.e., situational constraints, safety control, safety climate, and workplace injuries) in both studies. Though the use of a single data source does raise the possibility that the relationships between the constructs may be inflated because of common method bias (Crampton and Wagner, 1994), some evidence exists that the effects may vary dependent upon the nature of the constructs under investigation (Spector, 1992). For instance, Spector suggested that variables that are affective in nature or assess job conditions are of the most concern with respect to method variance.

While the situational constraints measure was an assessment of job conditions, the information included on the measure (e.g., lack of equipment) was more physical in nature compared to other types of job conditions (e.g., time pressure). Also, the response scale of the situational constraints measure was in terms of frequency instead of something more affective in nature such as agreement. Regarding safety control, it was necessary for the participants to provide their own beliefs about safety control given its definition of a participant's perceptions. Safety climate was also assessed via the participant's self-perceptions, which is consistent with the definition of safety climate being "shared perceptions." Additionally, the analyses for both studies showed that participants' safety climate responses were similar when they belonged to the same work unit or contractor as well as different when they belonged to different groups. These results suggest that the participants were actually reflecting on their work unit or contractor when completing the safety climate measure.

Finally, information about workplace injuries was also collected directly from the participants. This method of collecting information about workplace injuries is an appropriate method of data collection and has been used previously in occupational safety research (e.g., Barling et al., 2002; Frone, 1998). The nature of the workplace injury measure (i.e., recall of injury experiences within a certain timeframe and with specific consequences) also made it less susceptible to method effects. Furthermore, though organizational records of workplace injuries were not a feasible option for information in the case of these two studies, evidence does exist that these types of organizational records are often not as accurate as one would hope (Eisenberg and McDonald, 1988; Pransky et al., 1999).

It should also be noted that traditional research examining the JDC and JDCS models typically gathered all information from a single source because of the types of information of interest (e.g., workload, psychological well-being) (van der Doef and Maes, 1999). The studies described here with their safety-oriented constructs and more cognitive and behavioral focused measures possess less of a concern about common method bias than this more traditional research, which often included affective variables.

Another limitation inherent in both studies was the use of the cross-sectional design. By using this design, no causal inferences could be made regarding the effects of situational constraints, safety control, and safety climate on workplace injuries. While not the most rigorous methodology, the cross-sectional design is by far the most common research method used to examine the JDC and JDCS models (van der Doef and Maes, 1999). Now that preliminary evidence exists that the JDCS model may possess merit to explain the experience of workplace injuries, future research can utilize more rigorous research designs to test the model's hypotheses (de Lange et al., 2003).

5. Conclusion

Explaining and predicting the experience of workplace injuries represents one of the foremost purposes of occupational safety research (Smith et al., 2003). Taken together, the results of these two studies suggest that the JDC model represents a useful way to conceptualize how the work environment and an individual's perceptions may interact to relate to the experience of workplace injuries. Likewise, researchers should continue to seek ways to apply other areas of occupational health research to the prediction of occupational safety phenomena (e.g., safety behaviors, workplace injuries) and to re-conceptualize workplace injuries (e.g., strains) in novel ways. By applying these established theories and models, the current knowledge in organizational and occupational health psychology can be leveraged, a more clear and integrated picture of the "safety experience" will emerge, and interventions targeting those variables found to be most influential can be subsequently developed.

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