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Review paper

The relationship between psychosocial work characteristics and low back pain: underlying methodological issues

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Abstract

Objective. To evaluate the current epidemiological evidence linking psychosocial work characteristics with low back pain.

Background. Psychosocial work characteristics have been widely evaluated as potential risk factors for low back injury. However, studies with different study populations and using various types of measures have had conflicting results.

Methods. This review is the most extensive to date, reviewing 66 articles that have provided empirical evidence about the relationship between psychosocial work characteristics and initial reporting of lower back pain. The studies are reviewed with an emphasis on certain methodological issues: controlling for potential confounding; timing of the data collection; and measurement of the exposures and outcomes.

Results. The results of this review suggest that controlling for potential confounding from occupational biomechanical demands had a large influence on the associations found between psychosocial work characteristics and lower back pain. In addition, the use of accurate and reliable measures for the occupational exposures (biomechanical and psychosocial) and the lower back pain outcomes appears to influence the strength of the associations found between psychosocial work characteristics and lower back pain.

Conclusion. Given the methodological concerns discussed in this review, it is difficult to draw strong causal inferences from this literature. However, it does appear that psychosocial characteristics are related to some lower back pain outcomes, and that employees' reactions to psychosocial work characteristics (e.g., job dissatisfaction and job stress) are more consistently related to lower back pain than are the psychosocial work characteristics themselves (e.g., work overload, lack of influence over work, quality of relationships with coworkers).

Relevance

This review attempts to identify and address methodological issues in the literature evaluating the relationship between psychosocial work characteristics and lower back pain. Implications for future research are presented.

Keywords: Prospective; Musculoskeletal disorders; Biomechanics; Epidemiology

1. Introduction

Low back pain (LBP) has been found to affect more workers and result in higher costs to industry than any other musculoskeletal disorder [1–4]. Traditionally, the most widely investigated occupational risk factors for LBP have been biomechanical demands of the job [5–10]. In more recent years, psychosocial characteristics of work have been investigated as potential risk factors for LBP [11]. Each of these approaches has provided some evidence about the complex relationships among work tasks, workplace environment, and LBP. A conceptual model of the potential relationships among psychosocial work characteristics, biomechanical work demands, and LBP is presented in Fig. 1. Psychosocial factors (see pathway a) and biomechanical factors (see pathway b) may independently contribute to the etiology and progression of LBP. Psychosocial factors may also influence the relationship between biomechanical factors and LBP (see pathway c), such that biomechanical demands have a greater effect on LBP under poor psychosocial work conditions. Additionally, poor psychosocial character-

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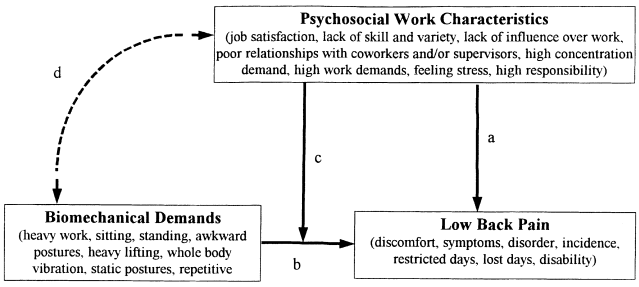

Fig. 1. Conceptual model of the relationship between psychosocial and biomechanical risk factors and LBP.

istics and high biomechanical demands may covary (e.g., tend to concentrate in similar jobs and occupations). This covariation (see pathway d) raises the possibility of confounding if both types of risk factors are not accounted for in risk models. Until fairly recently, biomechanical demands and psychosocial work characteristics were rarely investigated as risk factors for LBP within the same study.

The biomechanical approach has been based on the premise that physical aspects of the job contribute to LBP. Biomechanical factors have been hypothesized to cause LBP through two mechanisms: excessive load and repetitive loading on the spinal structures. Excessive loads can result from lifting heavy loads, awkward postures, and high trunk velocities [12–19] while repetitive loading results from an elevated number of lifting cycles over long periods of time [7,8,10,20].

Biomechanical factors such as lifting, awkward postures, static postures, repetitive trunk motions, whole-body vibration, and heavy loads have been found to be risk factors for LBP [21–29]. Loads on the spine that accompany the above risk factors have also been found to be moderately associated with LBP [10,30].

The psychosocial approach is based on the premise that social aspects of the work environment and psychological demands of work contribute to LBP. This approach has its intellectual roots in the occupational stress literature which has established the effects of exposure to psychosocial stressors on numerous health outcomes [31,32]. Psychosocial stressors are conditions that are likely to be perceived as harmful, threatening, or bothersome [33] or that place a demand on employees that results in a physiological adaptational response [34]. Examples of psychosocial stressors include work overload, role ambiguity, interpersonal conflict, having responsibility for the well-being of others, lack of opportunity for advancement, and having little say in decisions that affect one's work [31,35]. Models of occupational stress also contend that characteristics of the social environment (e.g., the extent to which social support is available from coworkers and supervisors) influence employees' health, well-being, and ability to cope with stressors [32].

Perhaps due to the high prevalence of LBP, the extensive associated financial and human costs, and the complexity of the etiology of LBP, this area has generated intense research interest over the last several decades. Recently, several review articles have attempted to summarize the studies of LBP risk factors more broadly [22–28] and of psychosocial risk factors more specifically [11]. This comprehensive review attempts to update our knowledge regarding psychosocial occupational risk factors for first time reports of LBP and to highlight methodological issues that should be addressed in order to further enhance our understanding of the influence of psychosocial work characteristics on LBP.

1.1. Potential causal mechanisms linking psychosocial work characteristics and LBP

The mechanisms through which psychosocial work characteristics might contribute to LBP are not clearly understood. Several different mechanisms have been hypothesized. Because these mechanisms represent quite different points of view and have different implications for intervention, a brief summary of the leading hypotheses is provided. First, it has been hypothesized that psychosocial factors are directly related to LBP by influencing the *loading on the spine* via changes in trunk kinematics, the forces exerted, or muscle activity [11,36]. Support for this premise can be provided by studies that use physiological measures of LBP. For example, Bergenudd and Johnell [37] found that symptomatic individuals with physical signs of LBP as determined by a physical examination (tenderness under palpation and loss of range of motion) were more likely to have higher job stress and lower job decision latitude than individuals without these physical symptoms. Other researchers have found increased muscle tension (estimated by electromyography) to be associated with high psychosocial demands (e.g., high concentration demands) and employee responses to a demanding job (e.g., high perceived stress levels, low job satisfaction) [38–43]. This increase in muscle tension could directly increase loading on the structures of the spine or increase loading through changes in trunk motion. Either way, the increased loading on the spine may contribute to LBP by increasing loads on the disc, devascularization of the nerve roots and other tissues, inflammation, and degeneration of the zygapophysial joint and ligaments [44–46].

Another possible mechanism is based on psychosocial factors influencing various *chemical reactions* in the body that take place during the performance of job tasks. Backus and Dudley [38] hypothesized that the increased muscle tension found with poor psychosocial factors may reduce blood flow resulting in the accumulation of metabolites that, in turn, result in muscle

pain. Long-term exposure to a poor psychosocial environment may result in the depletion of the oxygen supply to the spinal tissues and an accumulation of metabolites through another mechanism also – the degeneration of the blood vessels (e.g., ossification) [47–50]. In addition, high psychological demands have been associated with changes in levels of plasma cortisol [51]. Theorell et al. [52] hypothesized that long-term elevated cortisol levels may make muscles vulnerable to mechanical load. While none of these chemicals have been directly related to LBP, it does raise the possibility that other chemicals in the muscles and nerves may be either insufficient or in excess, ultimately leading to pain. At the present time, little research has investigated how psychosocial factors influence metabolic processes in the muscles, discs, nerves and other structures in the lower back.

A third potential mechanism entails psychosocial factors influencing the reporting of an injury by *altering tolerance to pain* [23,24,41]. In other words, psychosocial factors may reduce the pain threshold of the individual, thus increasing the likelihood of reporting LBP. Through this mechanism, an employee in a stressful psychosocial environment might be more sensitive to pain and more likely to report an injury than an employee in a non-stressful environment, all else being equal. For example, Theorell et al. [52] found that individuals with low decision latitude had lower pain thresholds than individuals with high decision latitude. In this study, an algometer was used to measure pain pressure thresholds for females and males that had different levels of job demands and decision latitude.

The reporting of LBP may also be influenced by psychosocial factors in another way [53]. Individuals who have a poor psychosocial work environment may be more likely to report LBP or call in sick, even when LBP is not severe, in order to *avoid stressors at work*. Frank et al. [25] suggested that LBP is a "modern day consequence" of poor job satisfaction and easily available workers' compensation.

2. Methods

2.1. Selection of the articles

The current review encompasses all articles published in English before January 1999 that evaluated the relationship between psychosocial work characteristics and initial reporting of LBP. While many investigators have included personality traits and indicators of employee mental health under the umbrella of "psychosocial factors", this review does not include studies investigating these factors. Instead, only studies that attempted to measure psychosocial aspects of the work or work environment are included. The only other selection criterion was that the studies had to evaluate the relationship of psychosocial factors with the incidence or prevalence of LBP (first time cases) rather than the effect of psychosocial factors on the LBP recovery process. By not utilizing further selection criteria and thus including a broad range of studies, we hope to enhance the review's ability to explain conflicting results and draw stronger conclusions.

Extensive searches of bibliographic databases such as MEDLINE, Institute for Scientific Information, and PsychInfo were conducted. Additional articles were gathered through the reference lists of published articles pertaining to psychosocial work factors and LBP. In all, 66 empirical articles investigating the relationship between psychosocial characteristics of work and LBP were identified.

3. Overview of the results

Table 1 provides a summary of the studies included in this review. For each study, the age and gender of the study population are described. In terms of gender, 23% of the study populations were composed of all females, 21% were all male, and 56% contained both men and women. As would be expected with studies of currently employed individuals, the participants' ages ranged from 17 to 76 yr but tended to concentrate in the 30–60 range. Table 1 also provides information about the study designs and how LBP data was collected. Many of the studies used a cross-sectional design where the exposure and the outcome were measured at the same point in time. The studies that collected data on the exposure and outcome simultaneously, but asked about LBP that occurred at some point in time before the data collection (e.g., during the previous year) are labeled "retrospective" in the table. One study used a case-control methodology [86]; this study is also categorized as retrospective. In order to be categorized as prospective, a study needed to measure the exposures to work characteristics before the collection of outcome data. LBP data were collected through employee self-reports (SR), through physical examinations by a health professional (PE), or through archival records (A) such as OSHA 200 logs, health care claims, and worker compensation claims.

The results for the association between psychosocial work characteristics and LBP are summarized in Table 2. The psychosocial variables presented in the table represent the work characteristics most commonly evaluated in the literature: lack of skill and variety, lack of control over work, social relationships at work (particular relationship unspecified), social relationships with supervisors, social relationships with coworkers, concentration demands, work overload, and responsibility. Two commonly studied variables that reflect

Table 1
Description of the study designs and populations for studies investigating the relationship between psychosocial work characteristics and LBP[a]

	Sex	Age groups (yr)	Prospective		Cross-sectional	Retrospective		
			1 + year[b]	3 + year		1 + month[c]	1 yr	Life
Ahlberg-Hulten et al. [54]	F	19–59				SR		
Astrand [55]	M	31–68			SR/PE			
Astrand and Isacsson [56]	M	31–68		A				
Barnekow-Bergkvist et al. [57]	B	Avg. 34					SR	
Bergenudd and Nelsson [58]	B	55			SR		SR	
Biering-Sorensen and Thomson [59]	B	30-, 40-, 50-, 60-	SR		SR		SR	SR
Biering-Sorensen et al. [60]	B	30-, 40-, 50-, 60-	SR					
Bigos et al. [61]	B	21–67		A				
Bigos et al. [62]	B	21–67		A				
Boos et al. [63]	B	20–50			PE			
Bru et al. [64]	F	Avg. 37.6					SR	
Brulin et al. [65]	F	Avg. 46.8			SR			
Dehlin and Berg [66]	F	Avg. 28.6						SR
Elovainio and Sinervo [67]	B	Avg. 41				SR 6M		
Engels et al. [68]	B	Avg. 29						SR
Feyer et al. [69]	B	No information			SR		SR	SR
Foppa and Noack [70]	B	<30, 30–39, 40–49, >50				SR		
Gyntelberg [71]	M	40–59	SR					
Hagen et al. [72]	B	<34, 34–49, >50					SR	
Hansen [73]	B	20–59					SR	
Heliovaara et al. [74]	B	30–64			SR/PE			
Hemingway et al. [75]	B	35–55		A				
Hilderbrandt [76]	M	Avg. 37.1					SR	
Holmstrom et al. [77]	M	<30, 30–49, >50					SR	
Houtman et al. [78]	B	18–65			SR		SR	
Hughes et al. [79]	M	21–58			PE		SR	
Hultman et al. [80]	M	45–55			PE			SR
Johansson [81]	F	20–64					SR	
Johansson and Nonas [82]	M	17–55					SR	
Johansson and Rubenowitz [83]	B	No information					SR	
Johansson et al. [84]	M	Avg. = 27.3					SR	
Josephson et al. [85]	F	19–62	SR 6M		SR			
Josephson et al.[d] [86]	F	20–59			PE			
Krause et al. [87]	B	25–65			SR			
Lagerstrom et al. [88]	F	20–64			SR			
Leino and Hanninen [89]	B	<27, 28–47, >48		PE/SR	PE		SR	
Leino and Lyyra [90]	B	No information		SR/PE	PE		SR	
Linton [91]	B	Avg. 42					SR	
Linton and Kamwendo [92]	F	19–64					SR	

Linton and Warg [93]	B	<25, 26–40, 41–55, >56					SR	
Magora [94]	B	No information					SR	
Marras et al. [7,8]	B	No information						A
Masset and Malchaire [95]	M	<30, 30–34, 35–40				SR	SR	SR
Masset et al. [96]	M	Avg. 35					SR	
Niedhammer et al. [97]	F	Avg. 40		SR			SR	
Ono et al. [98]	F	30–59				SR		
Papageorgiou et al. [99]	B	18–76	SR/A		SR			
Ready et al. [100]	F	Avg. 33.5	A 18M					
Riihimaki et al. [101]	M	25–49		SR		SR	SR	SR
Saraste and Hultman [102]	B	30–59						SR
Skov et al. [103]	B	Avg. 41.4					SR	
Skovron et al. [104]	F	Avg. 36.2				SR 6M		
Skovron et al. [105]	B	15 and above			SR		SR	
Svensson and Andersson [106]	M	40–47				SR		SR
Svensson and Andersson [107]	F	38–64				SR		SR
Symonds et al. [108]	B	70% below 45					SR/A	
Theorell et al. [41]	B	25–60						SR
Thorbjornsson et al. [109]	B	18–34, 42–56		SR	SR		SR	
Toomingas et al. [110]	B	20–64			SR/PE		SR	
Valfors [111]	B	16–65			SR/PE			SR
van Poppel et al. [112]	B	Avg. 34.3	SR					
Viikari-Juntura et al. [113]	B	45					SR	
Westgaard et al. [114]	F	21–65					SR	
Wickstrom and Pentti [115]	M	18–56	SR 24M				SR	
Xu et al. [116]	B	18–59					SR	

[a] For gender, F = female, M = male, and B = both. A = archival data, PE = physical exam, SR = self-report.
[b] 1-Yr follow-up unless otherwise noted (e.g., 24M would be a 24-month follow-up).
[c] LBP in the previous month unless otherwise noted (e.g., 6M would be a 6 month previous).
[d] These authors used a case-referent design.

Table 2
Results of the associations between psychosocial work characteristics and LBP as a function of analysis type[a]

	Low job satisfaction		Lack of variety and skill		Lack of influence over work		Poor social relations		Poor supervisor relations		Poor coworker relations		High concentration demands		High work demands		High responsibility		High feeling of stress		Multi-component variables	
	U	B	U	B	U	B	U	B	U	B	U	B	U	B	U	B	U	B	U	B	U	B
Ahlberg-Hulten et al. [54]			+		+		0+		0						+				0		+	
Astrand [55]	0		0				0								0		0					
Astrand and Isacsson [56]				0		0												0				
Barnekow-Bergkvist et al. [57]	0	0			0+	0	0	0							0	0						
Bergenudd and Nelsson [58]	+						0						+									
Biering-Sorensen and Thomson [59]	+	0	0		0																	
Biering-Sorensen et al. [60]	0	0	0	0	0	0																
Bigos et al. [61]	+								0+		0+											
Bigos et al. [62]	+	+							0	0	0	0									+	+
Boos et al. [63]		+						0					0	0								0+
Bru et al. [64]																						
Brulin et al. [65]				0		0				0										0		
Dehlin and Berg [66]	+				0		+															
Elovainio and Sinervo [67]																				+		
Engels et al. [68]		0														0						
Feyer et al. [69]	0																					0
Foppa and Noack [70]	+	+			+	+									+	0	0	0			+	0
Gyntelberg [71]																			+			
Hagen et al. [72]					0										+	+						
Hansen [73]																					0	
Heliovaara et al. [74]																					+	
Hemingway et al. [75]	0+				0+		0+								0+				0+			
Hilderbrandt [76]																					+	
Holmstrom et al. [77]	+		0		+		0								+						0+	
Houtman et al. [78]			0+	+											+	+						
Hughes et al. [79]	0	−			0	0	+	0+							0	0					0	0
Hultman et al. [80]			0		0		0														0+	
Johansson [81]			+	0	0+	0			0	0	0	0							0	0		
Johansson and Nonas [82]			0+		0				+		0								+			
Johansson and Rubenowitz [83]			+		0				+		0								+			
Johansson et al. [84]			+		+				0		+				+				+			
Josephson et al. [85]					0										0							
Josephson et al.[b] [86]			0	0	+	0	0	0							0	0					0	0
Krause et al. [87]		+				0				+		0		+								0+
Lagerstrom et al. [88]			0		0				+						0							
Leino and Hanninen [89]				0+		0+		0+						0+								
Leino and Lyyra [90]							0												0+			

Linton [91]			+	+			+								0+							+	+
Linton and Kamwendo [92]																						+	
Linton and Warg [93]	+																						
Magora [94]	+												+				+						
Marras et al. [7,8]	+	0																					
Masset and Malchaire [95]	0	0	0	0													0	0					
Masset et al. [96]	0	0	0	0													0	0					
Niedhammer et al. [97]																							0
Ono et al. [98]					+		0						0		+		+						
Papageorgiou et al. [99]	+										0												
Ready et al. [100]	0	+																					
Riihimaki et al. [101]				0				+								+							
Saraste and Hultman [102]			0+										0		0+								
Skov et al. [103]			0		0				0		0+				0					+			
Skovron et al. [104]							0	0	0	0	−	−											
Skovron et al. [105]	0+																						
Svensson and Andersson [106]	+	0	+	+	+	0							+	0									
Svensson and Andersson [107]	0+	0+	0	0	0+	+							0+	+						+	0+		
Symonds et al. [108]	0+						0+						0+										
Theorell et al. [41]					0	0	0+	0							+	+							
Thorbjornsson et al. [109]			0+	0+					0	0+					0	0							
Toomingas et al. [110]						0		+								0							0
Valfors [111]	+		+		+						+		+										
van Poppel et al. [112]	+	+																					
Viikari-Juntura et al. [113]	0												0										
Westgaard et al. [114]																						0	0
Wickstrom and Pentti [115]					0+	0	0+	0												0+	+		
Xu et al. [116]														+									

Type of association	Summary frequencies (percentages in italics)																						
Positive association	14	6	7	3	8	2	3	2	3	1	2	0	4	3	9	4	2	0	5	2	7	2	
	50	*35*	*32*	*20*	*33*	*13*	*18*	*20*	*30*	*17*	*22*	*0*	*36*	*50*	*47*	*36*	*33*	*0*	*50*	*40*	*54*	*18*	
Negative association	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	
	0	*6*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*11*	*25*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	
Null association	10	9	11	9	11	12	9	6	6	4	5	3	5	2	7	7	4	4	2	2	4	7	
	35	*53*	*50*	*60*	*46*	*80*	*53*	*60*	*60*	*67*	*56*	*75*	*46*	*33*	*37*	*64*	*67*	*100*	*20*	*40*	*31*	*64*	
Positive and null association	4	1	4	3	5	1	5	2	1	1	1	0	2	1	3	0	0	0	3	1	2	2	
	14	*6*	*18*	*20*	*21*	*7*	*29*	*20*	*10*	*17*	*11*	*0*	*18*	*17*	*16*	*0*	*0*	*0*	*30*	*20*	*15*	*18*	

[a] + Denotes positive associations , − Denotes negative associations, 0 Denotes null associations, 0+ Denotes mixed associations (positive and null), 0− Denotes mixed associations (negative and null).
[b] These authors used a case-referent design.

employee reactions to jobs with high psychosocial demands or a poor psychosocial environment are also listed in the table: low job satisfaction and high job stress. In addition to these individual psychosocial work characteristics, some studies used multicomponent variables that combined two or more of the characteristics listed.

In Table 2, a positive association indicates that higher levels of the potential risk factors are associated with greater likelihood of LBP. A negative association indicates that higher levels of or greater exposure to the potential risk factors are associated with a lesser likelihood of LBP. A null association indicates that the relationship between the risk factor and LBP was not of sufficient magnitude to achieve statistical significance at the $P = 0.05$ level. Mixed results (e.g., null and positive or null and negative) occurred when a study examined sub-groups of the study population and found different results for the various groups (e.g., white-collar versus blue-collar or male versus female). The results presented in the columns labeled "U" are unadjusted for potential confounders; those in the columns labeled "B" are adjusted for biomechanical demands of the job.

In general, the results are quite inconsistent across studies, with as many null results as positive associations. Only low job satisfaction, high perceived stress, high concentration demands, and multicomponent variables were found to have a majority of results be positive associations. Only two studies [79,104] found a negative association between a poor psychosocial work characteristic and LBP. With the exception of these two results, all non-null results were in the hypothesized direction. However, even the most optimistic interpreter of this body of results would be cautious in terms of inferring that psychosocial work characteristics are contributing to the occurrence of LBP.

With such a wide variety of study designs and statistical analyses, the determination of the magnitude of the average effect size for any of the psychosocial work characteristics is very difficult. However, Burdorf and Sorock [22], by limiting their review to studies from which odds ratios could be calculated, did estimate effect sizes. In their review, the odds ratios found for "mental job stress" ranged from 1.3 to 2.08, for job satisfaction ranged from 1.39 to 2.4, and for monotony on the job ranged from 1.35 to 2.34. These ranges of odds ratios were very similar to those found in studies of biomechanical demands such as lifting, bending, and heavy physical load [22].

4. Methodological issues

Several methodological issues may be contributing to the inconsistent results presented in Table 2. These include: uncontrolled confounders, timing of the measurement of exposure and outcome, and the reliability and validity of measures of study variables (exposure and outcome). These issues are discussed below.

4.1. Controlling for potential confounders

While there appears to be some evidence that psychosocial variables are related to LBP, the interpretation of the results may depend upon whether other potential confounding variables were controlled for in the analyses. Two types of variables are important to take into account when evaluating the association between psychosocial factors and LBP. First, demographic variables such as age, gender, and occupation have been associated with both LBP and with exposure to psychosocial work characteristics [74,88,89,101,105,109,110,117,118]. Thus, it is important to include demographic variables in multivariate models when assessing the relationship between psychosocial work characteristics and LBP. Some of the studies reviewed here included demographics in multivariate analyses. In general, there were only small or no differences in the results when comparing unadjusted models and models adjusted for demographic variables (not shown in table; details available from authors).

Biomechanical factors have also been shown to be related to both psychosocial work factors and LBP. Several studies have found that jobs with high biomechanical demands are likely to be associated with poor psychosocial work factors such as low job decision latitude, low levels of social support, and high workload [82,89,110,119]. While some studies have found that the relationship between psychosocial factors and LBP is independent of biomechanical factors [81,87,91,104,115], there is other evidence that biomechanical demands may confound the relationship between psychosocial work factors and LBP. When the results of analyses that controlled for biomechanical demands (B columns in Table 2) were compared to unadjusted analyses (U columns in Table 2), the inclusion of biomechanical resulted in a 20% increase in null results.

As indicated in Fig. 1, it is also possible that biomechanical and psychosocial work characteristics have an interaction effect on LBP. This hypothesized effect has not been adequately tested. Johansson [81] found that workers exposed to heavy physical demands as well as poor psychosocial work characteristics were twice as likely to have an episode of LBP than a worker with few physical demands and a good psychosocial work environment. However, no statistical test was provided to indicate if the magnitude of this effect was due to the main effects of the two predictors or to an interaction. Only one study conducted such a test. Barnekow-Bergkvist et al. [57] found that the effect of heavy lifting on LBP was stronger when employees were performing

monotonous work that provided little variety in job tasks.

4.2. Timing of the exposure and outcome variables

In order for any relationship between a risk factor and LBP to be causal, the exposure to the risk factors must precede the outcome. Cross-sectional designs, which have been widely used to evaluate the association between psychosocial work factors and LBP, have limited ability to establish a causal relationship. Often, study participants are asked to report how they are currently experiencing their work (e.g., how stressful it is), and then are asked to report any LBP that they experienced during some previous time period (e.g., over the last year). Thus, the exposure is being measured after the experience of the outcome. A relationship established by such a study is just as likely to reflect an effect of symptoms on how the worker experiences the job as it is the reverse.

At best, a cross-sectional design can measure co-occurrence of exposure and outcome (e.g., respondents report symptoms being experienced at the time of the data collection). All cross-sectional studies are vulnerable to a selection effect whereby workers with back pain may choose less stressful or less physically demanding jobs. Such an effect will lead to an underestimation of the effect of the exposure on the outcome. Cross-sectional studies that rely on self-reports of potential risk factors are also vulnerable to a bias due to workers being aware of the supposed relationship between work characteristics and LBP. Thus, when workers are experiencing LBP, they may attribute their pain to a worksite exposure. This may increase their perception of being exposed to physical or psychosocial demands at the workplace, resulting in an overestimation of the relationship.

Among the cross-sectional studies reviewed here, 35 studies asked participants to report LBP for the previous year, three asked about LBP over the last 6 months, six asked about LBP during the last month, 12 asked about any LBP experienced during the worker's lifetime, and 16 asked about LBP experienced at the time of data collection. For the studies that asked about outcomes that occurred before the measured exposures, 39% yielded positive associations between psychosocial factors and LBP, 47% yielded null results, and 14% yielded mixed results. This set of studies produces results that are the least interpretable, for all of the reasons stated above. The 16 cross-sectional studies that evaluated current LBP yielded even a higher proportion of null results: 31% showed positive results and 64% showed null results. These studies are susceptible to the same biases as those that asked about previously experienced symptoms and thus may not offer any additional insights.

Two other types of study designs have been used to investigate the relationship between work characteristics and LBP: case-control studies and prospective cohort studies. Since case-control studies are vulnerable to recall bias [120] and the "attribution" bias described above, prospective cohort studies have typically been touted as the most practical design for providing reliable evidence of a causal relationship between work factors and LBP [11]. However, the ability of a prospective cohort study to discern a cause and effect relationship is dependent on measuring the exposure (whether it be biomechanical or psychosocial) and the outcome with a time interval that best reflects the hypothesized underlying injury mechanism. An "initial impact" model suggests that the measurement of the exposure and the outcome need to be relatively close in time, while injuries related to chronic exposure are best predicted when there is a longer lag time between the measurement of the two [121]. Cross-sectional studies, particularly those that measure current symptoms, could provide evidence for an initial impact or acute effect. The results of these studies, as reported above, are not supportive of the initial impact model for psychosocial characteristics on LBP.

Unfortunately, little work has been done to identify an appropriate time lag from exposure to injury. A majority of the prospective studies in this review used a time lag of 2 yr or more, with the shortest time lag being 6 months. A chronic exposure model necessitates measurement of exposures at multiple points in time if the exposures might be expected to change over time. In population- or community-based studies, study participants may change jobs during the course of the study. In these studies, changes in psychosocial characteristics are particularly likely, and have indeed been documented (see e.g., [89]). However, even in studies where participants remain employed in the same jobs, rapidly changing technology, market pressures, organizational changes, and personnel changes can affect psychosocial work characteristics. Karasek and Theorell [122] provided evidence that some psychosocial work characteristics vary over a 3–4-month period. Wickstrom and Pentti [115] found that the percentage of workers exposed to stressors such as job insecurity, a lack of recognition at work, and a lack of respect from others increased by as much as 13% over a 2-yr period. With this amount of variation, studies that used long time lags between measurement of the exposure and the outcome, without measuring exposures at multiple points in time, are likely to provide a very conservative estimate of the effect of the work characteristic on LBP.

Unfortunately, only three of the 66 studies that examined the effect of psychosocial work characteristics on LBP collected exposure data at more than one point in time [89,109,115]. Of these three, only Thorbjornsson et al. [109] looked at the effect of experiencing chronic

psychosocial stressors on the job. They found that individuals who had monotonous jobs at two points in time were more likely to be injured than individuals who were experiencing a monotonous job at only one of the data collection points.

4.3. Reliability and validity of the exposure measures

The subjectivity of the exposure measure, or the extent to which the measure depends on one employee's perception, is likely to affect the results of a study. A person's perception of his work is likely to be a reflection of both the work itself and the person's expectations about work, previous work history, resources for coping with work, and general mood and well-being. Thus, a subjective measure of a worksite exposure provides uncertain cues as to what is contributing to injury incidence – is it the demands of work or the inadequate resources of the employee or both? In addition, when the LBP outcome is also measured through employee self-report, negative affect [123] and common method variance [124] can artificially inflate the association between workplace exposures and LBP.

All employee self-reports of work characteristics, whether biomechanical or psychosocial characteristics, are vulnerable to the criticism of subjectivity. However, the amount of subjectivity involved in a given self-report measure depends on how the questions are worded. For example, questions that involve the workers making judgments or interpretations (e.g., "Is the lifting that you do risky?" or "Do you have a heavy, medium, or light workload?") introduce more subjectivity than do questions that ask for more descriptive, quantifiable assessments (e.g., "Do you lift 10 lb boxes more than 10 times a day?").

4.4. Quality of the biomechanical assessment

Although reliable, validated tools for objective assessments of biomechanical work demands are available (e.g. goniometers, electromyography, video-based tools, loading models), all but three of the 49 studies reviewed here used self-reported questionnaires to assess these work demands [7,8,80]. Several authors have found that employee self-reports of biomechanical work demands are not particularly accurate assessments [125–129]. For example, Wiktorin et al. [128] found that employee responses to questions assessing trunk flexion and lifting agreed with the reports of trained observers only one-third of the time. Viikari-Juntura et al. [130] found that correlations between employee self-reports and expert observations were between 0.42 and 0.55. When workers have been asked to provide estimates of the time spent lifting or flexed forward, the agreement between observations and self-reports was less than 12% [126]. In general, the self-reported duration of trunk flexion and lifting have been overestimated as compared with direct observations [126,130].

These biomechanical assessments may also lack adequate reliability because of the use of single item measures. Basic psychometric principles suggest that, because answers to any single question contain random error, combining the answers to multiple questions will provide a more reliable estimate of the true score. Only 13 of the studies reviewed used multiple item indexes to measure biomechanical demands.

As stated previously, biomechanical and psychosocial work demands tend to covary. Thus, the reliability of the measures of biomechanical variables may not only affect the magnitude of the relationship between biomechanical demands and LBP, but may also influence the magnitude of the relationship found between psychosocial work characteristics and LBP (when using multivariate models that include biomechanical factors). The effects of biomechanical demands on LBP are only partially controlled for when measures of low reliability are used.

Indeed, among the studies reviewed here, those that included more reliable and valid measures of biomechanical factors typically showed: (1) more consistent and stronger relationships between biomechanical demands and LBP, and (2) less consistent relationships between psychosocial factors and LBP. Among the studies that provided no information about or no assessment of biomechanical demands, 30% found associations between poor psychosocial work characteristics and LBP while 59% found no association. When single item self-reported biomechanical assessments were entered into multivariate models, studies were more likely to yield mixed results. The percentage of studies finding the hypothesized association between poor psychosocial characteristics and LBP decreases even further (18%) when multiple item biomechanical assessments were entered into the models. In the Marras studies [7,8] where trunk kinematics were directly measured using a goniometer, job dissatisfaction was a significant predictor of LBP in bivariate models but not in multivariate models that controlled for biomechanical demands.

In summary, the ability to accurately assess the biomechanical demands of the study participants' jobs significantly affected the magnitude of the relationships found between biomechanical demands and LBP as well as the relationships between psychosocial factors and LBP. Future research needs to incorporate validated, reliable measures of biomechanical work demands.

4.5. Quality of psychosocial assessments

There are very few validated, non-self-report measures of psychosocial work characteristics. Quantitative workload has been measured through direct observation of discrete events (such as number of calls handled by a

police dispatcher or number of parts assembled by an autoworker), and some observational protocols exist for measuring other stressors [131]. However, psychosocial characteristics of work such as concentration demands or responsibility for others are inherently subjective to some degree. Measures that explicitly measure employee attitudes (e.g., job satisfaction and perceived stress) rather than environmental exposures will, by their very nature, be the most subjective.

As with biomechanical assessments, self-report measures of psychosocial work characteristics have been found to be only moderately correlated with other types of measures. For example, Melamed et al. [132] investigated the level of agreement between monotony on the job as measured through self-administered questionnaire and monotony as measured through observation of repetitions of tasks in work with short, medium, and long cycle times. For all of these types of jobs, the self-report and observational measures were only moderately associated at best ($r = 0.09$–0.42). Similarly, Kirmeyer and Dougherty [133] found that police dispatchers' self-reported workload was moderately correlated ($r = 0.35$) with workload as measured by the number of work activities completed per hour.

Although there are few validated non-self-report measures of psychosocial work conditions currently available, there are several well-validated, multiple-item, self-report measures available [134]. Unfortunately, only 22 (33%) of the studies reviewed here used such a measure. Psychosocial work characteristics were measured using a single, unvalidated item in 21 (32%) of the studies. Examples of these types of items include "are you satisfied with your job?", "do you get along with coworkers?", and "is your job monotonous?". Often, such items would call for a dichotomous response that is unlikely to capture the full range of variance in psychosocial characteristics. In nine (14%) of the reviewed studies, questions about psychosocial work characteristics were combined into summary scales with little or no attention given to internal consistency or conceptual clarity. The limitations in the measurement of the psychosocial work characteristics are likely to contribute to the inconsistency of the results in the literature. More specifically, the use of unreliable measures may increase the likelihood of getting null results due to measurement error masking true underlying relationships.

4.6. Quality of the LBP assessment

The relationship between psychosocial work characteristics and LBP may also be influenced by the operationalization of the outcome variable. The overwhelming majority of studies ($n = 59$) used a self-administered questionnaire to measure LBP, while only 10 studies included physical examinations. Nine studies used some type of archival data to identify episodes of LBP. Almost all of the studies defined LBP in a non-specific way, not differentiating between various clinical conditions.

The ability to discern a relationship between psychosocial work characteristics and LBP is affected by the reliability of the outcome measure. The reliability of self-reported LBP is determined, in part, by the length of the recall period and by the nature of the questions asked. The longer the recall period, the less reliable the response [135,136]. For example, Riihimaki et al. [101] found that approximately 26% of individuals reporting sciatic pain failed to remember the episode of LBP three years later. As far as we can tell, none of the studies reviewed used the state-of-the-art procedures to aid recall that have been employed in the stressful life event literature [137]. In terms of how the LBP questions are structured, many ($n = 47$) of the studies in this review used a single, generic, vague item to assess the presence of LBP (e.g., do you have pain in the back?). These types of questions can be interpreted in multiple ways, and thus introduce unnecessary measurement error. Although more detailed questionnaire measures of LBP have been recommended for use [138], only four [57,64,72,88] of the studies have used them.

Other types of LBP measures also suffer from threats to their reliability. Physical examination measures introduce the subjectivity of the physician or other health professional who is performing the exam. Few studies examined intra-rater or inter-rater reliability. In addition, some clinical examination techniques have been shown to be better predictors of LBP than have others [139]. Even archival data is vulnerable to changing record-keeping systems, careless or error-prone record-keeping, and modifications in regulatory definitions and practices.

While there is no "gold standard" for the assessment of LBP, the appropriateness of the outcome measure depends on the research question being investigated. If a researcher is interested in the financial ramifications of LBP, measures of sickness absence and health care claims might be best suited. On the other hand, if a researcher is interested in quality of life issues, self-reports of pain and functional status might be most appropriate. Including different types of measures of LBP within a single study may be useful. For example, comparisons between the relationship of psychosocial work characteristics to self-reported symptom outcomes and the relationship of these same work characteristics to physiological assessments of LBP (e.g., the results of physical examinations) could shed some light on the mechanisms underlying the demonstrated relationships. If the relationship is predominantly due to employees being more likely to report pain or injury when experiencing a stressful or non-supportive work environment, then the psychosocial characteristics should be most strongly associated to self-reported outcomes. However,

if the underlying mechanism involves psychosocial work characteristics affecting loading on the spinal structures, then the relationship between psychosocial factors and LBP should also be discernible using physiological or physical examination outcomes.

Similar to the results of a previous review [24], this review found that the associations between psychosocial work characteristics and LBP differed by the type of outcome measure used. More positive associations with psychosocial work characteristics were found when self-reports of symptoms or injuries were used (about 35% of the associations were positive) than when LBP was determined by physical examination (about 13% of the associations were positive). One interpretation of this difference is that psychosocial stressors are influencing the reporting of injuries or pain rather than influencing physiology. However, since the bulk of the studies were retrospective in nature, these results may also reflect the influence of LBP on the reporting of poor psychosocial work characteristics.

4.7. Summary assessment of methodological rigor

While the above sections provide an evaluation of the literature with respect to individual methodological issues, a summary rating was constructed which allowed for the assignment to each study of an overall score for methodological rigor. This summary rating is based on four of the methodological issues discussed above: timing of the measurement of the exposure compared to the outcome; control for potential confounding; quality of biomechanical assessment; and reliability of the measures of psychosocial variables. Each of these factors could contribute up to 3 points to the overall score. For example, controlling for potential confounders was scored as "0" for providing no information about or no adjustment for potential confounders, "1" for adjustment for demographic variables, "2" for adjustment for biomechanical demands, and "3" for adjustment for both demographic factors and biomechanical demands. The points associated with the timing of the exposure measurement were assigned as follows: a cross-sectional design with LBP measured for a time period before the measured exposure (0), a cross-sectional design with LBP and exposure measured concurrently (1), a prospective design (2), and a prospective design with multiple exposure measures (3). Thus, more points indicate an increasing ability to establish a causal relationship. The points assigned for biomechanical assessment were based on the reliability of the method used: no information or no assessment (0), single question measures (1), multiple question measure (2), and validated, non-self-report measures (3). Lastly, points given for the quality of the psychosocial work characteristic assessment were assigned as follows: no information provided (0), single item questions (1), multiple item scales with low internal consistency or no information on internal consistency (2), and multiple item scales with at least adequate internal consistency (3). A Cronbach's α equal to or above 0.7 was considered to provide adequate internal consistency [140]. Table 3 presents the scores on each criterion and the total score for the studies in this review.

Based on these four methodological criteria, none of the studies satisfy all the criteria needed to optimally assess a causal relationship. Whereas the potential high score was 12, none of the studies scored above 9. Only 12% of the studies had scores of 8 or above while 42.4% scored 4 or below. In order to discern if methodological rigor was influencing the results of the studies, the results of the more rigorous studies (scoring 7 or above) were compared to those with scores of 3 or below. Each group consists of 16 studies. Although the results for some of the psychosocial work characteristics (e.g., low job satisfaction, high concentration demands, lack of skill and variety, and poor social relationships at work) were relatively similar across the two groups, there were differences in the results for the other psychosocial factors. This indicates that methodological rigor may be influencing the results of the studies, and thus, that examining the results of the more rigorous studies could be beneficial.

None of the high scoring studies investigated the effects of having high responsibility on the job. Only one study examined the effects of coworker relationships. Thus, no conclusions can be drawn about these variables. Of the remaining variables, two variables show relatively consistent positive effects on LBP: low job satisfaction (three out of five analyses) and high feelings of stress on the job (two out of three analyses). Poor supervisory relationships, with two out of four analyses showing a positive effect, also appear to have some correlation with LBP. None of the tests for lack of influence over work showed a significant relationship to LBP. As for the other characteristics (e.g., lack of skill and variety, poor work relationships more generally, high work demands, and the multicomponent variables), no more than 25% of the analyses for any of these variables showed a significant relationship with LBP.

What conclusions can be drawn from these results of the more rigorous studies? First, even among the most methodologically rigorous studies, the results are inconsistent and not conclusive. Second, the psychosocial variables that most consistently exhibited a relationship with LBP are not measures of psychosocial work characteristics. Instead, they are measures of employee responses or reactions to their work conditions – reactions that are determined, at least in part, by the resources and temperaments that employees bring to their jobs. It is difficult to partial out the role of psychosocial work characteristics versus employee characteristics with such measures.

Table 3
Summary of the methodological criteria scores for all studies included in the review (potential total score = 12)[a]

	Control for confounding	Timing of exposure to outcome	Quality of biomechanical assessment	Quality of psychosocial assessment	Total score
Hughes et al. [79]	3	1	2	3	9
Josephson et al. [86]	3	1	2	3	9
Krause et al. [87]	3	1	2	3	9
Niedhammer et al. [97]	3	2	2	2	9
Wickstrom and Pentti [115]	3	3	2	1	9
Barnekow-Bergkvist et al. [57]	3	0	2	3	8
Leino and Hanninen [89]	2	3	1	2	8
Thorbjornsson et al. [109]	2	3	1	2	8
van Poppel et al. [112]	3	2	1	2	8
Boos et al. [63]	3	1	1	2	7
Brulin et al. [65]	2	1	2	2	7
Elovainio and Sinervo [67]	2	0	2	3	7
Lagerstrom et al. [88]	3	1	0	3	7
Riihimaki et al. [101]	3	2	1	1	7
Theorell et al. [41]	3	0	1	3	7
Toomingas et al. [110]	3	1	No information	3	7
Astrand and Isacsson [56]	2	2	1	1	6
Biering-Sorensen et al. [60]	2	2	1	1	6
Bigos et al. [62]	2	2	1	1	6
Engels et al. [68]	2	0	2	2	6
Hemingway et al. [75]	1	2	0	3	6
Houtman et al. [78]	2	1	1	2	6
Johansson [81]	2	0	1	3	6
Johansson and Rubenowitz [83]	1	0	2	3	6
Marras et al. [7,8]	2	0	3	1	6
Ready et al. [100]	2	2	1	1	6
Skovron et al. [104]	2	0	1	3	6
Biering-Sorensen and Thomson [59]	2	1	1	1	5
Hagen et al. [72]	2	0	0	3	5
Heliovaara et al. [74]	0	1	2	2	5
Hilderbrandt [76]	0	0	2	3	5
Holmstrom et al. [77]	1	0	2	2	5
Hultman et al. [80]	0	1	1	3	5
Johansson et al. [84]	0	0	2	3	5
Josephson et al. [85]	0	2	1	2	5
Leino and Lyyra [90]	1	2	0	2	5
Svensson and Andersson [107]	3	0	1	1	5
Bigos et al. [61]	1	2	No information	1	4
Bru et al. [64]	1	0	0	3	4
Feyer et al. [69]	0	1	0	3	4
Foppa and Noack [70]	3	0	1	No information	4
Gyntelberg [71]	0	2	1	1	4
Hansen [73]	1	0	0	3	4
Johansson and Nonas [82]	0	0	1	3	4
Linton [91]	2	0	1	1	4
Papageorgiou et al. [99]	1	2	0	1	4
Svensson and Andersson [106]	2	0	1	1	4
Westgaard et al. [114]	2	0	No information	2	4
Xu et al. [116]	2	0	1	1	4
Dehlin and Berg [66]	0	0	0	3	3
Ono et al. [98]	1	0	1	1	3
Saraste and Hultman [102]	1	0	1	1	3
Skovron et al. [105]	1	1	0	1	3
Symonds et al. [108]	0	0	0	3	3
Ahlberg-Hulten et al. [54]	0	0	0	2	2
Bergenudd and Nelsson [58]	0	1	1	No information	2
Linton and Kamwendo [92]	0	0	0	2	2
Linton and Warg [93]	1	0	0	1	2
Magora [94]	0	0	1	1	2
Masset and Malchaire [95]	2	0	No information	No information	2

	Control for confounding	Timing of exposure to outcome	Quality of biomechanical assessment	Quality of psychosocial assessment	Total score
Masset et al. [99]	2	0	No information	No information	2
Valfors [111]	0	1	1	No information	2
Viikari-Juntura et al. [113]	0	0	1	1	2
Astrand [55]	0	1	No information	No information	1
Skov et al. [103]	0	0	1	No information	1

[a] Control for confounding (no information or none – 0, demographic – 1, biomechanical – 2, both – 3). Timing of exposure to outcome (dependent variable refers to time before exposure – 0, cross-sectional with current dependent variable assessment or case-control – 1, prospective – 2, prospective with multiple exposure measurements – 3). Quality of biomechanical assessment (no information or none – 0, self-report single item – 1, self-reported multiple items or checklist – 2, physical measurements – 3). Quality of psychosocial assessment (no information – 0, single items – 1, multiple items with either no information or low reliability (Cronbach's $\alpha < 0.7$), multiple items with high reliability (Cronbach's $\alpha > 0.7$)).

5. Conclusion

Previous reviews [11,22–25] have concluded that certain psychosocial work factors are associated with LBP. For example, Bongers et al. [11] concluded that monotonous work, poor work content, and low levels of coworker support are associated with LBP. Burdorf and Sorock [22] provide a qualified endorsement of a relationship between LBP and low job decision latitude, as well as low job satisfaction. While the empirical evidence reviewed here does seem to suggest some association between psychosocial work characteristics and LBP, we believe that it is premature to draw causal inferences.

We are hesitant to draw such conclusions because of two of the findings of our methodological critique of the literature. First, controlling for potential confounding from biomechanical factors had a large influence on the associations between psychosocial work characteristics and LBP. This finding, coupled with the fact that very few studies were able to adequately control for biomechanical demands, suggests that caution should be exercised. Second, as would be expected, the use of valid and reliable measures of biomechanical and psychosocial work exposures exerted an influence on the associations found between psychosocial work characteristics and LBP. Based on the articles reviewed, it is rare for a study to include high quality measures of both psychosocial work characteristics and biomechanical demands. More recently, strong interdisciplinary teams of researchers have begun to address the etiology and progression of LBP. Such collaborations bode well for the inclusion of strong measures of various types of exposures, as well as clinical outcomes. However, until the results of these collaborations are published, we would recommend drawing only tentative conclusions from the literature.

From the studies included in this review that had the highest scores on our specific methodological criteria, it does appear that job satisfaction and job stress are more consistently and more strongly associated with the development of LBP than are psychosocial work characteristics themselves. As mentioned previously, these findings provide limited guidance for the development of effective interventions to reduce LBP. Research is needed to investigate not only the relationship between job satisfaction and LBP, but also the relationship between work characteristics (both psychosocial and physical) and job satisfaction. Once these critical linkages are established, interventions can be more effectively targeted.

Where do we go from here? In order to acquire a better understanding of the relationship between psychosocial work characteristics and LBP, future research needs to address many of the methodological issues discussed above. Future studies need to: (i) utilize high quality measures of occupational exposures (biomechanical and psychosocial) and LBP, (ii) incorporate appropriate statistical analyses that control for potential confounders (biomechanical and demographic variables), (iii) conduct prospective studies with multiple measurements of exposure and outcome, (iv) perform studies that evaluate the potential mechanisms through which psychosocial stressors may be linked to LBP, and ultimately (v) conduct intervention research to assess the effectiveness of modifying psychosocial work characteristics for reducing LBP. While the body of evidence reviewed here suggests that employee reactions to psychosocial work characteristics may play a role in the development of LBP, more conclusive evidence is needed. Only through the gathering of such evidence will we be able to ultimately develop interventions that effectively and efficiently reduce the human and financial costs of LBP.

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