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Review Paper

A literature review of low back disorder surveillance measures and risk factors

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Abstract

Objective. The goal of this literature review was to gain insight into low back disorder risk factors via a critical examination of the surveillance measures and analysis techniques employed in existing literature.
Design. Fifty-seven original articles were evaluated and categorized as a function of their surveillance measures.
Background. There have been a plethora of articles concerning the causes of low back disorder, yet no specific risk factors are consistently associated with the development of these disorders. It was hypothesized that different low back surveillance measures and variations in risk factor (dependent variable) measurements have led to the inconsistencies in the literature.
Methods. Five low back disorder surveillance measures and five risk factor categories were defined for this review. Each article was classified on several criteria including: surveillance measures, risk factors, statistical methods, population and type of study. Summary statistics were calculated for the percentage of positive findings as a function of surveillance measure and risk factor category.
Results. The most consistently defined surveillance measure was incidence of low back disorder, with 82% of those investigating it as claims from medical records or Occupational Safety and Health Administration records. The combination of surveillance measures and risk factor influenced the outcome of investigations. Ninety-one percent of the direct or video methods of measuring exposure risk factor influenced outcome. Psychosocial measures had positive findings in 70% of the studies examining lost time. Finally, statistical methodology was critical in the outcome of these investigations.
Conclusions. The surveillance measure of incidence had more positive findings, with exposure risk factors and the surveillance measures indicating more advanced stages of low back disorder such as lost time had more positive findings with psychosocial risk factors. Thus, as low back disorders progress to disability, the psychosocial risk factors play a more prominent role.

Relevance

In order to prevent low back disorders we must first understand the plethora of epidemiological literature. This literature review provides new insight on the critical issues that have contributed to the results of previous research. © 1997 Elsevier Science Ltd.

Key words: Low back disorders, risk factors, epidemiology

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Introduction

There are a myriad of epidemiological articles investigating risk factors of low back disorders. In a review of the literature, Andersson[1] cited over 300 articles on the topic, with a multitude of findings. Andersson's literature review described both positive and negative results for all risk factors discussed, but offered no theories or explanations for why these conflicting results occurred. The state of the literature today indicates that no specific risk factors are consistently associated with the development of low back disorders. It is hypothesized that these inconsistencies in the literature may be due to variations in the surveillance measures and definitions of dependent measures (risk factors).

Low back disorders may be viewed as a progession of events, as shown in Figure 1. The disorders may begin

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with spinal loading, progress to discomfort, which would be identified if asked, then symptoms that would be apparent in active surveillance, and then disorder (injury or illness) followed by the report of an incidence, possibly leading to restricted work activities, and may culminate in lost time from work or disability. Low back disorders may be reported at any point in this progression of events, or may never be reported. The nature of this progression suggests that the findings of a study are a function of which point of the process is explored. Furthermore, the exploration process depends upon (1) what one is looking for (risk factors); and (2) how one derives the information (methodology).

The measures used for the surveillance of low back disorder may influence the outcome of the study. Load, the preliminary stage of low back disorder, may be evaluated with a quantitative analysis or checklist. Discomfort is usually assessed with a survey, and the period of time evaluated may influence the outcome. Symptoms can be evaluated by medical techniques, the results of which may be a function of the sensitivity of the medical detection technique. Incidence, restricted days, and lost days, the later stages of low back disorders as shown in Figure 1, may be influenced by individual company policies. The different evaluation processes may influence the outcome of studies at each surveillance point in the progession of low back disorder. However, epidemiological review articles rarely discuss the influences of the different surveillance measures or the notion that the intervening point in the progression of low back disorder (Figure 1) may influence the outcome of the study[1].

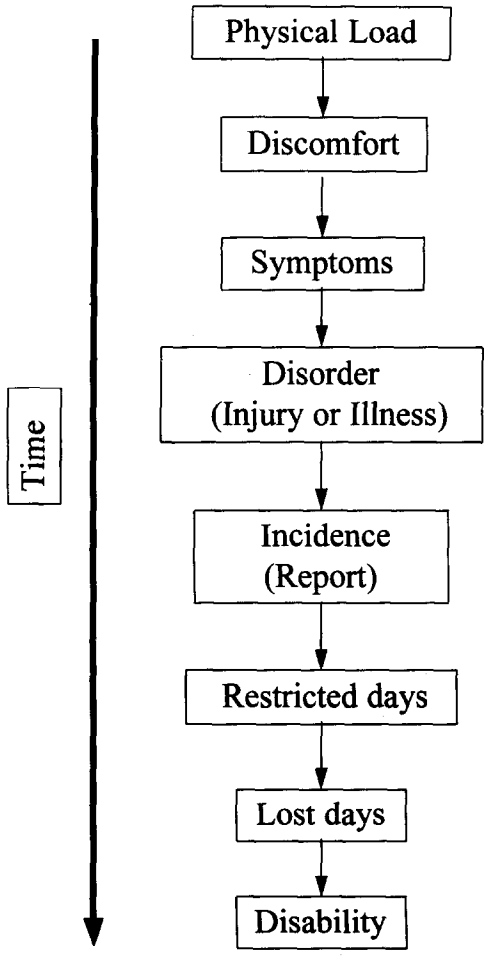

Figure 1. Time progression of low back disorders.

The are several categories of risk factor disorders (personal, physical, exposure, psychological and psychosocial) that have been associated with low back disorders in the literature[1,2]. The methods used to evaluate these risk factors include questionnaires, outside observers or direct measures. The precision and accuracy of the evaluation methods may influence the outcome of the investigation[2]. The outcome of a study may also be influenced by the surveillance measure used to evaluate the risk factor. Thus the combination of surveillance measure and risk factor evaluation method may influence the outcome of an experiment. The outcome of a study may also be a function of the statistical methods or the population investigated. However, the epidemiologcal literature does not discuss these influences on the outcome of studies, instead concentrating on whether or not the risk factor significantly influenced low back disorders.

Review articles of the epidemiological literature rarely discuss the influences of surveillance measures, risk factor measuring techniques, statistical methods or populations evaluated on the outcome of the study[1,2]. It is hypothesized that certain risk factor categories (i.e. psychologcal, personal, workplace exposure) may influence different events in the progession of low back disorders in different ways. For example, psychosocial risk factors may influence lost days the most, whereas psychologcal risk factors may predominantly influence discomfort. Thus, the goal of this literature review was to glean new ideas and insights concerning the risk factors of low back disorders through careful examination of the existing literature.

Methods

To be included in this review, articles needed to meet certain criteria. The study must have used one of six low back disorder surveillance measures: (1) discomfort survey, (2) symptom survey, (3) injury, (4) incidence, (5) lost time and (6) restricted time. Secondly, the articles must have analysed risk factors that could be incorporated into one of five categories: (1) personal factors defined as demogaphic, habits, and personal health factors, (2) physical factors defined as functional capacity measures, physical attributes, or diagnostic tools, (3) exposure factors defined as biomechanical risk from the workplace, (4) psychological factors defined as measures indicating individual behaviour status or tests that evaluated behaviour and (5) psychosocial factors defined as interactions with others (co-workers, friends, family) and attitudes

towards work. Finally, the articles needed to have clearly defined independent variables, dependent variables, statistical methods, population and study type (prospective, cross-sectional, cohort etc.). Fifty-seven articles met all the criteria for this review; however, it should be noted that many articles lacked definitions for several of these criteria. In a review article, Burdorf[2] noted a lack of clearly defined independent and dependent variables in the literature.

Tables 1 and 2 list the articles that were incorporated in this literature review. Table 1 indicates which surveillance measures and risk factor categories were evaluated in each investigation. The surveillance measures of discomfort surveys and symptom surveys were combined in one category (D/S) because the two categories were indistinguishable in most of the literature. Table 1 indicates which measures were used as independent variables (I), covariates (C) and dependent measures (+/−). The dependent measures that were associated with their respective independent variables are indicated by a positive sign (+) and those that were not are indicated by a negative sign (−). The combination of both a positive and a negative sign (+/−) indicates that more than one risk factor in that category was analysed, and subsequent analysis will indicate which particular factors were associated with

Table 1. Surveillance measures and risk factors of low back disorders for each article reviewed

	Surveillance measures					Risk factor categories				
Author	D/S	INJ.	INC.	Lost T.	R. T.	Pers.	Phys.	Exp.	Psychol.	Psychos.
Battie et al.[3]			I_A			I_B	$+_B$ $-_A$			
Biering-Sorensen[4]	I					+I	+/−			
Bigos et al.[5]			I			+/−	−		+/−	+
Bigos et al.[6]		$+_B$	I_A	I_B				$-_A$		
Bigos et al.[7]			I_A	I_B		+/−$_A$				$+_B$
Cady et al.[8]			I			+	+			
Chaffin[9]			I				+	+		
Chaffin et al.[10]			I			−	+	+/−		
Frymoyer et al.[11]	I			x		+/− I		+/−	+	
Frymoyer et al.[12]	I			+		+		+/−		
Johanson et al.[13]	I					−		+/−		+/−
Linton et al.[14]	I									+
Marras et al.[15]			I	I	I	−		+/−		−
Riihimaki et al.[16]	I					C +/−	−	+	+	
Riihimaki et al.[17]	I					+/−		+/−		+/−
Theorel et al.[18]	I_A			I_B		C	$-_{AB}$	+/− $_{AB}$	− $_{AB}$	+/− $_{AB}$
Troup et al.[19]	I_A	I_B		$+_B$		+/−$_A$	+/−$_A$			
Troup et al.[20]	I_B $+_A$					I_A	+/−$_B$	+/−$_B$		
Videman et al.[21]	I	I					+/−	+	+/−	
Leavitt[22]	$-_{AB}$	$+_B$ I_A		I_B		+/−$_A$		$+_B$		
Leavitt[23]	+			+		−			I	
Leavitt et al.[24]	+ I					−			+/−	
Beals et al.[25]		$+_A$ I_B		I_A		$+_B$	$+_A$	$+_A$	$+_A$	
Punnett et al.[26]			I			+/−		+		
Gallagher et al.[27]	−			I		+/−	−	−	+/−	+/−
Magni et al.[28]	$+_B$ I_A					+/−$_B$			$+_A$ I_B	
Lieno et al.[29]	I					I		+	+	
Bergenudd et al.[30]	I					I +		+		+
VonKorff et al.[31]	I					+/−			−	
Hansen et al.[32]	I					I			−	
Croft et al.[33]	I					−			+	
Rowe[34]				I		+/−	−			
Hilderbrandt et al.[35]	I					−		+/−		+/−
Masset et al.[36]	I					+	−	+/−	−	−
McIntyre et al.[37]	I					C	+			
Masset et al.[38]	I					−	+/−	I		−
Svensson et al.[39]	I					I		+/−	+	+
Videman et al.[40]	$+_A$ $-_B$		$+_A$	$+_A$			I_B	I_A		
Damkot et al.[41]	I					−		+/−		
Magora[42]	I									+
Magora[43]	I							+/−		
Magora[44]	I							+/−		
Volinn et al.[45]				I		+/−		+/−		
Magnussen et al.[46]	I						+/−	−		+
Kelsey et al.[47]	I							+/−		
Vallfor[48]	I_A			I_B		+/−$_A$		+/−$_{AB}$	+/−$_A$	$+_{AB}$
Biering-Sorensen et al.[49]	I					I +/−		−		−
Sandstrom et al.[50]				I		−			+	
Harbor et al.[51]	I			I		+/−	−	+/−		
Lloyd et al.[52]	−			+		I		I		
Huang et al.[53]	+					−		I +/−		
Skovron et al.[54]	I					+		+		+/−
Burdorf et al.[55]	$+_A$ I_B					C_A $-_A$		I_A $+_B$/$-_B$		
Bongers et al.[56]	I					+/−	−	+		+
Valkenburg et al.[57]	$-_A$ $+_{BA}$		I_B			I_A	$+_A$	$+_B$		
Symonds et al.[58]	I			I		−		+		+/−
Mandell et al.[59]	I					I −	+/−			

Bold type, prospective study; I, independent variable; C, covariate; +/−, dependent measures with both positive and negative association to the independent variable.
D/S, discomfort/symptom surveys; INJ, injury; INC, incidence; Lost T., lost time; R.T., restricted time; Pers., personal; Phys., physical; Exp., exposure; Psychol., psychological; Psychos., psychosocial.

Table 2. Statistical methods, population and exposure measure for each article reviewed

Author	Statistics	Population	Exposure methods	Exposure
Battie et al.[3]	**Correlation**	**Within Plant**		
Biering-Sorensen[4]	**Stepwise**	**Gen. Pop.**		
Bigos et al.[5]	**Regression**	**Within Plant**		
Bigos et al.[6]	Descriptives	Within Plant	Occupational Title	$-_A$
Bigos et al.[7]	Descriptives	Within Plant		
Cady et al.[8]	**Descriptives**	**Within Occupation**		
Chaffin[9]	**Corr./Descriptive**	**Several Plants**	**Dir. Meas./Ord. Scale Spec.**	+
Chaffin et al.[10]	**Descriptives**	**Several Plants**	**Dir. Meas./Ord. Scale Spec.**	+/−
Frymoyer et al.[11]	T-test/Chi-square	Gen. Pop., Vis. Phys.	Occupational Title	+/−
Frymoyer et al.[12]	Stepwise	Gen. Pop., Vis. Phys.	Questionable	+/−
Johanson et al.[13]	Correlation	Many Occupations	Ordinal Scale Specific	+/−
Linton et al.[14]	Regression	Within Occupation		
Marras et al.[15]	Stepwise Logistic	Sev. Plants Many Occ.	Direct Measure	+/−
Riihimaki et al.[16]	**Risk Ratio**	**Many Occupations**	**Occupational Title**	+
Riihimaki et al.[17]	**Risk Ratio**	**Many Occupations**	**Occ. Title/Ord. Scale**	+/−
Theorel et al.[18]	Correlation	Many Occupations	Frequency	$+/-_{AB}$
Troup et al.[19]	T-test/Chi-square	Many Occupations		
Troup et al.[20]	Saturated/T-test	Many Occupations	Ordinal Scale	$+/-_B$
Videman et al.[21]	Regression	Within Occupation	Ordinal Scale Specific	+
Leavitt[22]	T-test/Chi-square	Visiting Physician	Ordinal Scale	$+_B$
Leavitt[23]	T-test/Chi-square	Visiting Physician		
Leavitt et al.[24]	Correlation	Visiting Physician		
Beals et al.[25]	**Descriptives**	**Visiting Physician**	**Ordinal Scale Specific**	$+_A$
Punnett et al.[26]	**Stepwise Logistic**	**Several Plants**	**Ord. Scale Spec./Video**	+
Gallagher et al.[27]	**Stepwise Logistic**	**Visiting Physician**	**Ordinal Scale**	−
Magni et al.[28]	**Logistic**	**General Population**		
Lieno et al.[29]	**Regression**	**Many Occupations**	**Occupational Title**	+
Bergenudd et al.[30]	ANOVA	General Population	Occupational Title	+
VonKorff et al.[31]	**T-test/Chi-square**	**General Population**		
Hansen et al.[32]	**Descriptives**	**General Population**		
Croft et al.[33]	**Logistic**	**Visiting Physician**		
Rowe[34]	Correlation	Normal vs Patient		
Hilderbrandt et al.[35]	ANOVA	Within Occupation	Ordinal Scale Specific	+/−
Masset et al.[36]	Logistic	Many Occupatins	Ordinal Scale	+/−
McIntyre et al.[37]	ANCOVA	Normal vs Patient		
Masset et al.[38]	Logistic	Many Occupations	Occupation Title	I
Svensson et al.[39]	ANOVA	Many Occupations	Ordinal Scale Specific	+/−
Videman et al.[40]	Logistic	General Population	Ordinal Scale Specific	I_A
Damkot et al.[41]	ANOVA/Regress.	Many Occupations	Frequency	+/−
Magora[42]	Descriptive	Many Occupations		
Magora[43]	Descriptive	Many Occupations	Ordinal Scale Specific	+/−
Magora[44]	Descriptive	Many Occupations	Ordinal Scale Specific	+/−
Volinn et al.[45]	Logistic	Many Occupations	Occupational Title	+/−
Magnussen et al.[46]	Descriptive	Within Plant	Direct Measure/Video	−
Kelsey et al.[47]	Logistic	General Population	Ordinal Scale Specific	+/−
Vallfor[48]	Descriptive	Within Plant	Ordinal Scale Specific	$+/-_{AB}$
Biering-Sorensen et al.[49]	**Stepwise Logistic**	**General Population**	**Questionable**	−
Sandstrom et al.[50]	**Logistic**	**Visiting Physician**		
Harbor et al.[51]	Logistic	Within Occupation	Frequency	+/−
Lloyd et al.[52]	Descriptive	Several Plants	Occupational Title	I
Huang et al.[53]	T-test/Chi-square	Several Plants	Ordinal Scale	I +/−
Skovron et al.[54]	Logistic	Within Occupation	Occupational Title	+
Burdorf et al.[55]	Logistic	Many Occupations	Occupational Title, Ques.	I_A $+_B/-_B$
Bongers et al.[56]	Logistic	Within Occupation	Ordinal Scale Specific	+
Valkenburg et al.[57]	Descriptive	General Population	Occupational Title	$+_B$
Symonds et al.[58]	ANOVA/Regress.	Within Plant	Occupational Title	+
Mandell et al.[59]	T-test/Regression	Vis. Phys./Within Occ.		

Bold type, prospective study; I, independent variable; +/−, dependent measures with both positive and negative association to the independent variable.
Dir. Meas., direct measure; Ord. Scale Spec., ordinal scale specific.

low back disorders. Table 2 lists the statistical methods, population, and type of exposure method used in each of the investigations. The exposure method is defined as the specific method used to measure exposure in the workplace including (1) ordinal scale (light, medium or heavy), (2) ordinal scale with specific cut-offs (0–5 kg light, 5–10 kg medium, or 10–15 kg heavy, (3) direct measure or the workplace or worker, (4) occupational title and (5) frequency of tasks. The final column of Table 2 lists the exposure risk factor from Table 1. This column was added to enhance the evaluation of trends between the dependent measure exposure results and the exposure measurement method.

The five risk factor categories that were defined for this review incorporated a wide variety of specific risk factors. Therefore, more in-depth analyses of specific risk factors within each category were performed. Tables 3–7 list the specific risk factors for each of the categories defined in this review. These tables display all the surveillance measure and risk factor combinations, and within each cell are reference numbers for articles that evaluated the particular combination. The positive sign next to the reference number denotes that some type of statistical analysis was performed, indicating an association between the risk factor and low back disorders with that surveillance

Table 3. Percentage of positive findings ( ) for personal risk factors as a function of low back surveillance measures

Personal risk factors	Low back disorder surveillance measures					Total (% positive)
	Discomfort/Symptoms	Injury	Incidence	Lost time	Restricted time	
Age[3,17,18,23,32,37,39,52,53−,55] (0)	**4+,11+**,12+,16−,19−,**28−,33−**,36+,38, 54+,56−,58−,59− (41%)	**22−,25+** (50%)	7+,8+,10−,**26+** (75%)	**27+**,45+, **50−** (66%)		31 (35%)
Sex[3,4,11,13,18,19,20,23,24,**28,29+**,30,32,35,37,45,49,57,59]	**33−**,58− (0)	22+ (*)	**5,26−** (0)	**50−** (*)		24 (8%)
Previous history	**16+**,**17−**,19+,48+,**49+** (80%)		**7+**,**26+** (100%)	34+ (*)		8 (87%)
Intelligence/Education[35] (*)	**17−**,**28+**,48+,**49−** (50%)	**22−**,**25+** (50%)		27−,45−, 48+ (33%)		10 (40%)
Duration of pain[23−] (*)						1 (*)
Race[23−] (*)	**28−** (*)	22− (*)				3 (0)
Number of years experience/ Seniority[13,35,36,53−,55−] (0)	**17−** (*)		**7+** (*)			7 (14%)
Marital status	**28,48−** (0)		**5−** (*)	**45+** (*)		4 (25%)
Household income/Unemployment	**33−**,**28+**,**48+** (66%)			**27−**,48+, 45+ (33%)		6 (66%)
Exercise/Recreational activity	11−,12+,**17+**,41−,48−,51− (33%)		**26−** (*)	**27+**,48−, 51− (33%)		10 (30%)
Smoking	11+,12+,**16+**,**17+**,**33−**,48−,**49+** (57%)			**27−**,**51−** (0)		9 (44%)
Length of time off				**27+** (*)		1 (*)
Headache	**51+** (*)			**51+** (*)		2 (100%)
Distance to work	**49+** (*)					1 (*)
Car ownership	**33−** (*)					1 (*)
Total (percent positive)	45 (44%)	6 (50%)	11 (54%)	19 (52%)	0 (0)	
Prospective studies (percent positive)	18 (36%)	2 (100%)	10 (50%)	8 (38%)	0 (0)	

Bold type, prospective study; +, indicates positive findings, meaning an association between the risk factor and low back disorders with that specific surveillance measure; −, indicates negative findings, meaning no association was found between the risk factor and low back disorders with that surveillance measure.
(*) One observation, therefore percentage was not calculated.
Note: References in the risk factor column were independent measures, covariates or associated with another risk factor.

measure. The negative sign implies that no association was indicated in the article between the risk factor and low back disorders. In some cases more than one type of statistical analysis was performed and the risk factors were positively associated in one case and not in another; therefore both a positive and negative sign were marked. In this review, positive findings are defined as papers with a positive sign next to the reference number. In each cell of the table the percentage of positive results was calculated. The percentage of positive results for a cell was the number of articles with positive findings divided by the total number of articles in the cell. Several specific risk factors have been investigated by only one researcher; therefore the percentage values were not calculated for these cells. In each table summaries were calculated for the percentage of positive finding for each specific risk factor and each surveillance measure. The percentage of positive findings was calculated by adding the number of articles that had an association between the risk factor and the low back disorder (indicated by positive sign) and divided by the total number of articles in that column or row. Figure 2 shows the percentage of positive findings for all the articles reviewed as a function of surveillance measures and risk factor for those combinations with more than two investigations. Figure 2 also shows trend lines (solid or dashed) for each risk factor category, indicating an increase or decrease in the percentage of positive findings as the surveillance measures change. In each of the tables a separate row of summary calculations was made for prospective studies only. Figure 3 shows the percentage of positive findings and trend lines (solid or dashed) for only the prospective studies as a function of surveillance measures and risk factor for those combinations with more than two investigations. It should be pointed out that the statistical methods used in each of the articles may influence the reader's opinion concerning the strength of the association between independent and dependent measures. However, no type of weighting process was used in summarizing the percentage of positive findings in this review.

Results/Discussion

Figure 1 displays our hypothesis of the progression of low back disorder and the events (surveillance measures) that may lead to disability. It is further hypothesized that where in the sequence of events the study intervenes may influence the outcome. In the process of events in Figure 1 a person would first experience spinal loading resulting in discomfort/symptoms, followed by incidence or reporting, and then possibly restricted time and lost time. From Table 1, it is apparent that most investigators evaluated only one surveillance measure. It is hypothesized that investigators who only use one surveillance measure may not capture all the risk factors of the progressing low back disorders. The few authors that did

Table 4. Percentage of positive findings ( ) for physical risk factors as a function of low back surveillance measures

Physical risk factors	Low back disorder surveillance measures: Discomfort/Symptoms	Injury	Incidence	Lost time	Restricted time	Total (% positive)
Isometric strength	16−,21−,38−59− (0)	21− (*)	3−5− (0)	27− (*)		8 (0)
Isometric extension strength	4+/− (50%)					2(50%)
Isometric endurance	4+ (*)					1 (100%)
Dynamic strength	19−,59+/− (33%)					3 (33%)
Anthropometry	4−,16−,21−,36−,38−,46+,51−,56− (12%)					8 (12%)
Range of motion[57+] (*)	4+/−,37+,19− (50%)		5− (*)	27− (*)		7 (33%)
Sit-up test	4−,19+,21+ (66%)	21+ (*)		34− (*)		5 (40%)
X-ray			57+ (*)	34− (*)		2 (50%)
Neurological finding			57+ (*)	34− (*)		2 (50%)
Straight leg raise			16−,57− (0)			2 (0)
Spinal canal size			5− (*)			1 (0)
Aerobic capacity	59− (*)		5− (*)			2 (0)
Velocity	36+,37+ (100%)					2 (100%)
Physical rating from physician				25+ (*)		1 (100%)
Weight handling skill	21+ (*)	21+ (*)				2 (100%)
Blood plasma level	18− (*)			18− (*)		2 (0)
Blood pressure	18− (*)			18− (*)		2 (0)
Combination	20+ (*)		8+,9+,10+ (100%)			4 (100%)
Total (percent positive)	32 (38%)	3 (66%)	12 (42%)	8 (12%)	0 (0)	
Prospective studies (percent positive)	7 (28%)	0 (0)	8 (38%)	3 (33%)	0 (0)	

Bold type, prospective study; +, indicates positive findings, meaning an association between the risk factor and low back disorders with that specific surveillance measure; −, indicates negative findings, meaning no association was found between the risk factor and low back disorders with that surveillance measure; +/−, indicates both positive and negative results, meaning more than one analysis was performed and are counted twice in the totals.
(*) One observation, therefore percentage was not calculated.

Table 5. Percentage of positive findings ( ) for exposure risk factors as a function of low back surveillance measures

Exposure risk factor	Low back disorder surveillance measures: Discomfort/Symptoms	Injury	Incidence	Lost time	Restricted time	Total (% positive)
Lifting	11+,18+,35+,39+,41−,44+,47+,49− (75%)			18+ (*)		9 (78%)
Bending	11+,13−,35+,36−,38+,39+,41−,47+ (62%)		26+ (*)			9 (66%)
Twisting	11+,13−,35+,38+,41−,47+ (66%)		15+ (*)	15+ (*)	15+ (*)	9 (78%)
Number of lifts/day (frequency)	13−,35−,39+,41+,47+,48−,56+ (55%)		10+,15+ (100%)	15+,48− (50%)	15+ (*)	13 (62%)
Weight lifted[53−]	36−,39−,41+,44−,47+,48−,56+ (43%)		10+,15+ (100%)	15+,27−,48+ (66%)	15+ (*)	14 (57%)
Posture[53−]	6−,13+/−,18+,35+,38+,41,48+ (62%)		15+ (*)	15+,18+,48− (66%)	15+ (*)	14 (64%)
Sitting/type of chair	11−,13−,35+,39+,41+,44+,51−,56− (50%)			51− (*)		9 (44%)
Vibration	11−,35−,36+,38−,41+,55+,56+ (57%)					7 (57%)
Driving	11+,12−,36+,41− (50%)					4 (50%)
Pulling	11+,13−,35+,41+ (75%)					4 (75%)
Stretching/reaching (moment arm)	43− (*)		15+ (*)	15+ (*)	15+ (*)	4 (75%)
Number of times in and out of car	41+ (*)					1 (*)
Unexpected loading	6−,35−,43+ (33%)			48− (*)		4 (25%)
Sedentary posture	18−,55− (0)			18− (*)		3 (0)
Kind of transportation	49− (*)					1 (*)
Carrying/pushing	13−,47+,51+ (66%)					3 (66%)
Heavy effort with shoulder	36+ (*)					1 (*)
Slipping/falling	35+ (*)					1 (*)
Walking	35+ (*)					1 (*)
Chainsaw usage	12+ (*)					1 (*)
Monotonous movement	55+,18+ (100%)			18+ (*)		3 (100%)
Moving furniture	51− (*)			51− (*)		2 (100%)
Action limit[53+]						1 (*)
Plant layout[53+]						1 (*)
Stooping[53−]						1 (*)
Velocity			15+ (*)	15+ (*)	15+ (*)	3 (100%)
Acceleration			15− (*)	15− (*)	15− (*)	3 (0)
Exposure rating				25+ (*)		1 (*)
Lifting strength ratio			9+,10+ (100%)			2 (100%)
Total (percent positive)	86 (58%)	0 (0)	12 (91%)	19 (58%)	7 (85%)	
Prospective studies (percent positive)	14 (57%)	0 (0)	5 (100%)	2 (50%)	0 (0)	

Bold type, prospective study; +, indicates positive findings, meaning an association between the risk factor and low back disorders with that specific surveillance measure; −, indicates negative findings, meaning no association was found between the risk factor and low back disorders with that surveillance measure; +/−, indicates both positive and negative results, meaning more than one analysis was performed and are counted twice in the totals.
(*) One observation, therefore percentage was not calculated.
Note: References in the risk factor column were associated with other risk factors.

Table 6. Percentage of positive findings ( ) for psychological risk factors as a function of low back surveillance measures

Psychological risk factor	Low back disorder surveillance measures: Discomfort/Symptoms	Injury	Incidence	Lost time	Restricted time	Total (% positive)
Depression	11+,24−,28−,29+,31−,33+,36− (43%)					7 (43%)
Stressful life events/stress	11+,16+,24+,29+ (100%)					4 (100%)
Irritated temper	36− (*)					1 (*)
Anxiety	11+,24+,33+ (100%)					3 (100%)
Worry	18−,39+ (50%)			18− (*)		3 (33%)
Afraid				50+ (*)		1 (*)
Sleep changes	18− (*)			18− (*)		2 (0)
Tiredness	18− (*)			18− (*)		2 (0)
Anger	18− (*)					2 (0)
Sadness	18− (*)			18− (*)		2 (0)
Hysteria (not using MMPI)	21+ (*)	21+ (*)				2 (100%)
Health locus of control	21− (*)	21− (*)	5− (*)	27− (*)		4 (0)
LBPSCL[23]	22+,24+ (100%)					3 (100%)
Waddell signs	48− (*)			48− (*)		2 (0)
MMPI	32− (*)		5+ (*)	27+ (*)		2 (0)
Psychological rating				25+ (*)		1 (*)
Total (percent positive)	27 (52%)	2 (50%)	2 (50%)	10 (30%)	0 (0)	
Prospective studies (percent positive)	6 (66%)	0 (0)	2 (50%)	4 (75%)	0 (0)	

Bold type, prospective study; +, indicates positive findings, meaning an association between the risk factor and low back disorders with that specific surveillance measure; −, indicates negative findings, meaning no association was found between the risk factor and low back disorders with that surveillance measure; +/−, indicates both positive and negative results, meaning more than one analysis was performed and are counted twice in the totals.
(*) One observation, therefore percentage was not calculated.
Note: References in the risk factor column were associated with other risk factors.

evaluate multiple surveillance measures predominantly evaluated the relationship of lost time and type of injury. One author combined incidence, lost time, and restricted time into one measure of severity. However, none of the literature reviewed evaluated low back disorders as a progression of events leading to disability (lost time).

The literature indicates that the risk of low back disorders is a function of personal factors, physical measures, exposure in the workplace, psychological factors, and psychosocial risk factors[1]. Personal risk factors were evaluated by 82% of the investigators, but 50% of the articles reviewed evaluated only one of the other four risk factors. Some of the researchers investigated a combination of risk factors and then published separate articles addressing different risk factors[6,7,42,43,46]. Researchers who evaluated two categories of risk predominantly investigated physical

Table 7. Psychosocial risk factors as a function of low back surveillance measures

Psychosocial risk factor	Low back disorder surveillance measures: Discomfort/Symptoms	Injury	Incidence	Lost time	Restricted time	Total (% positive)
Job satisfaction	30+,35−,36−,38−,39+,42+,48+,49+,58+ (55%)		15+/− (50%)	15+/−,48+,58− (50%)	15+/− (50%)	17 (52%)
Monotony	17−,38− (0)					2 (0)
Satisfaction with environment	14−,36−,39+,42+ (50%)					4 (50%)
Relation with supervisor	13+,17+,64+ (100%)					3 (100%)
Relation with co-workers	13−,17+/− (33%)					3 (33%)
Mental workload	13+,18+,35− (66%)			18+ (*)		4 (75%)
Control over work or autonomy	13−,18−,35+,48+,54+ (60%)			18−,48+ (50%)		7 (57%)
Organizational/Social support	35−,58+ (50%)			58− (*)		3 (33%)
Stimulus from work	13+ (*)					1 (*)
Mental stress	42+,56+,58− (66%)			58− (*)		4 (50%)
Social status	42+ (*)					1 (*)
Responsibility at work	42+ (*)					1 (*)
Nervousness at work	42+ (*)					1 (*)
Fatigue at work	42+ (*)					1 (*)
Supervisor appraisal rating				7+ (*)		1 (*)
Possibility to talk with other	18+ (*)			18+ (*)		2 (100%)
Work APGAR			5+ (*)			1 (*)
Inevitability beliefs	58+ (*)			58+ (*)		2 (100%)
Disability attitudes	58− (*)			58+ (*)		2 (50%)
Physical activity beliefs	58− (*)			58+ (*)		2 (50%)
Work activity beliefs	58− (*)			58+ (*)		2 (50%)
Pain control attitudes	58+ (*)			58+ (*)		2 (100%)
Pain responsibility attitudes	58− (*)			58+ (*)		2 (50%)
Total (percent positive)	46 (56%)	0 (0)	3 (66%)	17 (70%)	2 (50%)	
Prospective studies (percent positive)	9 (33%)	0 (0)	1 (*)	0 (0)	0 (0)	

Bold type, prospective study; +, indicates positive findings, meaning an association between the risk factor and low back disorders with that specific surveillance measure; −, indicates negative findings, meaning no association was found between the risk factor and low back disorders with that surveillance measure; +/−, indicates both positive and negative results, meaning more than one analysis was performed and are counted twice in the totals.
(*) One observation, therefore percentage was not calculated.
Note: References in the risk factor column were associated with other risk factors.

and exposure risk factors or exposure and psychosocial risk factors. Interestingly, a large proportion of these investigators had the same results for both risk factor categories[9,13,17,20,29,30,35,49,57]. One hypothesis for this observation is that the sensitivity of the low back surveillance measure may have created the similarity in the results. In a review article, Winkel and Mathiassen[60] state that imprecise estimates of exposure underestimate the risk due to exposure and that psychosocial factors may be overestimated. While this does not appear to be the case based on this review, there is clearly a lack of literature investigating two or more categories of risk factors simultaneously. Frank et al.[61] pointed out the importance of measuring or controlling all variables and that neglecting some risk factors may influence the outcome of the study; however, only three of the 57 articles reviewed investigated all five categories of risk factors[18,27,36]. The effectiveness of combining categories is illustrated by Troup et al.[20], who created a model of predominantly physical factors to predict symptoms and improved the results from 35 to 52% correct classification by adding one personal risk factor (previous history of LBP). Thus, examining all the surveillance measures and all the risk factor categories together allows one to evaluate low back disorders with a more global perspective.

Surveillance measures and risk factors of low back disorders

In this review there are five categories of risk factors. Within each category there are a multitude of specific risk factors that have been investigated, as shown in Tables 3–7. These tables show the predominance of the discomfort/symptom survey surveillance measure in all five risk factor categories. However, the five different surveillance measures all measure different points in the progression of low back disorders. Discomfort/symptom surveys elicit the participants' perception of pain. In most cases the participants have not perceived pain to be a problem and have not sought treatment. In some cases the population studied were patients visiting a physician, as listed in Table 2. In those visiting a physician a discomfort/symptom survey would indicate that the person interpreted the pain as a problem and decided to seek medical attention. An incidence is defined as a reporting of symptoms, which means the person has perceived pain and interpreted it as a problem that needs reporting. Masset and Malchaire[36] reported that 31% of the population studied reported symptoms, but only 17% of those reported seeking medical attention. It appears from the Masset and Malchaire[36] finding that discomfort/symptom surveys may cause an overreporting of low back disorders, or discomfort may be viewed as a precursor to incidence, lost time, and restricted time as shown in Figure 1. Injury is usually defined as symptoms attributable to a specific cause or event. Lost time indicates that the person was unable to work due to a low back disorder. Once the person is not working, returning to work is a function of several factors that will be discussed in a subsequent section. Restricted time indicates the person may be able to work but not at all jobs. The difference between restricted time and lost time low back disorders may be a function of an individual's pain tolerance. The low back disorder surveillance measure or its point in the progession of the disorder (Figure 1) may influence the outcome of a study.

Influence of surveillance measures on outcome

Discomfort/symptoms

Seventy-seven percent of the 57 articles reviewed used the discomfort/symptom survey surveillance measure. Thus it would appear that some common surveillance measures are used in the literature. However, only 14% of those using discomfort/symptom surveys had a similar question which evaluated low back problems in the past 12 months. The questionnaires used to evaluate symptoms varied in several dimensions including the history of time being surveyed, the severity of symptoms and the duration of symptoms. Figure 2 shows that the percentage of positive results based on discomfort/symptoms ranged from 38% for physical risk factors to 59% for exposure. Figure 3 shows that prospective studies had fewer positive outcomes, with 28% for physical risk factors, but increased to 66% positive results for psychological risk factors. In all the studies reviewed, discomfort/symptom surveys yield approximately 50% positive results across all categories of risk factors. It is hypothesized that the lack of consistency in the results among all the risk factor categories may be due to the variations or insufficient reliability in the discomfort/symptom questionnaires.

Injury

Three of the five researchers who used the injury surveillance measure defined injury as symptoms attributable to a specific cause[6,19,21]. The injury surveillance measure was employed in only 9% of the articles reviewed. Figures 2 and 3 illustrate the lack of research investigating exposure, psychological and psychosocial risk factors using the injury surveillance measure. Eighty percent of those evaluating injury investigated the association of injury and lost time[6,19,22,25]. Table 1 shows that all four of these investigations found a positive association between cause of injury and lost time, even though injury was defined differently. Videman and associates[21] were the only research group that investigated physical and psychological risk factors via injury and discomfort/symptoms surveys. These authors created separate models for the two different low back disorder surveillance measures. Interestingly, the model for

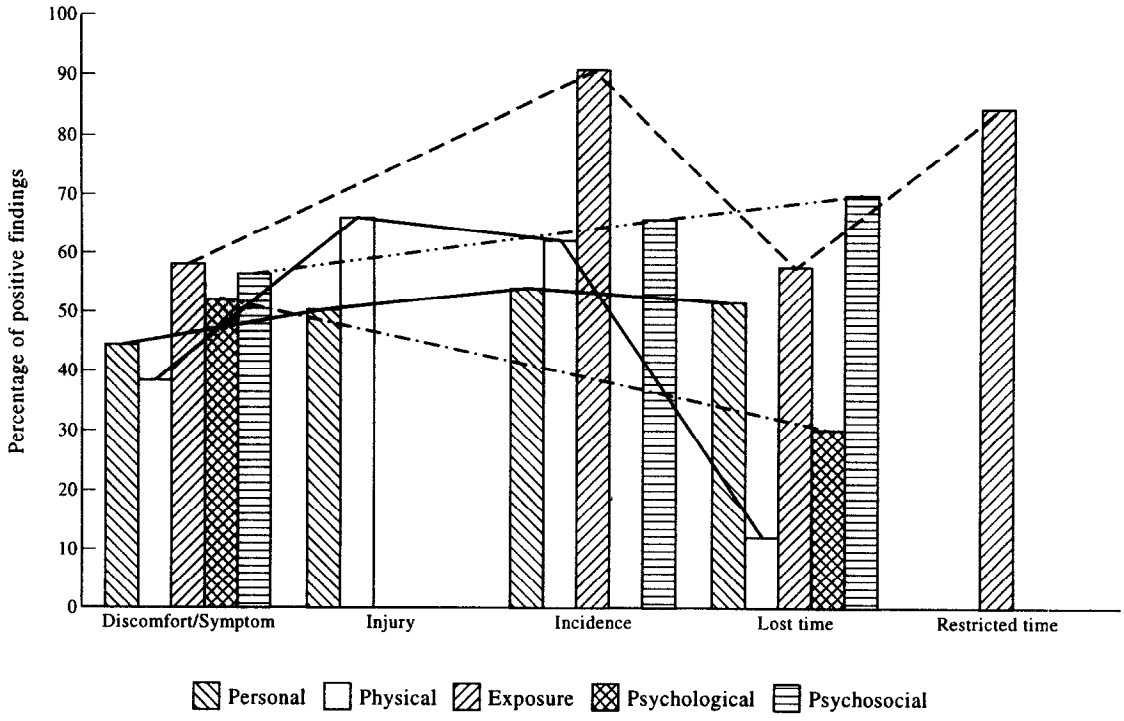

Figure 2. Percentage of positive findings and trend lines on all studies for each surveillance measure and risk factor combination. Note the increasing percentage of positive findings as the surveillance measure moves from discomfort/symptoms to incidence.

symptoms included risk factors from the physical and psychological categories, whereas the injury model combined risk factors from the physical and exposure categories. The differences in the models supports the hypothesis that different points in the progression of low back disorders have different causal mechanisms which are more sensitive to certain categories of risk factors.

Incidence

Eighty-two percent of investigators who evaluated low back disorders as a function of the incidence surveillance measure defined incidence as claims to medical records or Occupational Safety and Health Administration (OSHA) records[3,5,6–10,15,26]. This definition of incidence was the most consistent definition among the five surveillance measures. The

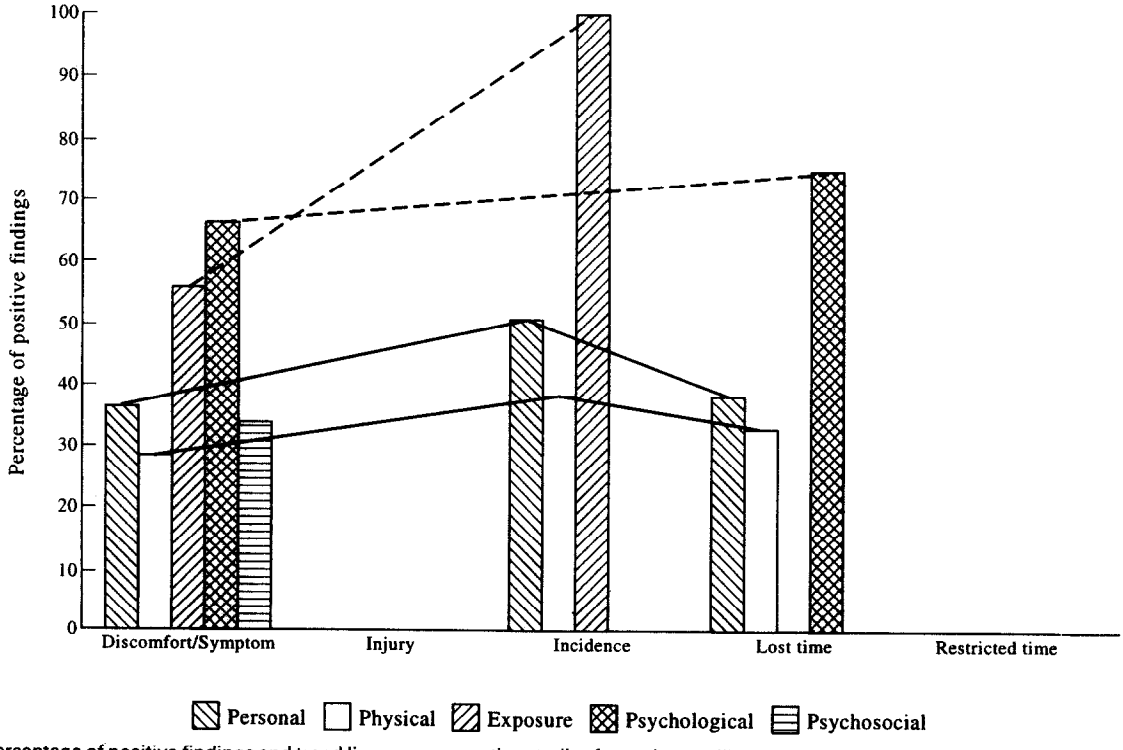

Figure 3. Percentage of positive findings and trend lines on prospective studies for each surveillance measure and risk factor combination. Note the increasing percentage of positive findings as the surveillance measure moves from discomfort/symptoms to incidence.

accuracy of medical and OSHA records may be influenced by several factors. Fitzler and Berger[62] found that reporting of incidence was influenced by management attitude towards reporting. Thus, if management discourages reporting, then the incidence measure will underestimate low back problems. Reporting of incidence may also be influenced by personal factors such as ethnic background and family history of incidence[63]; Chaffin and Park[10] was the only article reviewed that discussed the influence of reporting on the results.

The incidence surveillance measure was most often used to assess exposure, physical risk factors, or personal risk factors. The incidence surveillance measure tended to have a higher percentage of positive findings than other surveillance measures when evaluating exposure risk factors. It should be noted that the exposure risk factors were evaluated via direct measure or video analysis when investigating incidence. This combination of incidence surveillance and direct or video measure of the exposure risk factor provided the highest percentage of positive findings (91%) when compared to all other summary percentage values, as illustrated in Figure 2. In addition, this combination of incidence assessment and direct exposure measures had 100% positive findings for prospective studies, as shown in Figure 3.

Lost time

Lost time has been measured via company records[6,7,15], physician records[45,50] and questionnaires[11,12,18,19,22,23,25,27,34,48,51]. Thirty-three percent of the questionnaires used in lost time investigations evaluated whether the person was working or not working after a specific period of time[22,23,27,34], but all the other investigators had different questionnaires. Figure 2 shows that the percentage of positive findings in the lost time surveillance measure was 52% for personal risk factors, 12% for physical measures, 58% for exposure risk factors, 30% for psychological risk factors and 70% in psychosocial measures. Thus, lost time would appear to be influenced by psychosocial risk factors more than the other risk factor categories. However, in prospective studies the percentage of positive findings was 75% for psychological risk factors, as shown in Figure 3. Unfortunately, no psychosocial risk factors were evaluated prospectively via lost time. The results of the researchers using questionnaires may have been influenced by management attitude, availability of restricted time, or how long ago the lost time occurred. Vallfors[48] noted that some participants in the study indicated that lost time would be reduced if restricted duty was available. Fitzler and Berger[62] found that when light duty was made available, the amount of lost time decreased. Leavitt[22] found lost time was a function of exposure in the workplace, and that those injured at work lost more time than those injured away from work, regardless of exposure level. Overall, it would appear that lost time is influenced by exposure, psychosocial, psychological, and personal risk factors and that more prospective studies are needed evaluating psychosocial risk factors and lost time.

Restricted time and combined surveillance measures

Table 1 shows that Marras and colleagues[15] were the only investigators in this review to evaluate restricted time. They combined the measures of incidence, lost time, and restricted time into a single multiplicative measure of severity. The Marras et al.[15] investigation is the only article that combined several of the surveillance measures into a single measure. The other researchers that investigated more than one surveillance measure either used one as a dependent measure or had separate analyses for each surveillance measure. Thus, there is a void in the literature of studies that evaluate the surveillance measures as a sequence of events creating a model for the development of low back disorders.

Summary of surveillance measures

In this review, surveillance methods were placed in one of five categories (discomfort/symptoms, injury, incidence, lost time, restricted time). These surveillance measures may be viewed as a time progression of low back disorder severity, as shown in Figure 1. There are trade-offs to consider when employing any of these surveillance measures. Discomfort/symptom surveys may be viewed as early detection measures of future problems and may be used in prevention progammes. Surveillance measures of incidence, lost time, and restricted time indicate more severe and costly stages of low back disorders compared to discomfort/symptoms. Across all risk factors the percentage of positive findings was 50, 55, 61, 44 and 67% for discomfort/symptoms, injury, incidence, lost time and restricted time, respectively. Thus, with the exception of lost time, there is an increasing percentage of positive findings as the surveillance measure intervenes in low back disorders at more severe points. The goal in prevention should be to detect low back disorders as early as possible in order to avoid the incidence or lost time stages of low back disorders.

Risk factors

Personal factors

Table 1 shows that personal risk factors were the most frequently investigated risk factors. These measures were used as independent, dependent and covariate factors, as indicated in Table 1. Figure 2 shows that as the surveillance measures progress from discomfort/symptoms to lost time there is increase in the percentage of investigations with positive findings. Table 3 shows that sex and age were the most commonly

evaluated personal risk factors. Seventy-five percent of those investigating sex used the measure as an independent variable. None of the prospective studies that evaluated sex as a dependent measure had significant findings. Of the studies that evaluated age as a dependent measure 75% found that age significantly influenced incidence; 66% indicated age affected lost time, 50% found that age influenced injury, and 41% found that age influenced discomfort/symptoms. The results of the exercise risk factor were not influenced by surveillance measure, with approximately one-third of the studies having positive outcomes regardless of the surveillance measure. On the other hand, the outcome of smoking was influenced by surveillance measure. Smoking was associated with symptoms in 57% of studies, but not associated with lost time in any studies. It appears that the percentage of positive findings for some specific personal risk factors are influenced by surveillance measures, as shown in Table 3.

One of the more interesting personal risk factors is previous history of low back pain. This risk factor was predominantly investigated in relation to symptoms and 80% of the researchers found previous history to be associated with an increased risk of symptoms[16,17,19,48,49]. Punnett et al.[26] and Bigos et al.[5] both found that incidence increased with previous history of low back disorder. Rowe[34] found an association between previous history and future lost time due to low back disorders. Previous history is associated with future low back disorders, regardless of the surveillance measure. The predominance of the previous history risk factor supports the concept of low back disorders as a progression of events as shown in Figure 1, and once the process begins the disorder may be more likely to progress.

Another interesting personal risk factor is years of employment or seniority, which Bigos et al.[7] associated with incidence rates. Bigos et al.[7] found that younger employees and those with fewer years of experience had a greater incidence of low back disorder. One theory explaining this finding is that newer employees have jobs that require more manual material handling because of their lower seniority. A second theory explaining the Bigos et al.[7] findings may be the healthy worker effect. A third hypothesis suggests that as the worker is on the job longer, then he or she becomes more conditioned and develops appropriate motor control to perform the job, which may reduce spinal loading during lifting or manual material handling.

Physical factors

Fifty-eight percent of the studies evaluating physical risk factors used the discomfort/symptom survey surveillance measure, with only 38% positive outcomes, as shown in Figure 2. In this review, isometric strength was not a predictor of discomfort/symptoms[16,21,38,59], injury[21], lost time[27], or incidence[3,5]. Conversely, Biering-Sorensen[4] found isometric endurance was a predictor of symptoms in both men and women and that isometric extension strength was a predictor of symptoms in women but not men. Mandell and colleagues[59] also found that isokinetic strength in flexion/extension distinguished between symptomatic and asymptomatic men but not women. In addition, isokinetic rotation strength did not distinguish between symptomatic and asymptomatic men or women[59]. Troup et al.[19] found no difference in isokinetic strength for symptomatic or asymptomatic groups. Videman et al.[21] found that weight handling skill judged by an independent observer was associated with the development of an injury. A possible explanation for this is that the weight handling skill required more practice and the development of more sophisticated motor control programmes than the isometric and isokinetic strength measures. Thus, strength measures that require higher levels of motor control were better indicators of low back disorders.

As shown in Table 4, some of the more common physical risk factors included anthropometry, range of motion, sit-up and velocity measures. The anthropometry measure was not related to discomfort/symptoms of low back disorders in 88% of the studies[4,16,21,36,38,51,56] that evaluated anthropometry. Range of motion (ROM) was not a significant risk factor for lost time[27], incidence[5], or symptoms[19]. On the other hand, McIntyre et al.[37] did find differences in preferred ROM between those with low back pain and those without. In addition, Biering-Sorensen[4] found that range of motion was indicative of symptoms in men but not women. Sit-up tests were used by a number of researchers, and the association of sit-up test with low back disorder appears to be a function of the surveillance measure[4,19,21,34]. The results may also be a function of the quality of sit-up permitted by the experimenter. A higher quality sit-up may require more trunk muscle control compared to a sit-up where momentum from other body parts creates the sit-up motion. Another physical measure is velocity, and two investigators found that velocity distinguished between those with symptoms and those without[36,37]. In fact, Masset and Malchaire[36] showed that velocity measures distinguished between symptomatic and asymptomatic controls more effectively than range of motion or maximum isometric torques. These findings are in agreement with Marras and Wongsam[64], who showed that velocity was better than ROM at distinguishing patients from controls. In general, as the physical measures progress from anthropometry to range of motion, to sit-ups, and to velocity, more motor control is required. From the findings of Masset and Malchaire[36] and Marras and Wongsam[64] it appears that a measure requiring higher levels of motor control may distinguish more effectively between those with and without low back disorder symptoms. Therefore, it is hypothesized that measures of sit-up tests and velocity that require

higher levels of motor control may distinguish low back disorder at earlier points in the progression of the disorder. Thus, these measures should be incorporated into diagnostic evaluations.

Exposure factors

Table 5 shows that the most common exposure risk factors evaluated were lifting, bending, frequency, weight lifted, posture, twisting, and vibration, with the percentage of positive findings in 78, 66, 62, 57, 64, 78 and 57% of the studies, respectively. Exposure was measured using one of several methods, including ordinal scales, ordinal with specific cut-offs, occupational title, direct measuring device, video analysis, frequency of task and unspecified questionnaire, as indicated in Table 2. These methods vary greatly in their precision, cost of measurement and interpretability. The differences in precision may influence whether or not the exposure risk factor is associated with a measure of low back disorder surveillance. Figure 2 shows that exposure risk factors evaluated via incidence had the highest percentage of positive findings. As shown in Table 2, these investigators all measured exposure using direct measuring devices or video analysis. Therefore, higher precision measuring systems appear to influence outcome. Researchers who investigated exposure measures with discomfort/symptom surveys had 58% positive findings. The decrease in the percentage of positive findings may be due to the inconsistencies in the discomfort/symptoms surveys or the exposure measuring methods. Most of these researchers used ordinal scales with specific cut-offs. Therefore, it is hypothesized that the outcome is influenced by both the specific cut-offs as well as the discomfort/symptom surveys. Burdorf and Lean[65] compared methods of exposure risk factor analysis and found that the method of measurement influenced the outcome.

The methodology employed in an investigation influences the outcome. Several investigators evaluated exposure with the occupational title measure: those who investigated two or three occupational titles had positive outcomes whereas those with multiple occupational titles (more than six) had negative outcomes. The important role of methodology influencing results also occurs in direct methods of exposure measures. Magnussen et al.[46] had five categories of flexion position and had no significant findings with trunk position, whereas Marras et al.[15] used continuous measures of trunk position, velocity and acceleration and two discrete levels of incidence, and had positive findings. A study by Chaffin[9] highlights the importance of methodology the best. In the first analysis, a lifting strength ratio was used as a continuous variable and the correlation with incidence was 0.38 ($R^2 < 0.14$). In a subsequent evaluation the lifting strength ratio was grouped in an ordinal scale with three specific cut-offs; it was found that lifting strength ratios greater than one were three times more likely to have an incidence than lifting strength ratios less than one. The importance of statistical methods can also be found in the physical risk factor of isometric strength. Researchers who created an ordinal scale variable from a continuous physical measure found significant results[8,10]. On the other hand, those who evaluated isometric strength as a continuous measure did not have an association with incidence[3,5]. From a statistical perspective, putting data in a few discrete categories increases the statistical power, thereby increasing the likelihood of statistically significant findings. Previous literature reviews[1,66,67] have failed to discuss the impact of statistical methodology, and specifically continuous *vs* discrete variables, on the outcome of studies. Generally, discrete measures of either surveillance measures or risk factors created positive results whereas continuous measures of risk factors and surveillance measures led to negative results. This may provide insight as to why contradictory findings occur in the literature for the same risk factor. From this information it may be hypothesized that the outcome of some investigations may be altered by changing the type of scale used to measure the risk factor.

Psychological factors

Psychological risk factors were investigated predominantly as dependent measures, as shown in Table 1. Nearly half of the papers researching psychological risk factors did not investigate additional exposure, physical, or psychosocial risk factors. Table 6 lists the specific psychological factors assessed or specific testing questionnaires implemented as a function of low back disorder surveillance measure. The most common psychological risk factors evaluated were depression and stressful life events, with positive results in 43 and 100% of the studies, respectively. The researchers all investigated depression in association with symptoms; however, they all evaluated symptoms and depression with different questionnaires. Thus the conflicting results may be due to differences in either symptom surveillance measures or depression evaluation techniques. Health locus of control was another psychological risk factor investigated. However, none of the authors found a positive association with discomfort/symptoms, injury, incidence, or lost time. Symonds et al.[68] classified (pain) locus of control as a psychosocial risk factor. Thus there appear to be some differences among researchers in the classification of psychosocial and psychological risk factors. Table 6 shows that within the psychological risk factor category are several specific risk factors that are synonyms for fear, including anxiety, being afraid and worry. Therefore, it appears that some standard psychological definitions are needed within the category, as well as clarification between the definition of psychosocial and psychological risk factor categories.

Table 6 shows that several researchers have used the MMPI for psychological evaluations. Those with positive results evaluated each specific scale and reported positive findings with the hysteria scale[5,27], whereas the researcher with negative findings assessed three scales using the conversion V[32]. Also, those with positive findings[5,27] assessed lost time as well as incidence, and Hanson[32], who had negative findings, assessed symptoms. Table 6 shows the percentage of positive findings for prospective studies was 75% for those who used lost time surveillance and 66% for discomfort/symptom surveillance. In applying this information to Figure 1, it appears that the psychological risk factors influence the advanced stage of lost time more than the preliminary stage of discomfort. It should be pointed out that there is a general lack of research evaluating psychological risk factors with injury, incidence and restricted time surveillance measures. Block[69] stated that psychological risk factors have been researched more extensively as treatment outcome measures, as opposed to predictors of symptoms.

Psychosocial factors

Table 1 shows that 18 of the 57 articles investigated some type of psychosocial risk factor. The most commonly investigated psychosocial factor was job satisfaction, which resulted in both positive[30,39,42,48,58] and negative[35,36,38,49] associations with symptoms. Two of the five studies that associated job satisfaction with symptoms performed descriptive statistics which only show trends and not statistical significance. Casting further doubt on job satisfaction as the cause of discomfort/symptoms are prospective studies[35,49] that had negative findings. In addition. Bongers et al.[70] performed a literature review and found that job dissatisfaction was associated with low back trouble in one of five studies.

Figure 2 shows an increasing trend in the percentage of positive findings as the surveillance measures progress from discomfort to lost time when evaluating psychosocial risk factors. It is hypothesized that as low back disorders progress (shown in Figure 1) the role of the psychosocial risk factors becomes more prominent. Table 7 shows that only 8% of the articles investigated psychosocial risk factors with injury, incidence, or restricted time surveillance measures. Additional research using psychosocial risk factors with these surveillance measures may provide new insight into the progression of low back disorders.

Riihimaki et al.[17] investigated worker relations with co-workers and supervisors in three occupational groups (office workers, carpenters and machine operators) using discomfort/symptom surveys. They found that relations with co-workers and supervisors were significantly related to symptoms in only one occupational group (office workers). The findings of relations with supervisors influencing discomfort/symptoms is supported by Skovron et al.[54]. The Riihimaki et al.[17] results may provide some insight on the reason for such diverse results in the epidemiological literature. There are a multitude of personal, physical, exposure, psychological and psychosocial risk factors for the progression of low back disorders, and these risk factors interact in different ways to cause low back disorders. In one situation the psychosocial risk factor may be the main contributor, resulting in positive findings for the psychosocial risk factors. In other cases it may be the exposure risk factors that are the primary causes of low back disorders. Thus, in every situation the risk factors would interact in a different manner to reach a critical tolerance level unacceptable to the person, and resulting in reporting of low back disorders.

Prospective studies

Prospective studies are indicated on the tables by bold type and there are separate summaries for prospective studies in Tables 3–7. Comparing the summaries of prospective studies and all studies, 80% of the surveillance measure risk factor combinations had a lower percentage of positive findings for prospective studies. Prospective studies had a higher percentage of positive findings for psychological factors assessed via discomfort/symptom surveys and lost time, as well as exposure factors assessed with incidence. One specific combination of particular note is the physical risk factor that used a combination of measures and the incidence surveillance measure, which showed 100% positive results. Figure 3 shows that the percentage of positive findings increased as the surveillance point progressed from discomfort/symptoms to incidence for personal, physical and exposure risk factors. In addition, the percentage of positive findings increased for the psychological risk factors as the surveillance measuring point progressed from discomfort to lost time. It is interesting to observe that when the surveillance measuring point progressed from incidence to lost time there was a decrease in the percentage of positive findings for personal and physical risk factors. Figure 3 shows the lack of prospective research for many combinations of surveillance measures and risk factors.

The interesting issue in the prospective studies reviewed was the type of follow-up evaluation. Questionnaires were used by 53% of the investigators and records were used by 37% of the investigators. Most investigators only followed up on the surveillance of low back disorders and not changes in risk factors. Lieno and Magni[29] were the only investigators who re-evaluated the risk factors, which in their case was a psychological evaluation. Pope[71] pointed out that none of the literature identifies how functional performance changes with exposure. In addition, there is a lack of literature investigating how psychological and psychosocial factors change with exposure or how subjective

rating of exposure changes with time. Thirty-two percent of the articles reviewed were prospective studies, demonstrating a void in the literature prospectively evaluating risk factors of low back disorders.

Conclusions and future needs

The most frequently used surveillance measure was discomfort/symptom surveys followed by lost time, incidence, injury and restricted time. However, only 14% of those that used discomfort/symptom surveys had equivalent questionnaires. Discomfort/symptom surveys have approximately the same percentage of positive findings, regardless of the category of risk factor evaluated. Therefore, it is theorized that the inconsistencies in the results are due to the discomfort/symptom surveys and not the risk factor evaluation method. Psychological risk factors have the highest percentage of positive findings using discomfort/symptom surveys in prospective studies. The most consistently defined surveillance measure was incidence. Incidence has a higher percentage of positive findings than discomfort/symptom surveys in physical, exposure and psychosocial risk factors. Incidence also has a higher percentage of positive findings compared to lost time in physical, exposure and psychological risk factors. The higher percentage of positive findings via incidence may be due to the consistent methods of evaluating incidence. The lost time surveillance measure had the highest percentage of positive findings in the psychosocial risk factor category. Overall, it would appear that specific low back surveillance measures may be more sensitive for detecting certain categories of risk factors.

Even with the inconsistent surveillance measures, it does appear that personal, physical, exposure, psychological and psychosocial risk factors all influence low back disorders. The precision of measurement of these risk factors seems to influence the results of investigations. Physical measures of the person (i.e. sit-up test, velocity) that require higher levels of motor control (more precision) distinguish between asymptomatic and symptomatic subjects more effectively than physical measures requiring less motor control. However, there is a void in the literature investigating all five categories of risk factors simultaneously. Due to the complexity of low back disorders, there is a need to investigate all five risk factors and how they may interact to cause or prevent low back disorders as well as long-term disability (lost time) or recovery. Frymoyer and Cats-Baril[72] reviewed the literature and developed a model predicting low back pain disability, the final stage of progressing low back disorders, with 25 specific risk factors. This model evaluated all five risk factor categories defined in this review. When interpreting the existing literature, as well as when future epidemiologcal research is considered, one needs to view low back disorders as a progession of events (discomfort/symptom survey, injury, incidence, lost time and restricted time) and evaluate the influences of all types of risk factors (personal, physical, exposure, psychological and psychosocial risk factors) at each stage of the disorder.

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