

A Prospective Study of Back Belts for Prevention of Back Pain and Injury

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BACK INJURIES HAVE BEEN THE leading cause of disability in the United States for people younger than 45 years and have been the most expensive health care problem for the 30- to 50-year-old age group.¹ Low back pain accounted for 23% (\$8.8 billion) of total workers' compensation payments in 1995.² The Annual Survey of Occupational Injuries and Illnesses conducted by the Bureau of Labor Statistics indicates that in 1998 there were 279 507 back injuries due to overexertion that resulted in lost work days (89% in material-handling).³ In response to the increasing human and economic costs of back injury, employers have attempted preventive measures; specifically, the widespread use of industrial back belts, approximately 4 million of which were purchased in 1995.⁴ This study was designed to address 2 objectives: (1) to examine the effect of store policy by comparing a belt-use requirement policy with a voluntary belt-use policy and (2) to compare employees who reported wearing back belts usually every day with those reported wearing the belt less frequently, based on interview responses.

METHODS

Study Design

Between April 1996 and April 1998, 50 new stores and 110 newly expanded stores (combination supermarket and

See also p 2780 and Patient Page.

Context Despite scientific uncertainties about effectiveness, wearing back belts in the hopes of preventing costly and disabling low back injury in employees is becoming common in the workplace.

Objective To evaluate the effectiveness of using back belts in reducing back injury claims and low back pain.

Design and Setting Prospective cohort study. From April 1996 through April 1998, we identified material-handling employees in 160 new retail merchandise stores (89 required back belt use; 71 had voluntary back belt use) in 30 states (from New Hampshire to Michigan in the north and from Florida to Texas in the south); data collection ended December 1998, median follow-up was 6½ months.

Participants A referred sample of 13 873 material handling employees provided 9377 baseline interviews and 6311 (67%) follow-up interviews; 206 (1.4%) refused baseline interview.

Main Outcome Measures Incidence rate of material-handling back injury workers' compensation claims and 6-month incidence rate of self-reported low back pain.

Results Neither frequent back belt use nor a belt-requirement store policy was significantly associated with back injury claim rates or self-reported back pain. Rate ratios comparing back injury claims of those who reported wearing back belts usually every day and once or twice a week vs those who reported wearing belts never or once or twice a month were 1.22 (95% confidence interval [CI], 0.87-1.70) and 0.95 (95% CI, 0.56-1.59), respectively. The respective odds ratios for low back pain incidence were 0.97 (95% CI, 0.83-1.13) and 0.92 (95% CI, 0.73-1.16).

Conclusions In the largest prospective cohort study of back belt use, adjusted for multiple individual risk factors, neither frequent back belt use nor a store policy that required belt use was associated with reduced incidence of back injury claims or low back pain.

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merchandise) of a single corporation were enrolled on the date they first opened for regular business. A prospective cohort study was conducted following sequential assignment (according to store opening date) of groups of stores to either the traditional belt-requirement policy or voluntary belt use. Employees were required to wear back belts during material-handling activities in the belt-requirement stores, while belts were made available only by request in the voluntary belt-use stores.

Of the 160 stores in the study, 89 required back-belt use and 71 had voluntary belt use. The original goals of introducing stores with voluntary belt

use were to create an environment in which employees were free not to wear back belts without violating store policy and to compare the back injury rate with stores that required belt use. The

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main focus of this study is on interview data: determining employee characteristics and belt wearing habits from a baseline interview for comparison of injury rates and a follow-up interview to determine the incidence of self-reported low back pain.

Study stores were distributed across 30 states from New Hampshire to Michigan in the north and from Florida to Texas in the south; most states included both belt-requirement and voluntary belt-use stores. We obtained payroll records of hours worked and workers' compensation injury reports for all stores for calculation of injury incidence rates. The National Institute for Occupational Safety and Health (NIOSH) Human Subjects Review Board formally approved the study's design and data collection instruments in August 1995, following a public peer review meeting in April 1995.

Data Collection

A survey contractor conducted telephone interviews using trained interviewers. Participants completed an informed consent form either in a prestudy employee meeting or at the beginning of the telephone interview. Telephone calls were placed to employees while working at the store during regular working hours. For each store, interviews were attempted for a period of at least 30 calendar days (excluding weekends). Follow-up interviews were attempted for all employees who had a baseline interview. Interviews were not conducted from mid-December to mid-January due to the holiday shopping season.

Both the baseline and follow-up interviews consisted of questions covering work history, lifestyle habits, medical history, job activities, psychosocial factors, belt wearing habits, and demographic information. Participants were asked 4 job satisfaction questions from the Quality of Employment Survey developed by the US Department of Labor and NIOSH.⁵ The sum of the responses for these 4 items were used to create a dichotomous measure of job satisfaction using the median cut point.

Job Titles

The job title *receiver/unloader* identified workers with the greatest exposure to physical work unloading freight trucks; *stocker* was used to designate employees with responsibility for moving stock to the merchandise floor. *Department managers* were employees whose physical work mostly involved arranging stock on shelves and other less strenuous activities, and the group designated as *others* were employees with various other jobs involving material handling. In a separate study⁶ receiver/unloaders had the highest exposure to manual material handling (based on lifting heavier loads more frequently), followed by department managers, then stockers. Job title was determined from an employee's first baseline interview response and consistency in reporting job title was evaluated from the follow-up interview: 85% of department managers, 75% of stockers, 71% of receiver/unloaders, and 31% of the others were working in the same job title that they reported during the baseline interview.

Self-reported Back Belt Use

Self-reported belt wearing was determined from the response to the question: "During the past month, how many days per week did you wear the back belt?" Response categories were: "never," "once or twice a month," "once or twice a week," or "usually every day." The "never" and "once or twice a month" categories were combined and are referred to herein as never. Consistency was evaluated from the follow-up interview with 75% reporting usually every day, 81% reporting never, and 31% reporting once or twice per week in the same baseline category.

Back Belt

The back belt provided by the corporation is designed to fit around the waist without shoulder straps. The belt is constructed of stretchable nylon material with Velcro ends and mesh in back. Tightness is adjusted by choosing the location to attach the Velcro and tight-

ening side panels when lifting. This same back belt was used in human subjects laboratory studies of biomechanics (Rebecca J. Giorcell, PhD, et al, unpublished data, 1998) and physiology effects (Thomas G. Bobick, PhD, et al, unpublished data, 1998). All employees, when first hired and regardless of the store policy, received a short introductory information and training session on proper lifting and belt use via videotape or interactive computer-based learning.

Back Pain Data

Self-reported low back pain (hereafter back pain) was defined as a positive response to a question asking if respondents experienced any low back pain in the 6 months preceding the follow-up interview, with a frequency of 4 or more episodes (\geq median). A history of previous back injury was determined by a positive response to questions about back pain (with the addition of a reported severity ≥ 7 on a 10-point scale) at the baseline interview; had previous back surgery; had "ever been told by a doctor" that he/she had arthritis of back joints, degenerative joint disease of the back, lupus erythematosus, ankylosing spondylitis, or spondylolisthesis; or had "seen a doctor, nurse, physical therapist, or chiropractor" for a strain or sprain of the lower back or ruptured disk in the back.

Injury Claims Data

The data consisted of the dates of occurrence and characteristics of work-related material-handling back injuries requiring medical care recorded in the company's own workers' compensation reporting system. The data consisted of all claims received by the corporation, regardless of whether the claim was accepted or rejected for compensation. Although compensation rules vary among states, corporation procedures and policies regarding which injuries are included in their corporate database do not vary among states. Material-handling compensation claims for back injuries consisted of those with an external cause code containing "strain" or "sprain" fol-

lowed by “lifting,” “pushing,” “pulling,” “reaching,” “holding,” or “carrying.” Back injuries unrelated to material handling (such as “fall,” “caught by,” “caught between,” “struck by,” “slip,” or “trip without fall”) were excluded.

Statistical Methods

The regression models used to investigate the effects of belt wearing and store policy were selected to control for type of store (new stores or newly expanded stores that are a combination of supermarket and merchandise), demographic risk factors (age, race, and sex), work exposure (job title and lifting frequency), variables found important in previous studies (history of previous back injury and job satisfaction), and a standard health-risk factor (smoking). These 11 covariates were investigated using Poisson regression to model the incidence rate of back injury claims, taking account of the variable work-hours of follow-up for each employee. Logistic regression was used to model the incidence of back pain as a binary outcome in which employees had similar length of follow-up. Potential effect modification was investigated using interaction terms and separate analysis of subgroups of data. Subgroup analyses were conducted for those who were concordant for belt wearing at both the baseline and follow-up interviews and for employees with the most strenuous job tasks. Regression analyses and confidence intervals (CIs) for odds ratios (ORs) and rate ratios (RRs) were calculated using SAS statistical software.⁷ Other CIs were calculated using StatXact.⁸

RESULTS

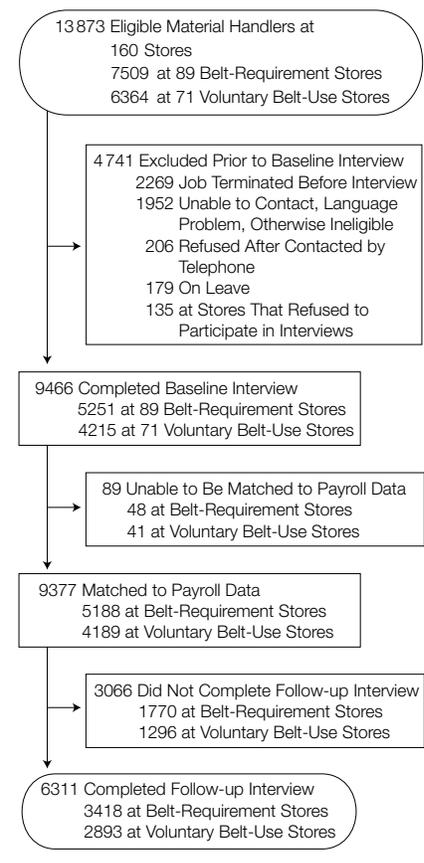
There were a total of 144 469 employees who worked in the 160 stores during the study period. Of these, 13 873 (10%) were identified by store management as involved in material handling tasks prior to the interview process (FIGURE). For the 6311 employees who completed both a baseline and a follow-up interview, the median (and mode) of the length of time between baseline and follow-up interview was 6½ months.

Payroll and workers' compensation data collection ended December 1998.

TABLE 1 shows employee characteristics from the baseline interview by store-belt policy and belt wearing. There was a lack of compliance with the store belt-wearing policy. In the stores requiring belt use, 58% of employees reported wearing belts usually every day; 14%, once or twice a week; and 28%, never. In the stores with voluntary belt-use, 33% of employees reported wearing belts usually every day; 11%, once or twice a week; and 56%, never. There was a slight difference in the proportions who completed a follow-up interview, worked in new stores, or had a history of previous back injury by frequency of belt wearing. Employees who reported belt wearing usually every day were more likely to be receivers/unloaders or stockers and were less likely to be department managers or others, and were also more likely to report lifting more than 9 kg (20 lb) at work usually every day.

Among the 9377 who completed a baseline interview and were matched to payroll data, there were 195 back injury claims (12.9 million work-hours) for a crude incidence rate of 3.03 per 100 full-time equivalent (FTE) (95% CI, 2.62-3.48). Among the 6311 who completed a baseline and follow-up interview, there were 1088 cases of back pain (17%; 95% CI, 16%-18%). There were no statistically significant protective effects comparing employees who wore belts usually every day with employees who never wore belts for either back injury claims (RR, 0.95; 95% CI, 0.56-1.59) or back pain (OR, 0.92; 95% CI, 0.73-1.16). TABLE 2 presents percentages reporting back-pain and back injury claim rates, stratified by risk factors. Table 2 also presents multivariate regression estimates with each variable adjusted for all other variables listed.

Figure. Interview Participants and Loss to Follow-up by Store Policy



Among the other risk factors in the models, a history of previous back injury was the strongest risk factor for both outcomes. Frequent lifting of heavier than 9 kg (20 lb) at work was associated with significantly increased odds of back pain but not for back injury claims. Women had significantly more back pain than men, but they did not have a higher back injury claim rate. Other races did not differ significantly from white persons for back pain but persons of other races had a higher back injury claim rate. Similarly, results for job satisfaction and smoking differed by outcomes. Poor job satisfaction was significantly associated with increased risk of back pain but not with a higher back injury claim rate. Current smokers had higher risk for back injury claims and former smokers had higher risk for back pain.

There was no statistically significant difference for the preplanned comparison of back injury claim rates among the 13873 employees identified by store management as involved in material-handling tasks prior to the interview process. Stores with a belt requirement had 236 material-handling back injury claims among 16.1 million work-hours for a crude incidence rate of 2.94 per 100 FTEs. Stores with voluntary belt use had 203 material-handling back injury claims among 12.5 million work-hours for a crude incidence rate of 3.26 per 100 FTE (RR, 0.90; 95% CI, 0.75-1.09). Additionally, we found no effect of the belt-requirement store policy among those interviewed for either back injury claims (RR, 0.94; 95% CI, 0.70-1.28) or back pain (OR, 1.06; 95% CI, 0.92-1.22).

No statistically significant effects of back belts were found among the subgroup of employees who had no history of previous back injury, using regressions with the same covariates shown in Table 2. Back pain was not different between those who reported belt wearing usually every day and those who reported never wearing a belt (OR,

0.98; 95% CI, 0.82-1.17), and the back injury claim rate was not different for these groups (RR, 1.34; 95% CI, 0.91-1.98). Among the subgroup who had a previous history of back injury, there were no effects of belt wearing on back pain (OR, 0.90; 95% CI, 0.65-1.25), or back injury claim rate (RR, 0.92; 95% CI, 0.47-1.79).

Back belt use may be considered as a measure of compliance with store policy, so an interaction term between belt wearing and store policy was examined for the models shown in Table 2. This interaction term shows that there is no effect of back belts when comparing employees who reported belt wearing usually every day in stores that required belt use with those employees who reported never wearing a belt in voluntary belt-use stores for back pain (OR, 1.07; 95% CI, 0.89-1.29) or for back injury claims (RR, 1.19; 95% CI, 0.79-1.78).

Back belt use is affected by store policy, so to assess the possibility that a model including both covariates might introduce excess error, the store policy covariate was removed from the regression models shown in Table 2. Back pain was not different between those

who reported belt wearing usually every day compared with those who reported never wearing a belt (OR, 0.99; 95% CI, 0.85-1.14), and the back injury claim rate was not different for these groups (RR, 1.20; 95% CI, 0.87-1.65) after removing the store policy covariate.

No statistically significant effects of belt wearing were found among a subgroup who reported consistent belt wearing habits on both the baseline and follow-up interviews. Using the same covariates shown in Table 2, regressions were used to compare employees who reported in both interviews wearing belts usually every day with those who reported in both interviews never wearing a belt. There was no evidence that wearing back belts reduced back pain (OR, 0.88; 95% CI, 0.73-1.07) or back injury claims (RR, 1.57; 95% CI, 0.98-2.50) in these groups that reported consistent belt-wearing habits.

To focus on those employees who frequently lifted heavier loads, regressions were restricted to the subgroup of employees with the most strenuous job. Using the same covariates as shown in Table 2, for an analysis restricted to receiver/unloaders, back pain was not different

Table 1. Characteristics of the Study Population by Self-reported Belt Wearing at Baseline Interview*

Characteristics	Self-reported Belt Wearing					
	Required Belt-Use Store			Voluntary Belt-Use Store		
	Usually Every Day	1 to 2 Times a Week	≤1 to 2 Times a Month	Usually Every Day	1 to 2 Times a Week	≤1 to 2 Times a Month
No. of baseline interviews†	3004	700	1474	1361	470	2349
Mean age, y	36	36	35	36	36	35
New store type‡	728 (24)	161 (23)	434 (29)	352 (26)	109 (23)	615 (26)
History of previous back injury	430 (14)	99 (14)	217 (15)	216 (16)	92 (20)	315 (13)
Lifting >9 kg/d§	1873 (62)	384 (55)	791 (54)	868 (64)	268 (57)	1328 (57)
Job titles						
Department manager	644 (21)	260 (37)	469 (32)	262 (19)	149 (32)	776 (33)
Receiver or unloader	795 (26)	112 (16)	278 (19)	394 (29)	76 (16)	442 (19)
Others	258 (9)	77 (11)	188 (13)	133 (10)	60 (13)	289 (12)
Good job satisfaction	1702 (57)	344 (49)	735 (50)	773 (57)	244 (52)	1226 (52)
Current smokers	1075 (36)	209 (30)	492 (33)	477 (35)	149 (32)	807 (34)
White	2334 (78)	585 (84)	1285 (87)	988 (73)	360 (77)	2003 (85)
Women	1490 (50)	387 (55)	799 (54)	611 (45)	264 (56)	1277 (54)
Follow-up interviews	1989 (66)	456 (65)	968 (66)	950 (70)	303 (64)	1633 (70)

*Data are presented as number (percentage) of subjects in each column unless otherwise indicated. Row categories are not mutually exclusive.

†Row total of 9358 is less than the number of completed interviews (n = 9377) because of missing values.

‡New stores vs newly expanded stores (see "Methods" section).

§To convert to pounds divide by 0.45.

||Row total of 6299 is less than the number of completed interviews (n = 6311) because of missing values.

between those who reported belt wearing usually every day compared with those who reported never wearing a belt (OR, 0.81; 95% CI, 0.58-1.14), and the back injury claim rates appeared to be the same for these groups (RR, 1.53; 95% CI, 0.82-2.84).

To assess the potential for selection bias, the effects of belt wearing on back injury claim rates were compared among employees who completed a follow-up interview and those who did not complete a follow-up interview. The crude back injury claim rate among the

3066 employees who completed a baseline interview but did not complete a follow-up interview (5.04 per 100 FTE; 95% CI, 3.88-6.44) was nearly twice the crude back injury claim rate compared with the 6311 employees who completed both interviews (2.61 per

Table 2. Risk Estimates and Regression Results for Low Back Pain and Back Injury Claims in Material Handlers

Variable	≥4 Self-reported Episodes of Low Back Pain (1088 Cases)		Back Injury Workers' Compensation Claims (195 Claims)	
	No. of Events/No. Interviewed (%) [*]	Adjusted Odds Ratio (95% CI) [†]	No. of Claims/Million Worker-Hours (Rate per FTE) [‡]	Adjusted Rate Ratio (95% CI) [§]
Belt wearing				
≤1-2 times per month	455/2601 (17.5)	1.00	70/5.08 (2.76)	1.00
1-2 times per week	130/759 (17.1)	0.92 (0.73-1.16)	21/1.61 (2.61)	0.95 (0.56-1.59)
Usually every day	502/2939 (17.1)	0.97 (0.83-1.13)	104/6.16 (3.38)	1.22 (0.87-1.70)
Store policy				
Voluntary belt use	486/2893 (16.8)	1.00	86/5.58 (3.08)	1.00
Belt use required	602/3418 (17.6)	1.06 (0.92-1.22)	109/7.30 (2.98)	0.94 (0.70-1.28)
Store type				
Newly opened	256/1585 (16.2)	1.00	66/3.23 (4.09)	1.00
Newly expanded	832/4726 (17.6)	1.11 (0.94-1.31)	129/9.65 (2.67)	0.69 (0.51-0.95)
Previous back injury				
No	770/5427 (14.2)	1.00	148/11.05 (2.68)	1.00
Yes	318/884 (36.0)	3.24 (2.75-3.82)	47/1.83 (5.14)	2.03 (1.45-2.86)
Frequency of lifting >9 kg				
Almost never	131/948 (13.8)	1.00	29/1.97 (2.95)	1.00
1-2 times per week	218/1413 (15.4)	1.29 (1.01-1.65)	42/2.89 (2.89)	0.88 (0.54-1.42)
Usually every day	706/3689 (19.1)	1.71 (1.38-2.13)	113/7.45 (3.03)	0.87 (0.57-1.35)
Job title				
Department manager	328/1896 (17.3)	1.00	56/3.86 (2.90)	1.00
Stocker	439/2419 (18.1)	1.01 (0.85-1.20)	62/4.96 (2.50)	0.98 (0.67-1.44)
Receiver or unloader	220/1379 (16.0)	0.95 (0.78-1.17)	59/2.65 (4.45)	1.50 (1.01-2.23)
Other	99/607 (16.3)	1.04 (0.79-1.38)	18/1.39 (2.59)	0.93 (0.49-1.75)
Job satisfaction				
Good	487/3493 (13.9)	1.00	108/7.09 (3.04)	1.00
Bad	600/2814 (21.3)	1.60 (1.39-1.84)	87/5.77 (3.01)	0.94 (0.70-1.26)
Smoking status				
Never	537/3328 (16.1)	1.00	83/6.90 (2.40)	1.00
Former	165/850 (19.4)	1.26 (1.03-1.56)	29/1.75 (3.31)	1.56 (0.99-2.45)
Current	383/2113 (18.1)	1.10 (0.94-1.28)	83/4.19 (3.96)	1.64 (1.19-2.26)
Race				
White	923/5213 (17.7)	1.00	149/10.64 (2.80)	1.00
Other	165/1097 (15.0)	0.89 (0.73-1.08)	46/2.23 (4.12)	1.46 (1.02-2.08)
Sex				
Men	429/2861 (15.0)	1.00	94/5.89 (3.19)	1.00
Women	659/3450 (19.1)	1.56 (1.34-1.82)	101/6.99 (2.88)	1.10 (0.80-1.52)
Age, y				
<25	219/1232 (17.8)	1.00	43/2.40 (3.58)	1.00
25-39	459/2740 (16.8)	0.87 (0.72-1.06)	103/5.61 (3.67)	0.96 (0.66-1.41)
40-54	319/1834 (17.4)	0.79 (0.64-0.97)	46/3.83 (2.40)	0.61 (0.39-0.96)
≥55	91/503 (18.1)	0.84 (0.63-1.13)	3/1.05 (0.57)	0.15 (0.05-0.47)

*Interview responses are based on 6311 total follow-up interviews. Some respondents did not answer all the questions.

†Logistic regression model with binary response outcome of pain reported at follow-up interview among 6311 employees. Estimates are adjusted for all other variables in this Table. Because of missing covariate values, 6011 observations were used for the multivariate model. CI indicates confidence interval.

‡Denominators in million worker-hours exposure are rounded to 2 decimal places. Rate per 100 full-time equivalents (FTEs) is per 200 000 work-hours.

§Poisson regression model using back injury counts and work-hours among 9377 employees with a baseline interview, estimates adjusted for all other variables in this Table.

||Because of missing covariate values, 8830 observations were used for the multivariate model.

||To convert to pounds divide by 0.45.

100 FTE; 95% CI, 2.19-3.09). However, there was no significant difference in back injury claim rates comparing those who reported wearing belts usually every day with those who reported never wearing them among those who did not complete a follow-up interview (RR, 0.97; 95% CI, 0.53-1.85) and among those who completed a follow-up interview (RR, 1.37; 95% CI, 0.91-2.05) in multivariable Poisson regressions. In another evaluation of potential selection bias, the effects of belt wearing on the prevalence of back pain were estimated using the baseline interview data as in a cross-sectional study. In a multivariable logistic regression there was no difference in the prevalence of back pain at baseline comparing those who reported wearing belts usually every day with those who reported never wearing them (OR, 1.07; 95% CI, 0.94-1.21).

COMMENT

The NIOSH prospective cohort study of back pain and back injury claims in 9377 employees, controlling for multiple individual risk factors, found no evidence to support the use of back belts as a preventive measure. We found no effects of belt wearing in various subgroups: employees with and without a history of previous back injury, employees with consistent self-reported belt wearing habits from baseline to follow-up interviews, and employees with the most strenuous job. Among 13873 material-handling employees in 160 stores, we found no difference in unadjusted back injury claim rates com-

paring a belt-requirement store policy to a voluntary belt-use store policy.

Previous studies have relied on worker compliance to a store policy to determine belt-wearing habits.⁹⁻¹¹ Accurate determination of workers' actual workplace belt-wearing habits is a recognized limitation of these studies. By directly interviewing employees about their belt-wearing habits, our study more closely measures typical belt use in the workplace rather than implied belt use based on store policy.

A recent study in California over a 6-year period found a higher injury rate during the months preceding the implementation of a mandatory back belt-use policy than during the months after the policy was implemented (RR, 1.52; 95% CI, 1.36-1.69).^{12,13} In this historical cohort study, estimates of back-belt effects were based on aggregate back injury claim rates without controlling for multiple individual risk factors. The NIOSH study was prospective with concurrent comparison groups, evaluated both back injury claim rates and self-reported low back pain and controlled for well-known back injury risk factors.

The potential effects of selection bias on the back pain results, due to the inability to complete follow-up interviews on all employees who had a baseline interview, is a limitation of our study. Ancillary analyses do not demonstrate that selection biases alter the main conclusions of this study. Other analyses of subgroups of employees and interaction effects attempted to discover belt effects among groups of employees who

were most likely to be affected by belt wearing. However, even these comparisons failed to find any back-belt effects.

Our study evaluates back belts using a prospective design in new stores distributed over a wide geographic region, concurrent comparison groups, comprehensive individual interviews, detailed exposure information, a job satisfaction measure, multivariable regression analysis, and sufficient sample size. This study considered 2 outcomes: the incidence of back pain and workers' compensation claims for material-handling back injury requiring medical care. Adjustment for multiple risk factors was incorporated in our investigation, especially a history of previous back injury and lifting frequency, which has been lacking in some previous studies on the effects of back belts. This is the largest prospective study to date of material-handling workers with individual data on back-belt use, back pain, and important confounders. Results based on these multiple analyses of data all converge to a common conclusion: back-belt use is not associated with reduced incidence of back injury claims or low back pain in material handlers.

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