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Association of Low Back Pain With Self-Reported Risk Factors Among Patients Seeking Physical Therapy Services

Background and Purpose. This study investigated the magnitude of association between low back pain (LBP) and self-reported factors thought to increase the risk of LBP. **Subjects and Methods.** Questionnaires were completed by 150 patients who were receiving physical therapy for LBP and by 138 patients who were being treated for other reasons. The solicited information was used to estimate odds ratios and 95% confidence intervals for the LBP-risk factor association. **Results.** Low back pain was positively associated with smoking status, pregnancy, industrial vibration exposure, and time spent in a car (odds ratios ≥ 2.21). Daily lifting, body mass index, activity level, and time sitting or standing showed at most a weak positive association with LBP. Comparisons with estimated associations from other studies were made. **Conclusion and Discussion.** Data from this study support a statistically significant association between LBP and some factors found in other research to increase the risk of LBP. Study findings may have implications for targeting at-risk groups for back care education or intervention programs. [Levangie PK. Association of low back pain with self-reported risk factors among patients seeking physical therapy services. *Phys Ther.* 1999;79:757–766.]

Key Words: *Case-control study, Cross-sectional study, Low back pain, Odds ratio, Risk factors.*

Pamela K Levangie

Identification of factors that might increase the risk for low back pain (LBP) may offer a method to reduce LBP-related costs and disability. Some identified risk factors may be reduced or removed through environmental interventions or health education. For risk factors that cannot be removed, identification of groups at increased risk may allow for targeting patient education and back pain prevention programs. Investigators have reported evidence of increase risk of LBP with exposure to a variety of factors, including mechanical stresses such as heavy or frequent lifting,¹⁻⁵ prolonged sitting or standing,⁵⁻⁷ hours in a vehicle,^{1,2,7-9} smoking,^{1,2,10,11} vibration exposure,^{1,2,4,9} activity level,^{1,8,12} pregnancy,^{2,8,13,14} and oral contraceptive use.^{15,16} Most of these investigators, however, did not include an estimate of the magnitude of association. Rather, they based their conclusions on significance testing (ie, whether a relationship existed). Among those investigators who included magnitudes of association, the values varied widely. Many researchers also used population-based samples in which subjects with LBP were identified as those with any recollection of LBP in the past year,^{7,12} rather than subjects whose symptoms affected their life or work or who used health care dollars.

The purpose of this study was to estimate, among a group of patients receiving physical therapy, the magnitude of association between LBP and self-reported factors thought to increase the risk of LBP (risk factors). A patient-based sample was chosen so that the impact of symptoms on health care costs could be seen. All subjects with LBP in this group were seeking medical attention for their LBP and were, therefore, incurring associated health care costs. They also incurred at least some time loss as a result of their LBP, which also affected other activities. A comparison group consisted of patients seeking physical therapy services for non-low back-related problems and, consequently, were similar to the

subjects with LBP in willingness to seek services, access to services, and potential impact of their problem on health care costs and quality of life. The magnitudes of association were estimated because the magnitudes of association are particularly important as physical therapists attempt to understand the cost-benefit ratios of education programs or the cost-benefit ratios of attempting to modify occupational stresses through ergonomic interventions. The sample and design used in this study allowed for estimation of the association between self-reported risk factors and LBP in the group most likely to use health care dollars and, therefore, likely to be the target of risk factor modification and cost-containment strategies.

Method

Subjects

Subjects in this study were recruited as part of a larger study of the association between pelvic asymmetry and LBP.¹⁷ A clinic-based sample of adult patients seeking physical therapy services was targeted. All subjects were recruited from the same facilities so that those with LBP and those without LBP would be as alike as possible on uncontrolled variables such as geographical distribution, socioeconomic group, health care access, and willingness to seek medical attention. All subjects were 21 to 50 years of age.

Patients referred to physical therapists for treatment of LBP of no more than 1 year in duration were the "cases" in this cross-sectional "case-control" design. Patients experiencing their current LBP for more than 1 year were excluded because it is believed that the pain and disability experienced by people with LBP become increasingly dissociated over time from the original physical basis of the problem.¹⁸ Patients who were being treated by physical therapists for an upper-extremity

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Levangie wrote the manuscript, with contributions from Dr Nancy Watts and Dr Ken Rothman; Levangie and Rothman provided data analysis; Levangie and research assistants managed the project and collected the data; and Levangie and the personnel of Beth Israel Hospital and Brigham & Women's Hospital provided subjects. Levangie provided the concept and research design; procured funds; and provided facilities and equipment, institutional liaisons, and clerical/secretarial support.

This study was approved by the Charles River Campus Institutional Review Board of Boston University and by the institutional review boards of the 7 hospitals from which subjects were recruited.

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problem that was not obviously neck- or back-related (eg, thoracic outlet syndrome) served as the comparison group. Patients who were eligible for the comparison group and who reported experiencing limiting LBP in the past year were excluded. *Limiting low back pain* was defined as LBP that limited activity for more than a few days or for which the patient sought medical care.

Sample Size and Recruitment

A sample size of 150 subjects with LBP and 150 comparison subjects was targeted. The number of subjects was estimated for the larger study to obtain a power of at least 80%.¹⁷ The sample size estimate was based on a univariate analysis, using the effect size (odds ratio) of 2.0. All subjects were recruited through outpatient physical therapy facilities in 7 hospitals and 32 private practices serving a range of inner-city and suburban communities in the metropolitan Boston (Mass) area. In some facilities, daily referral information was used to identify potentially eligible subjects. In other facilities, volunteers were sought through study information brochures placed in the waiting room. Follow-up telephone calls were used to determine interest and eligibility. Data collection appointments were made at the participating facility most convenient to the subject. Subjects received \$25 for their participation. Recruitment and enrollment were continued until the target sample size was reached.

Data Collection

At the time of data collection, informed consent was obtained and each subject completed a self-administered questionnaire. The questionnaire solicited information on descriptive characteristics and on factors found or suspected in other studies to be associated with LBP. These factors included age; height; weight; average number of hours per week spent sitting, standing, in a trunk, in a car, or exposed to industrial vibration; activity level; smoking status; lifting habits; history of back pain over the past year; and, for female subjects, pregnancy history and oral contraceptive use.

Calculation of Odds Ratios

The associations between LBP and self-reported risk factors were obtained using an estimated odds ratio (\hat{OR}) from 2×2 contingency tables. An odds ratio estimates the association between 2 dichotomous variables, typically with 1 variable being the “disease” (LBP) and 1 factor being an “exposure” (risk factor for LBP). The odds ratio (\hat{OR}) is constructed as follows:

$$\hat{OR} = \frac{\text{Odds of disease among exposed subjects}}{\text{Odds of disease among unexposed subjects}}$$

From this proportion, it can be seen that the odds ratio will be 1.0 if the odds of disease are similar among exposed and unexposed subjects. Odds ratios greater

	Disease	No Disease	
Exposure	a	b	$\hat{OR} = \frac{(a)(d)}{(b)(c)}$
No Exposure	c	d	

Figure.

A 2×2 contingency table of frequency counts is used to compute the mathematically simplified formula for estimating an odds ratio (\hat{OR}). Disease=patients with low back pain, No Disease=patients with non-LBP-related problems, Exposure=higher level of a given risk factor, No Exposure=lowest level of a given risk factor.

than 1.0 indicate an increased disease risk among exposed subjects, whereas odds ratios less than 1.0 indicate that the exposure reduces disease risk (ie, is “protective”). The Figure shows how the 2×2 contingency table is used to calculate the estimated odds ratio.

In this study, rather than dichotomizing the exposure and labeling people simply as exposed or not exposed to a given risk factor for LBP, each risk factor was categorized into 2, 3, or 4 levels, depending on the variable and the number of subjects per level. One odds ratio was then calculated to compare each higher level of the risk factor (exposure) with the lowest level of the risk factor (no exposure) among the subjects with LBP (those with the “disease”) and the comparison subjects (those without the “disease”). Where there were 4 levels of a risk factor, 3 odds ratios were estimated, comparing 3 higher exposures with the lowest level of exposure. The lowest level of the risk factor was the no-exposure referent in all analyses except for activity level, where an activity level perceived as similar to others was compared with lower and higher levels of perceived activity.

All odds ratios were calculated with 95% confidence intervals (CIs) using the general formula: $\exp[\ln(\hat{OR}) \pm 1.96 (SD[\ln\hat{OR}])]$.¹⁹ The 95% CI is an indication of the precision of the estimated odds ratio. A wide interval indicates a relatively imprecise estimate. The 95% CI also can be used to estimate statistical probability. When the null value for the odds ratio (1.0) lies within the 95% CI, the corresponding probability value for the odds ratio will be greater than .05. The more centrally the null value lies in the interval, the larger the corresponding probability value. If a person were simply to assess whether the null value were in the 95% CI, there would be no benefit over probability values. The width of the CI, however, indicates how precise, or how “accurate,” the estimate might be. An indication of precision of an estimate is not available through a probability value.

Possible effect modification or confounding of the risk factor-LBP relationship by age group and sex was explored. Effect modification exists when subgroups (eg, 2 different age groups) differ on the studied association. Effect modification, therefore, might be considered analogous to an interaction in a factorial analysis of variance. To explore possible effect modification, the estimated odds ratios for levels of the risk factor with LBP were computed separately for male and female subjects and separately for subjects aged 21 to 34 years and subjects aged 35 to 50 years. If there was effect modification by age group or by sex, the 2 stratum-specific estimates for comparable odds ratios would differ. In such an instance, the primary association would be more validly represented by the stratum-specific estimates.

Confounding exists when an uncontrolled variable (eg, sex) is independently related to each of the 2 primary association variables under study (eg, LBP and the risk factor under consideration). The relationship of the confounding variable to the 2 primary association variables, if uncontrolled, distorts the estimated relationship between the primary variables. If the association between the primary variables differs substantively when the potential confounding variable is controlled, the uncontrolled (referred to as the “crude”) estimate is considered to be confounded or biased. In such an instance, the controlled estimate may be considered a more valid estimate of the true association between the primary variables. To control possible confounding of the LBP-risk factor association by age group or sex, a standardized odds ratio (S \acute{O} R) was computed across age group or sex strata for each association. If the summary measure (S \acute{O} R) differs substantively from the crude (uncontrolled) association, confounding of the crude estimate must be considered. A standardized odds ratio standardizes the crude odds ratios to the distribution of sex or age group in the lowest level of the risk factor (calculated as S \acute{O} R = $[\sum a_i d_i / c_i] / [\sum b_i]$).¹⁹ Most computations and statistical analyses were conducted using Statistix Analytic Software for Windows^{20*} and Microsoft Excel 7.0.^{21†}

Results

Sample

A total sample of 150 subjects with LBP and 150 comparison subjects (subjects without LBP) was enrolled over a 27-month period. Data from 4 comparison subjects were discarded because of data recording omissions or incomplete entries. Eight comparison subjects who reported experiencing LBP on the day of testing were

Table 1.
Descriptive Statistics for Subject Demographic Characteristics

Characteristic	Subjects With LBP ^a (n=150)	Subjects Without LBP (n=138)
Mean age (y)	35.2	35.5
Sex (%)		
Male	40.0	39.1
Female	60.0	60.9
Mean height (cm)	171.5	170.3
Mean weight (kg)	74.1	70.8
Acute LBP (\leq 3 mo)	59.7%	
Chronic LBP ($>$ 3–12 mo)	40.3%	NA ^b
Oswestry Low Back Pain Disability Questionnaire score		
0%–20% (minimal disability)	59.5%	NA
22%–40% (moderate disability)	32.6%	
40%–54% (severe disability)	6.8%	

^a LBP=low back pain.

^b NA=not applicable.

also dropped from the data set, yielding a final complement of 150 subjects with LBP and 138 comparison subjects. Descriptive data on the subjects are presented in Table 1.

Association of Low Back Pain and Smoking

The crude, stratum-specific, and standardized estimated odds ratios and 95% CIs for the LBP-smoking association are presented in Table 2. The odds ratios comparing current smokers with those who quit smoking less than 1 year previously, with those who quit smoking 1 to 2 years previously, and with those who never smoked were all similar. Consequently, only the categories of current smokers and current nonsmokers were retained for subsequent analyses. When current smokers were compared with current nonsmokers, the LBP-smoking association was 2.21 (CI=1.09, 4.46). When data were stratified by sex, the LBP-smoking associations were fairly similar. When data were stratified by age group, the associations again were not markedly different. There did not appear to be important effect modification, given the fairly similar stratum-specific estimates. The standardized odds ratios did not indicate any confounding of the LBP-smoking association by sex or age group.

Association of Low Back Pain and Vaginal Delivery

In order to consider whether number of pregnancies or number of vaginal deliveries was associated with LBP, 7 women who had a pregnancy of at least 6 months but less than 9 months in duration were eliminated from the analyses. The small number of such women did not permit control of the potentially confounding factor of number of months of pregnancy. The association between LBP and the number of full-term pregnancies

*Analytical Software Co, PO Box 12185, Tallahassee, FL 32317.

†Microsoft Corp, 1 Microsoft Way, Redmond, VA 98052.

Table 2.

Association of Low Back Pain With Levels of Self-Reported Risk Factors: Frequencies and Estimated Crude, Stratum-Specific, and Standardized Odds Ratios (OR) With 95% Confidence Intervals (CIs)

Risk Factor	Exposure	Subjects With Low Back Pain (n=150)	Subjects Without Low Back Pain (n=138)	Estimated Crude or Stratum-Specific OR ^a (95% CI)	Standardized OR ^b (95% CI)
Smoking status	Nonsmoker	122	125	2.21 (1.09, 4.46)	
	Current smoker	28	13		
	Male				
	Nonsmoker	47	49		
	Current smoker	13	5	2.71 (0.90, 8.19)	2.21 (1.09, 4.50)
	Female				
	Nonsmoker	75	76		
	Current smoker	15	8	1.90 (0.76, 4.74)	
	<35 years of age				
	Nonsmoker	58	55		
Current smoker	14	5	2.66 (0.90, 7.86)	2.27 (1.08, 4.78)	
35–50 years of age					
Nonsmoker	59	69			
Current smoker	13	8	1.90 (0.74, 4.90)		
Full-term vaginal delivery	No pregnancies ^c	41	58	Referent	
	1 delivery	10	7	2.02 (0.71, 5.75)	
	2 deliveries	18	5	5.09 (1.75, 14.81)	
	≥3 deliveries	4	5	1.13 (0.29, 4.47)	
	No pregnancies vs ≥1 vaginal delivery			2.66 (1.31, 5.42)	
	<35 years of age				
	No pregnancies	32	35		
	≥1 vaginal delivery	11	4	3.01 (0.87, 10.39)	3.33 (1.30, 8.54)
	35–50 years of age				
	No pregnancies	8	23		
≥1 vaginal delivery	21	13	4.64 (1.61, 13.41)		
Vibration exposure ^d (h)	<1	119	133	Referent	
	≥1	14	3	5.22 (1.46, 18.59)	
Time spent in a car (h)	<1 (low)	25	46	Referent	
	1 (moderate)	55	33	3.07 (1.60, 5.88)	
	>1 (high)	68	58	2.16 (1.18, 3.93)	
	≥1	123	91	2.49 (1.42, 4.34)	

^a Association of low back pain and upper level(s) of risk factor compared with referent level of the risk factor.

^b Standardized odds ratios: stratum-specific estimates weighted by the product of the distribution of sex or age groups in the referent level of the risk factor and the rate in that group.

^c No pregnancies of 6 months' duration or longer.

^d Hours of exposure daily.

or number of full-term vaginal deliveries was then examined, using those women who had not had a pregnancy of at least 6 months' duration as the referent group. The number of full-term vaginal deliveries was a slightly stronger risk factor than the number of full-term pregnancies (regardless of type of delivery). The crude, stratum-specific, and standardized estimated odds ratios and 95% CIs for the LBP-vaginal delivery association are presented in Table 2. The estimated odds ratio for LBP for the women with one full-term vaginal delivery (as compared with the women with no pregnancies of 6 months' duration or longer) was 2.02 (CI=0.71, 5.75). For women who delivered 2 children vaginally, the odds

ratio was 5.09 (CI=1.75, 14.81). For women who delivered 3 or more children vaginally, the odds ratio was 1.13 (CI=0.29, 4.47). Given the wide CIs around these estimates, no conclusions about the presence or absence of a trend of increased risk with more pregnancies should be drawn.

To examine the effect of age group and obtain estimates of reasonable precision, categories were collapsed. Women with 1 or more full-term vaginal deliveries were compared with women with no pregnancies of 6 months or more. The resulting crude odds ratio was 2.66 (CI=1.31, 5.42). Controlling for age group, the odds

ratio for women aged 21 to 34 years was 3.01 (CI=0.87, 10.39), whereas the odds ratio for women aged 35 to 50 years was 4.64 (CI=1.61, 13.41). The standardized odds ratio was 3.33 (CI=1.30, 8.54). There may be weak effect modification and confounding by age group, although the imprecision of the estimates makes this difficult to assess. The slight differences in association by age group may suggest that 1 or more full-term vaginal delivery increases the odds of LBP slightly with increasing age. The estimate of the association between LBP and vaginal delivery status is slightly stronger when the age group is controlled.

Association of Low Back Pain and Daily Vibration Exposure

Subjects were asked to estimate the number of hours on an average day they spent sitting on, standing on, or holding equipment that vibrated heavily (including industrial tools, machines, equipment, chain saws, and mowers). When subjects with less than 1 hour of vibration exposure daily were compared with subjects with 1 hour or more of exposure (Tab. 2), the association of the exposure with LBP was 5.22 (CI=1.46, 18.59). Given the small number of comparison subjects who reported vibration exposure (n=3), stratified analyses were not done. Data for 4 subjects who reported vibration exposure and that they were currently not working or had a reduced workload due to their injury were removed from the analysis, and the odds ratio was recomputed. This analysis was done as the only available mechanism to explore whether the LBP-vibration association might be inflated by differential recall of those subjects with work-related injury claims. The odds ratio with the data for these people removed was 6.15 (CI=1.34, 28.30).

Association of Low Back Pain and Hours Spent in a Car Daily

The reported number of hours spent in a car daily was categorized into 3 levels (less than 1 hour, 1 hour, and more than 1 hour). The highest stratum (>1 hour) contained 44% of the subjects, but the distribution of subjects precluded further stratification. The association of LBP with hours spent in a car daily, using those subjects who spent less than 1 hour in a car daily as the referent group, is shown in Table 2. The estimated odds ratio for LBP among subjects who spent 1 hour in a car daily as compared with subjects who spent less than 1 hour in a car daily was 3.07 (CI=1.60, 5.88). For those subjects who spent more than 1 hour in a car daily, the odds ratio was 2.16 (CI=1.18, 3.93). The data were then stratified by sex and age group, but no substantive differences in the odds ratios were found. That is, there was neither effect modification nor confounding of the association between LBP and time spent in a car by sex or age group. Because the estimated associations for subjects who spent 1 hour in a car daily and for subjects

who spent more than 1 hour in a car daily were fairly similar and the differences in exposure not substantial, the 2 higher categories were collapsed. The resulting association between LBP and spending 1 or more hours in a car daily (as compared with less than 1 hour daily) was 2.49 (CI=1.42, 4.34).

Association of Low Back Pain and Other Potential Risk Factors

The associations of LBP with hours of sitting daily, hours of standing daily, daily lifting, activity level, and body mass index (BMI) were categorized into their respective quartiles. Odds ratios were computed using the lowest level of exposure as the referent group and are reported in Table 3. Although some of the odds ratios for hours of sitting daily and hours of standing daily were as high as 1.54, the wide CIs around the estimates across increasing levels of exposure appear to indicate that daily sitting and standing were not important risk factors for LBP in this sample. No evidence of either effect modification or confounding by sex or age group was found for either variable.

Subjects were asked to identify their average daily lifting activities by checking off 1 of 5 possible categories. Very few people identified themselves as "lifting 50 lb[†] often," so this category was collapsed with the category of "lifting 35 lb often," with the remaining 4 categories used to compute the odds ratios. None of the estimates indicate that there was an important overall association between magnitude of daily lifting and LBP in this group. Although sex did not modify the LBP-lifting relationship at lower levels of lifting, some potential modification was evident between men and women lifting 35 lb or more often. For women, the odds ratio was 2.45 (CI=0.86, 6.98). The odds ratio for men in the same category was 0.89 (CI=0.35, 2.26). In spite of some apparent effect modification at the highest level of lifting, sex did not appear to confound the estimates at any of the lifting levels. There was no apparent effect modification or confounding of the LBP-lifting association by age group.

Subjects were asked to check off 1 of 4 categories that best described their work and recreational activity level in comparison with others of their age and sex. The category "as active as their peers" was used as the referent, and odds ratios were calculated. Although the odds ratio for LBP among subjects identifying themselves as less active than their peers ($\hat{OR}=1.39$) was greater than for the higher activity levels (1.08 and 0.95, respectively), activity level did not appear to be an important risk factor in this sample.

[†]1 lb=0.4536 kg.

Table 3.

Association of Low Back Pain (LBP) With Levels of Self-Reported Risk Factors: Frequencies and Estimated Odds Ratios (\hat{OR}) With 95% Confidence Intervals (CIs)

Risk Factor	Exposure	Subjects With Low Back Pain (n=150)	Subjects Without Low Back Pain (n=138)	\hat{OR}^a for LBP:Risk Factor
Hours of sitting	≤ 4	39	40	Referent
	$>4 \leq 6$	45	30	1.54 (0.81, 2.91)
	$>6 \leq 8$	29	42	0.71 (0.37, 1.35)
	≥ 9	36	26	1.42 (0.73, 2.78)
Hours of standing	≤ 3	46	43	Referent
	4–5	34	31	1.03 (0.54, 1.94)
	6–8	35	37	0.88 (0.47, 1.65)
	≥ 9	34	27	1.18 (0.61, 2.25)
Daily lifting	10 lb ^b rarely	56	51	Referent
	10 lb often	34	38	0.81 (0.45, 1.48)
	20 lb often	25	24	0.95 (0.48, 1.87)
	≥ 35 lb often	34	24	1.29 (0.68, 2.46)
	10 lb rarely			
	Men	19	17	Referent
	Women	37	34	
	≥ 35 lb often			
Men	18	18	0.89 (0.35, 2.26)	
Women	16	6	2.45 (0.86, 6.98)	
Activity level (compared with peers)	Less active	25	18	1.39 (0.76, 2.74)
	As active	50	50	Referent
	More active	54	50	1.08 (0.74, 1.59)
	Much more active	19	20	0.95 (0.51, 1.78)
Body mass index (kg/m ²)	<21.5	34	38	Referent
	21.5–23.5	31	38	0.91 (0.47, 1.77)
	23.6–26.2	38	32	1.33 (0.69, 2.57)
	>26.2	44	27	1.82 (0.94, 3.55)

^a Crude association between LBP and upper level(s) of risk factor compared with referent level of the risk factor.

^b 1 lb=0.4536 kg.

Sex and age group were neither modifiers nor confounders of the association.

Body mass index was calculated as weight (in kilograms) divided by height (in meters squared). The highest levels of BMI showed a weak, but positive, association with LBP ($\hat{OR}=1.82$ [CI=0.94, 3.55]) that declined across decreasing levels of BMI ($\hat{OR}=1.33$ and 0.91, respectively). Although there is some suggestion of a linear increase in risk with increased BMI, the estimates are too similar and the CIs are too wide to draw such a conclusion from these data. There was no evidence of effect modification or confounding of these associations by sex or age group.

Multivariable Analyses

Multivariable logistic regression was used to evaluate the independent effects of one risk factor controlling for other risk factors. There were only minor changes in estimates across a number of multivariable models. That is, the estimated odds of LBP with exposure to the

studied factors appeared to be reasonably independent of each other.

Discussion

Smoking, parity, motor vehicle driving, vibration exposure, and repetitive heavy lifting are among the limited number of factors that seem to be consistently considered in literature reviews as increasing the risk for LBP, although there is no consensus on role or magnitude of association.^{1,3,7,11,14,22,23} This study provides estimates of association that support the role of smoking, parity, motor vehicle driving, and vibration exposure in increasing the odds of LBP. The calculated associations do not support the role of lifting or BMI as important risk factors for LBP. The determined associations for each of the risk factors, however, permit comparisons with the limited number of other investigations that cite magnitudes for these associations. For occupation-related risk factors, the magnitude of association may be reduced by the “healthy worker effect.” That is, it may be that people with potentially problematic LBP reduce or eliminate

exposure, whereas people with relatively healthier backs can sustain higher levels. This effect may be stronger for more avoidable exposures, such as heavy lifting, spending time in trucks, and industrial vibration. Where associations may be reduced by such self-selection, identified magnitudes of association are still the most valid variables for understanding the potential impact to be made by education and risk factor modification.

Smoking as a Risk Factor for Low Back Pain

Both Skov and associates⁷ and LeBoeuf-Yde and associates¹⁰ found odds ratios of 1.3 comparing current smokers and nonsmokers. The data from both studies yielded similar 95% CIs of approximately 0.9 and 1.8. These estimates are lower than the odds ratio of 2.21 (CI=1.09, 4.46) found in my study. Each of the other studies, however, was population-based and defined low back pain as any back symptoms in the past year (including tenderness or stiffness). When LeBoeuf-Yde and associates looked at the association of smoking with LBP lasting more than 30 days, the odds ratio increased to 2.3 (CI=1.6, 3.2), an association very similar to that found in my study. Frymoyer and associates¹ found current smokers to be at higher risk for moderate back pain, with moderate pain defined as any symptoms from mild discomfort through distress. From the data presented by these investigators, odds ratios could be calculated for both subjects with moderate LBP and subjects with severe LBP. The odds ratios and 95% CIs calculated from their presented data were 1.34 (CI=1.05, 1.72) for current smoking with moderate LBP and 1.71 (CI=1.25, 2.34) for current smoking with severe LBP. Because 86.1% of the subjects with severe LBP in the study by Frymoyer et al reported seeking medical attention, these subjects might be considered more similar to the subjects with LBP in my study, all of whom had back pain for which they sought medical attention. When considering all of these findings, there is evidence that the association between smoking and LBP may be stronger among people with more severe symptoms or with symptoms of longer duration. That is, smoking may be a relevant risk factor for LBP among those people who are most likely to experience activity or work restrictions and to use health care dollars.

Parity as a Risk Factor for Low Back Pain

Women in this study who had one or more full-term children delivered vaginally had a 3-fold increase in odds of LBP as compared with women who had not had a pregnancy of at least 6 months' duration (crude \hat{OR} =2.66 [CI=1.33, 5.42], standardized \hat{OR} controlling for age group=3.33 [CI=1.30, 8.54]). As noted earlier, however, the wide CIs indicate that these estimates are relatively imprecise. Although other recent studies^{13,16,24} have demonstrated a positive association between LBP and parity, only one other study¹⁴ could be found that

identified the magnitude of the studied association. Silman and associates¹⁴ reported the odds ratios for the association of LBP with number of live births among a sample of married women. Adjusting for age at first birth, the authors identified a linear trend of increased risk with a greater number of children. They reported an odds ratio of 1.01 (CI=0.84, 1.52) for women with one child as compared with none, up through an odds ratio of 1.52 (CI=1.07, 2.16) for women with 4 or more live-born children. The associations reported by Silman and associates are substantially lower than those found in my study. Silman and associates, however, defined low back pain as any LBP ever that lasted more than 24 hours. Given such a broad definition, it is somewhat surprising that even weak associations were found in their sample. The data from my study indicate that women who have had one or more vaginal deliveries are at increased risk for LBP and that the risk may increase slightly with age. Although pregnancy and delivery are not risk factors that necessarily can be modified, targeted back pain prevention programs might be more effective in reducing disability and health care costs in this potentially high-risk group.

Time Spent in a Car as a Risk Factor for Low Back Pain

Subjects in this study who spent an hour or more in a car on an average day had more than twice the odds of LBP than did subjects who spent less than 1 hour in a car daily (\hat{OR} =2.49 [CI=1.42, 4.34]). This association is similar to those of most of the studies in which magnitudes of association were identified. Skov and associates⁷ found odds ratios of 2.23 (CI=1.29, 3.85) for active salespersons driving 15,000 to 30,000 km annually and up to 2.79 (CI=1.54, 5.07) among those driving more than 50,000 km annually. They defined low back pain as any symptoms in the last 12 months. Magnusson and associates⁴ found an increased risk among male American occupational drivers as compared with sedentary workers (\hat{OR} =1.79 [CI=1.16, 2.75]). No definition of LBP was given. Masset and Malchaire⁹ (using the definition of any LBP problems in the past 12 months) cited a risk of 1.17 for "each twofold increase of duration" of vehicle driving among male steelworkers younger than 40 years of age. They noted that their results were statistically significant ($P<.001$), but they failed to include CIs around their estimates of association.

In contrast to these studies, Macfarlane and associates⁵ were not able to demonstrate anything but a very weak positive association between LBP and occupational driving of 4 hours or more per day in a population-based 1-year longitudinal study. Using any low back symptoms in the past year that lasted more than 24 hours as their definition, the age-adjusted odds ratio for male subjects driving 4 hours or more was 1.3 (CI=0.7, 2.4). The effect

was similar among female subjects. The association was not markedly different for people who consulted physicians for their LBP, but the number of such individuals was quite small (22 men and 37 women). From data presented by Frymoyer and associates,¹ the odds ratio for the risk of LBP among men spending time in cars could be calculated (no duration of time spent in cars was given). For subjects with severe LBP (as compared with no pain), the odds ratio was 1.45 (CI=0.90, 2.33). For subjects reporting any LBP symptoms, the odds ratio was 1.71 (CI=0.92, 1.88). There does not appear to be consistency in the literature as to the role of time spent in a car as a risk factor for LBP. There appears to be a building consensus around fairly similar data, however, that time spent in a car does increase the risk of LBP. This consensus would argue that time spent in a car may be an appropriate target for design intervention and education in reducing disability and medical costs from LBP.

Vibration Exposure as a Risk Factor for Low Back Pain

Exposure to an hour or more of vibration daily among subjects in this study increased the odds of LBP approximately 5 times as compared with less than 1 hour of such exposure. Subjects were asked, "About how many hours on an average day do you spend sitting on, standing on, or holding equipment that vibrates heavily (eg, industrial tools, machines, equipment, chain saws, mowers)?" Subjects were asked separately about hours spent in a big truck. Although there appears to be consensus that vibration exposure is a risk for LBP or degenerative changes in the spine, the magnitude of association was found in only one other study that examined LBP. Magnusson and associates⁴ reported that long-term vibration exposure (using a measured daily exposure extrapolated to years of employment) yielded an odds ratio of 2.0 (CI=0.98, 4.1) for LBP. They concluded that daily vibration exposure "did not relate to the reporting of low back pain." The authors, however, were not clear about how data were dichotomized for the analysis or who served as the referent group (sedentary workers or drivers with lower levels of exposure).

The magnitude of association found in this study was substantially higher than those reported previously. It may be that the broad definition of vibration exposure to which subjects responded included more potential sources of exposure than considered elsewhere. Data in this study also were not subject to the "healthy worker effect" that may exist in job-based samples. That is, the association of vibration exposure to LBP may be reduced in an occupation-based sample when workers who have vibration-induced LBP leave the job and are not part of the studied sample. The number of subjects in my study who reported vibration exposure was quite small, resulting in wide CIs around the estimate of association. The

small number of exposed subjects also precluded examination of other risk factors as potential confounding variables.

Repetitive Heavy Lifting as a Risk Factor for Low Back Pain

Macfarlane and associates⁵ found that women who frequently lifted 25 lb or more were twice as likely to seek medical attention for LBP ($\hat{OR}=2.3$ [CI=1.1, 5.0]). Data in my study showed a similar point estimate for women lifting 35 lb or more, but the CI was wider ($\hat{OR}=2.45$ [CI=0.86, 6.98]). The parallel relation for men in the study by Macfarlane et al was a lower odds ratio of 1.2 (CI=0.5, 3.0). Data from my study indicated an inverse association for men ($\hat{OR}=0.89$ [CI=0.35, 2.26]). LeBoeuf-Yde and associates¹² found an odds ratio of 3.4 (CI=2.3, 5.1) for LBP lasting more than a month when subjects who performed heavy physical activity at work (lifting was not specified or quantified) were compared with subjects in sedentary jobs. Effect modification by sex was not ascertained. When any LBP was included (regardless of duration), the association dropped to 1.3 (CI=0.8, 1.9). Magnusson and associates⁴ found an odds ratio of 2.06 (CI=1.3, 3.3) for LBP when frequent and heavy lifting were combined as risk factors. Their subjects, however, were occupational drivers and sedentary workers. The effect of lifting adjusted for driving status was not reported. Repetitive heavy lifting did not appear to be as important a risk for LBP as other factors investigated in my study. There was some indication, however, that the risk may be increased among women.

Limitations to the Study

Elimination from the comparison group of subjects with limiting LBP within the past 12 months was intended to draw a clear line between the subjects with LBP and the comparison subjects. The effect, however, may have been to inflate estimates of association between risk factors and LBP. If a risk factor is positively associated with LBP, excluding subjects from the comparison group who experienced limiting LBP may have reduced the number of comparison subjects with the risk behavior. Inflation of estimated associations, however, would occur only in the presence of an otherwise positive relation between the risk factor and LBP.

Conclusion

Among the studied group of patients seeking physical therapy services, this study determined the magnitude of the associations between LBP and self-reported risk factors for LBP. The data indicate increased odds of LBP among subjects who were smokers, subjects who were exposed to heavy vibration daily, subjects who spent an hour or more in a car daily, and women who had one or more children delivered vaginally. Estimates of the magnitudes of association in this physical therapy patient-

based sample may permit comparisons with other risk factor studies and should facilitate consideration of the cost-effectiveness of risk factor intervention, education, and back pain prevention programs among physical therapy clients with higher risk factor profiles.

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