ORIGINAL ARTICLE

Working hours spent on repeated activities and prevalence of back pain

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Background and Aims: Back pain is the most common reason for filing workers' compensation claims in the United States and affects large numbers of workers in many other countries. To evaluate the associations between working hours spent on repeated activities and back pain, data gathered through the 1988 National Health Interview Survey were analysed. The data were also used to identify high risk occupations.

Methods: A total of 30 074 workers participated in the survey. They were asked to provide information on their job, including the time spent on repeated strenuous physical activities (RSPA) and the time spent on repeated bending, twisting, or reaching (RBTR) on a typical job. A case of back pain was defined as a worker who had back pain every day for a week or more during the past 12 months. Each case was asked to report the cause of back pain. Those who attributed their back pain to repeated activities (RA) or a single accident or injury (AI) were asked to recall whether they performed RA or had the AI at work.

Results: Whereas the prevalence of back pain increased as the number of working hours spent on RSPA or RBTR increased, the dose–response relations were not linear for either factor, suggesting the involvement of other unmeasured factors. The estimated overall prevalence of RA back pain was 8.9% among male workers and 5.9% among female workers. "Carpenters" had the highest prevalence (19.2%) and most cases (338 000) among the major occupations of men, and "nursing aides, orderlies, and attendants" had the highest prevalence (15.2%) and most cases (217 000) among the major occupations of women.

Conclusions: The number of hours spent on repeated activities at work was associated with the prevalence of back pain. This study identified high risk occupations for future research and intervention.

Back pain is the most common reason for filing workers' compensation claims in the United States and accounts for about one quarter of all claims.[1 2] However, because the compensation for back pain is generally above the average, about one third of total compensation is paid for back pain claims.[3] After the common cold, back pain is the second most common cause of sickness leave and accounts for about 40% of sick absences from work.[3] The total cost of back pain in the United States was estimated to be 50–100 billion dollars in 1990.[4] Back pain also affects many workers, leads to large numbers of lost workdays, and results in huge economic loss in many other countries.[5–12]

Although the social and economic impacts of back pain are huge, the amount of data and research efforts to address the problem at the national level has been limited. Only a small number of nationwide studies on back pain have been conducted, and most were unable to indicate specific occupational risk factors.[1 2 4 13–15] In 1988, an Occupational Health Supplement was included in the National Health Interview Survey (NHIS), a personal interview survey conducted annually by the National Center for Health Statistics (NCHS). An analysis of the data gathered through this survey estimated that there were about 22.4 million cases of back pain among workers in the United States in 1988 who lost a total of about 149.1 million workdays.[16 17] Because a large proportion of the cases and the lost workdays were attributable to activities at work,[16 17] further analyses of the data were conducted to evaluate the association between the number of working hours spent on repeated activities at work and work related back pain. In addition, the analyses aimed to identify high risk occupations of back pain for future research and intervention efforts.

MATERIALS AND METHODS

The National Health Interview Survey Occupational Health Supplement

The National Health Interview Survey (NHIS) is a personal interview survey conducted on a probability sample of civilian non-institutionalised population living in dwellings with addresses across the United States. Because the interviewees are selected through a multistage probability sampling procedure, national estimates can be generated by applying the sampling weight to the data obtained from each participant.[18] Since 1957, NCHS conduct NHIS annually using a similar core questionnaire, and different supplements are added each year to study special topics. In the 1988 NHIS, the National Institute for Occupational Safety and Health (NIOSH) and the Bureau of Labor Statistics (BLS) co-sponsored an Occupational Health Supplement (NHIS-OHS) to study certain occupational diseases and conditions, including back pain.

In the 1988 NHIS, one member 18 years of age or older was randomly selected from each family in each participating household (some households had more than one family) to receive an interview with the NHIS-OHS. No proxy respondents were accepted. Official documentation with detailed information on the survey is available from NCHS,[19] and reports of previous analyses also contain extensive description of selected features.[16 17]

Abbreviations: AI, accident or injury; BLS, Bureau of Labor Statistics; BOC, Bureau of Census; NCHS, National Center for Health Statistics; NHIS, National Health Interview Survey; NIOSH, National Institute for Occupational Safety and Health; OHS, Occupational Health Supplement; RA, repeated activities; RBTR, repeated bending, twisting, or reaching; RSPA, repeated strenuous physical activities

Main messages

- The prevalence of back pain increased as the number of working hours spent on repeated strenuous physical activities (RSPA) and the time spent on repeated bending, twisting, or reaching (RBTR) increased.
- The dose–response relations between RSPA and back pain and between RBTR and back pain were not linear.
- The estimated overall prevalence of back pain owing to repeated activities at work (RA back pain) was 8.9% (SE 0.3%) among male workers and 5.9% (SE 0.2%) among female workers.
- "Carpenters" had the highest prevalence (19.2%) and most cases (338 000) of RA back pain among the major occupations of men, and "nursing aides, orderlies, and attendants" had the highest prevalence (15.2%) and most cases (217 000) among the major occupations of women.
- Among the workers whose jobs involved RBTR, about one third spend almost all their working hours on such activities.

Policy implications

- Back pain related to repeated motions and bending, twisting, and reaching in the work place is prevalent among workers.
- Measures should be taken to reduce repeated motions as well as bending, twisting, and reaching in the work place to reduce back pain among workers.
- Nationwide surveys should be conducted periodically to identify occupations and industries at high risk of causing back pain so that strategies for prevention and intervention can be developed.

Definitions of cases

A "worker" was defined as a respondent who worked at a job or business, not counting work around the house, at any time during the past 12 months. Those who engaged in unpaid work in the family business or farm were included. Workers were then asked to give further information on their job, including the time spent on repeated strenuous physical activities (RSPA; such as lifting, pushing, or pulling heavy objects) and the time spent on repeated bending, twisting, or reaching (RBTR) on a typical workday.

A case of back pain was defined as a worker who had back pain every day for a week or more during the past 12 months, excluding menstrual back pain for women under 50 years of age. Each case was then asked to report the cause of their back pain. Those who attributed their back pain to repeated activities (RA) or a single accident or injury (AI) were asked to recall whether they performed RA or had the AI at work.

A case of work related back pain owing to RA (RA back pain) was defined as a case who reported RA as the cause of back pain and recalled performing RA at work. A case of work related back pain owing to an AI (AI back pain) was defined as a case who reported an AI as the cause of back pain and recalled having the AI at work. Because cases were allowed to report both RA and an AI as the causes of back pain, they were further categorised as cases of "RA only back pain" (cases of RA back pain who did not report an AI as a cause of back pain) and cases of "AI only back pain" (cases of AI back pain who did not report RA as a cause of back pain).

Definitions of occupational groups

In the Work History section of the NHIS-OHS, respondents were also asked to give information on their jobs, and the occupations were coded with the three digit 1980 Bureau of Census (BOC) occupation and industry codes.[20] In the identification of high risk occupations, the analyses only included major occupations in order to ensure that estimates were based on sufficient observations and were thus relatively stable. A "major occupation" was defined as an occupation group with a specific three digit BOC code in which more than 0.5% of the total working population of either gender were employed. Among the 502 occupation categories with specific BOC three digit codes, 49 were identified as major occupations for men (each had more than 349 000 male workers), and 45 for women (each had more than 290 000 female workers). For convenience, these occupation categories are referred to as "occupations" in this paper.

Cases of all categories of work related back pain as defined previously were further asked to report the jobs at which the RA were performed or, in the cases of AI back pain and AI only back pain, the jobs at which the AI occurred. The jobs were also coded by the three digit BOC codes. For a given case, the job at which the RA were performed or the AI occurred might be different from the job that the case had in the study period.

Table 1 Average time spent on repeated strenuous physical activities and repeated bending, twisting, or reaching at work on a typical workday, by gender, age, and back pain status, the USA, 1988

Attributes	Strenuous physical activities		Bending, twisting, or reaching	
	Males Minutes (SE)	Females Minutes (SE)	Males Minutes (SE)	Females Minutes (SE)
All workers	132 (3)	62 (2)	197 (3)	133 (3)
18–24 years	169 (6)	67 (4)	244 (6)	155 (6)
25–34 years	146 (5)	63 (3)	213 (5)	133 (4)
35–44 years	121 (5)	60 (4)	176 (5)	121 (5)
45–54 years	107 (5)	62 (5)	173 (6)	132 (7)
55–64 years	118 (7)	65 (6)	182 (7)	137 (8)
>64 years	77 (9)	41 (7)	128 (11)	104 (11)
Cases of back pain				
All back pain	177 (6)	91 (4)	250 (6)	180 (5)
18–24 years	219 (18)	99 (11)	314 (15)	200 (15)
25–34 years	203 (11)	86 (7)	268 (11)	190 (9)
35–44 years	171 (10)	93 (8)	231 (11)	170 (9)
45–54 years	155 (12)	84 (11)	238 (14)	148 (12)
55–64 years	141 (16)	96 (15)	226 (18)	196 (17)
>64 years	82 (20)	100 (29)	162 (29)	199 (45)
RA back pain	260 (9)	168 (8)	341 (8)	292 (9)
RA only back pain	274 (11)	163 (10)	350 (10)	291 (12)
AI only back pain	171 (19)	142 (23)	222 (21)	215 (26)

Table 2 Prevalence and all back pain and work related back pain due to repeated activities (RA back pain) by gender, age, and work activities, the USA, 1988

Attributes	Workers (n=1000)*		Prevalence of back pain			
			All back pain		RA back pain	
	Males	Females	Males % (SE)	Females % (SE)	Males % (SE)	Females % (SE)
Age						
18–24 years	11098	10548	13.6 (0.9)	14.0 (0.8)	7.6 (0.8)	4.3 (0.5)
25–34 years	19767	16420	18.1 (0.6)	17.1 (0.7)	9.6 (0.5)	6.4 (0.4)
35–44 years	16235	13935	22.0 (0.8)	18.7 (0.7)	10.7 (0.6)	6.2 (0.5)
45–54 years	10643	8683	19.8 (0.9)	19.5 (1.0)	8.4 (0.6)	6.8 (0.6)
55–64 years	7305	5737	17.8 (1.2)	18.2 (1.1)	7.3 (0.8)	6.2 (0.7)
>64 years	2358	1886	17.9 (1.7)	13.9 (1.6)	3.4 (0.7)	2.1 (0.7)
p (among age groups)			<0.01	<0.01	<0.01	<0.01
Hours spent on repeated strenuous activities at work on a typical workday						
No	40437	43852	14.8 (0.4)	15.2 (0.4)	4.1 (0.3)	3.3 (0.2)
Yes†	26935	13421	24.2 (0.7)	24.1 (0.9)	16.4 (0.6)	14.7 (0.7)
P (yes *v* no)			<0.01	<0.01	<0.01	<0.01
<2 hours	8369	5836	21.6 (1.1)	21.3 (1.4)	12.4 (0.9)	11.7 (1.1)
2–4 hours	4787	2515	24.8 (1.6)	24.0 (2.0)	17.1 (1.3)	16.7 (1.9)
4–6 hours	3676	1474	25.3 (1.7)	27.8 (3.0)	17.8 (1.6)	18.0 (2.4)
6–8 hours	6270	2358	25.8 (1.4)	25.9 (2.2)	19.0 (1.2)	17.5 (1.8)
>8 hours	1993	441	30.0 (2.6)	39.4 (5.5)	24.4 (2.6)	24.9 (4.5)
p (among groups)			<0.001	<0.001	<0.001	<0.001
Hours spent on repeated bending, twisting, and reaching at work on a typical workday						
No	32731	34174	13.7 (0.5)	13.9 (0.4)	3.0 (0.3)	2.1 (0.2)
Yes†	34781	23114	23.0 (0.6)	22.3 (0.6)	14.6 (0.5)	11.8 (0.5)
P (yes *v* no)			<0.01	<0.01	<0.01	<0.01
<2 hours	6411	6035	20.9 (1.4)	19.3 (1.1)	9.8 (0.9)	7.8 (0.8)
2–4 hours	6207	4729	23.4 (1.3)	20.4 (1.3)	14.0 (1.1)	10.4 (1.0)
4–6 hours	5431	3794	20.3 (1.2)	23.4 (1.5)	13.8 (1.0)	13.7 (1.3)
6–8 hours	11519	6341	24.3 (0.9)	25.9 (1.2)	17.1 (0.9)	15.3 (1.0)
>8 hours	2867	858	29.8 (2.1)	27.5 (3.1)	20.9 (1.9)	17.1 (2.7)
p (among groups)			<0.01	<0.01	<0.01	<0.01

*Number in thousands.
†Including those who were not sure how much time they spent.

Study sample and data analysis

According to the definition described above, 30 074 respondents were identified as workers, representing 127.0 million working people in the USA. A total of 5256 cases of back pain by our definition were identified, which projected to a total of about 12.5 million male and 9.9 million female cases.[16]

To estimate the prevalence of a given type of work related back pain, a ratio was calculated with the number of cases relating their back pain to that occupation as the numerator, and the total number of workers in a given occupation as the denominator. The total number of workers in an occupation was estimated using the data gathered through the Work History section, and the number of cases in that occupation was estimated on the basis of the information obtained trough the Back Pain section.[18] The 15 major occupations with the highest prevalence were defined as "high risk occupations".

The Software for Survey Data Analyses (SUDAAN), which was designed to analyse data from complex multistage surveys,[21] was used for data analyses. In accordance with the practice of NCHS,[22] this paper reports estimated statistics for the US population obtained by applying a weighting factor to each respondent, not the crude survey results directly. The weighting factor was chosen on the basis of the sampling frame.

RESULTS

Time spent on repeated activities on a typical workday

Of the 30 074 workers, 29 507 answered the question on whether they spent time on RSPA at work, and 28 903 gave an estimate of the time spent on a typical workday. Overall, more male workers (39.9%, SE 0.6%) spent time on RSPA at work than female workers (23.5%, SE 0.5%) ($p < 0.01$ for χ^2 test for the difference). On average (including those who did no RSPA at work), male workers spent 132 (SE 3) minutes on RSPA on a typical workday, more than female workers, who spent 62 (SE 2) min/day ($p < 0.01$ for two sample test for the difference). Whereas the average time spent on RSPA by men varied across the age groups, women of different ages spent about the same amount of time (table 1). When workers were divided into six groups by two-hour intervals of the time spent on RSPA at work on a typical workday, in both genders, the ">8 hours" group had the least, and the "<2 hours" group had the most workers who spent time on RSPA (table 2). Male back pain cases spent an average of 177 (SE 6) min/day, and female cases spent 91 (SE 4) min/day; both were above the overall average. Cases of RA back pain spent even more time: 260 (SE 9) min/day by males, and 168 (SE 8) min/day by females. Male cases of AI only back pain spent about the same amount of time as back pain cases in general, but female cases of AI only back pain spent more time on RSPA than back pain cases in general (table 1).

A total of 29 493 workers answered the question on whether they spent time on RBTR at work, and 28 650 gave an estimate of the time spent on a typical workday. These data indicated that more male workers (51.6%, SE 0.6%) spent time on RBTR at work than female workers (40.4%, SE 0.5%) ($p < 0.01$ for χ^2 test for the difference). The overall (including those who did not spend any time) average time spent was 197 (SE 3) min/day among men and 133 (SE 3) min/day among women ($p < 0.01$ for two sample test for the difference). As in the cases of RSPA, whereas the average time spent on RBTR by men varied across the age groups, women of different ages spent similar amounts of time (table 1). In both genders, the ">8 hours" group had the least, and the "6–8 hours" group had the most workers who spent time on RBTR at work (table 2). Cases of back pain also spent more time than average on RBTR: 250 (SE 6) min/day for males, and 180 (SE 5) min/day for females. Again, cases of RA back pain spent even more

Table 3 Top 15 major occupations* requiring the most time on repeated strenuous physical activities at work on a typical workday, the USA, 1988

Occupation (Bureau of Census code)	Time required Minutes (SE)	Risk ranking	
		RA back pain†	AI back pain‡
Male workers			
Construction labourers (869)	365 (23)	7	1
Farmers, except horticultural (473)	360 (23)	9	11
Freight, stock, and material handlers, n.e.c.§ (883)	355 (28)	17	10
Carpenters (567)	307 (12)	1	6
Groundskeepers, and gardeners, except farm (486)	293 (32)	16	7
Farm workers (479)	277 (30)	18	4
Labourers, except construction (889)	270 (18)	11	16
Plumbers, pipefitters, and steamfitters (585)	263 (21)	4	14
Welders and cutters (738)	261 (26)	12	17
Stock handlers and baggers (877)	234 (36)	3	33
Printing machine operators (734)	229 (110)	27	24
Automobile mechanics (505)	228 (24)	2	20
Supervisors, n.e.c. (558)	211 (24)	4	19
Machine operators, n.e.c. (779)	210 (29)	24	22
Truck drivers, heavy (804)	205 (13)	13	2
Female workers			
Nursing aides, orderlies, and attendants (447)	212 (14)	1	1
Maids and housemen (449)	204 (28)	5	2
Farmers, except horticultural (473)	192 (42)	21	8
Labourers, except construction (889)	166 (29)	6	5
Miscellaneous food preparation occupations (444)	160 (27)	23	19
Licensed practical nurses (207)	136 (17)	2	4
Assemblers (785)	131 (25)	17	15
Cooks, except short order (436)	130 (15)	13	11
Janitors and cleaners (453)	130 (15)	4	12
Waiters and waitresses (435)	123 (12)	9	14
Registered nurses (095)	123 (10)	11	6
Textile sewing machine operators (744)	110 (22)	10	28
Production inspectors, checkers, and examiners (796)	96 (28)	12	3
Private household cleaners and servants (407)	88 (20)	18	21
Child care workers, except private (468)	76 (14)	23	22

*Major occupations were defined as occupations with more than 349000 male workers or 290000 female workers.
†Back pain caused by repeated activities.
‡Back pain caused by a single accident or injury.
§Not elsewhere classified.

time: 341 (SE 8) min/day for males, and 292 (SE 9) min/day for females. Whereas male cases of AI only back pain spent less time on RBTR than back pain cases in general, female cases of AI only back pain spent more time on RBTR than back pain cases in general (table 1).

Among the major occupations of men, "construction labourers" required the most time on RSPA (365 min/day), and "carpenters" required the most time on RBTR (419 min/day). Among the major occupations of women, "nursing aides, orderlies, and attendants" required the most time on RSPA (212 min/day), and "maids and housemen" required the most time on RBTR (350 min/day) (tables 3 and 4).

Prevalence of back pain

Among the seven age groups, male workers between 35 and 44 years old and female workers between 45 and 54 years old had the highest prevalence of all categories of back pain (tables 2 and 5). Workers in the youngest and the oldest groups generally had lower risks. Except for AI only back pain among women, the differences in prevalence among the age groups were statistically significant ($p < 0.05$ for χ^2 tests for the differences). Workers who spent time on either RSPA or RBTR at work had higher prevalence of all categories of back pain than those who did not ($p < 0.05$ for all χ^2 tests for the differences) (tables 2 and 5). When workers were divided into six groups by two hour intervals of the time spent on those activities at work on a typical workday, the analyses showed that the prevalence of all categories of back pain generally increased as the number of hours spent on these two types of activities increased ($p < 0.05$ for χ^2 tests for the differences), except for AI only back pain (tables 2 and 5). For all kinds of back pain except for AI only back pain, χ^2 tests for trend generally showed a statistically significant trend. Nonetheless, the dose–response relation was not entirely linear. For example, female workers spending 6–8 hours on RSPA had lower prevalence of RA back pain and all back pain combined than those who spent 4–6 hours, and male workers spending 4–6 hours on RBTR had lower prevalence of RA back pain and all back pain combined than those who spent 2–4 hours.

The estimated overall prevalence of RA back pain was 8.9% (SE 0.3%) among male workers and 5.9% (SE 0.2%) among female workers. "Carpenters" had the highest prevalence (19.2%) and most cases (338 000) among the major occupations of men, and "nursing aides, orderlies, and attendants" had the highest prevalence (15.2%) and most cases (217 000) among the major occupations of women (table 6). For both genders, "labourers, except construction" ranked among the high risk occupations for RA back pain. Nonetheless, workers of different genders in the same occupation may have very different risks of RA back pain. For example, in "janitors and cleaners", women had a prevalence of 12.4% (ranked fourth among the major occupations), but the prevalence among men was 9.8% (ranked twenty first).

For both men and women, 10 of the top 15 major occupations requiring most time on RSPA were high risk occupations for RA back pain (tables 3 and 6). Likewise, most (nine for men and 11 for women) of the top 15 major occupations requiring most time on RBTR were high risk occupations

Table 4 Top 15 major occupations* requiring the most time on repeated bending, twisting, and reaching at work on a typical workday, the USA, 1988

Occupation (Bureau of Census code)	Time required Minutes (SE)	Risk ranking	
		RA back pain†	AI back pain‡
Male workers			
Carpenters (567)	419 (12)	1	6
Construction labourers (869)	408 (22)	7	1
Automobile mechanics (505)	403 (20)	2	20
Welders and cutters (783)	386 (22)	12	17
Freight, stock, and material handlers, n.e.c.§ (883)	382 (28)	17	10
Farmers, except horticultural (473)	381 (19)	8	11
Farm workers (479)	378 (29)	17	4
Assemblers (785)	376 (31)	15	12
Machine operators, n.e.c. (779)	368 (25)	24	22
Plumbers, pipefitters, and steamfitters (585)	358 (25)	4	14
Groundskeepers, and gardeners, except farm (486)	343 (32)	16	7
Labourers, except construction (889)	340 (20)	11	16
Painters, construction and maintenance (579)	339 (36)	19	21
Stock handlers and baggers (877)	331 (40)	3	33
Electricians (575)	320 (20)	23	3
Female workers			
Maids and housemen (449)	350 (27)	5	2
Labourers, except construction (889)	340 (33)	6	5
Nursing aides, orderlies, and attendants (447)	284 (13)	1	1
Assemblers (785)	280 (30)	17	15
Farmers, except horticultural (473)	269 (60)	21	8
Janitors and cleaners (453)	266 (17)	4	12
Cooks, except short order (436)	245 (18)	13	11
Waiters and waitresses (435)	232 (15)	9	14
Licensed practical nurses (207)	230 (22)	2	4
Hairdressers and cosmetologists (458)	215 (19)	3	45¶
Textile sewing machine operators (744)	208 (27)	9	28
Private household cleaners and servants (407)	206 (20)	18	21
Registered nurses (095)	201 (14)	11	6
Child care workers, except private (468)	199 (19)	28	22
Cashiers (276)	193 (11)	14	26

*Major occupations were defined as occupations with more than 349000 male workers or 290000 female workers.
†Work related back pain caused by repeated activities at work.
‡Work related back pain caused by a single accident or injury at work.
§Not elsewhere classified.
¶No cases of back pain caused by a single accident or injury were observed among workers in seven major occupations for women, which included "hairdressers and cosmetologists".

for RA back pain (tables 4 and 6). In both genders, many of the top 15 major occupations requiring most time on RSPA or RBTR were also high risk major occupations of AI back pain (tables 3, 4, and 7).

DISCUSSION

Time spent on repeated activities at work

In the literature, data on the time spent on a specific activity by workers of different occupation are quite limited, and therefore data from the NHIS-OHS are unique and valuable. Workers of different genders in the same occupation may have very different work activities. For example, although male and female workers in "cashiers" spent almost the same amount of time on RSPA (73 min/day and 75 min/day respectively), females spent much more time on RBTR (193 min/day versus 150 min/day). In contrast, male and female workers in "labourers, except construction" spent the same amount of time on RBTR (340 min/day), but men spent much more time on RSPA (270 min/day versus 166 min/day). Of course, the time spent on those types of activities can be very different as in the case of "janitors and cleaners" described previously.

Association between repeated activities and back pain

Many studies observed associations between heavy physical work and back pain.[23–31] However, data on effects of RSPA were very limited, especially those on the dose–response relations. A study by Chaffin and Park[23] failed to find a dose–response correlation between the frequency of lifting and prevalence of back pain. Likewise, data on the specific effects of RBTR were also very limited, especially those on the dose–response relation. A study by Riihimki and colleagues[32] observed a dose–response correlation between sciatic pain and bending or twisting.

The NHIS-OHS data supported the association between RSPA and back pain as well as that between RBTR and back pain. Workers who performed such activities at work had a higher prevalence than those who did not. In general, the prevalence of back pain increased as the time spent on those activities increased, except for AI only back pain, which was not surprising, because those activities were not regarded as being related to such back pain.

The dose–response relations observed for RSPA, however, were not linear. One of the possible reasons for the non-linear relation is that the actual frequency of body motion and workload were not taken into consideration. Obviously, an ordinary worker cannot perform heavy work with high repetitive frequency for a prolonged period of time. Therefore, it was not surprising that prevalence did not vary much from the second to the fourth group by two hour intervals (table 2). The last group (>8 hours) had a much higher prevalence than the fourth group, which might partially be attributable to the fact that workers in this group work overtime (more than eight hours a day). The dose–response relations between RBTR and back pain were even more complicated. Although the same explanations can be applied, more factors might affect the relations.

Table 5 Prevalence of work related back pain due to repeated activities only (RA only back pain), work related back pain due to a single accident or injury only (AI only back pain), and work related back pain due to an accident or injury (AI back pain), by gender, age, and work activities, the USA, 1988

	Prevalence of back pain					
	RA only back pain		AI only back pain		AI back pain	
Attributes	Males % (SE)	Females % (SE)	Males % (SE)	Females % (SE)	Males % (SE)	Females % (SE)
Age						
18–24 years	4.0 (0.5)	3.3 (0.4)	0.6 (0.2)	0.5 (0.2)	4.2 (0.6)	1.6 (0.3)
25–34 years	5.8 (0.4)	4.0 (0.3)	2.1 (0.3)	0.8 (0.2)	5.9 (0.4)	3.2 (0.3)
35–44 years	6.3 (0.4)	3.8 (0.4)	2.1 (0.2)	1.1 (0.2)	6.5 (0.4)	3.5 (0.4)
45–54 years	5.3 (0.5)	4.2 (0.5)	1.8 (0.3)	1.2 (0.3)	4.9 (0.5)	3.8 (0.5)
55–64 years	4.3 (0.7)	4.2 (0.6)	2.4 (0.4)	0.7 (0.2)	5.3 (0.6)	2.8 (0.5)
>64 years	2.4 (0.6)	1.8 (0.7)	2.3 (0.8)	1.0 (0.4)	3.3 (0.9)	1.3 (0.4)
p (among groups)	<0.01	0.04	<0.01	0.15	<0.01	<0.01
Hours spent on repeated strenuous activities at work on a typical workday						
No	2.2 (0.2)	2.3 (0.2)	1.6 (0.2)	0.7 (0.1)	3.5 (0.2)	1.7 (0.2)
Yes*	10.1 (0.4)	9.1 (0.6)	2.3 (0.2)	1.7 (0.3)	8.5 (0.5)	7.3 (0.5)
p (yes *v* no)	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
<2 hours	7.2 (0.6)	7.5 (0.9)	2.4 (0.4)	1.4 (0.4)	7.6 (0.7)	5.6 (0.8)
2–4 hours	10.9 (1.1)	9.4 (1.6)	1.9 (0.5)	1.5 (0.6)	8.1 (1.0)	8.8 (1.4)
4–6 hours	11.4 (1.3)	10.6 (1.9)	1.6 (0.5)	1.5 (0.9)	7.9 (1.1)	8.9 (1.7)
6–8 hours	11.1 (1.0)	11.6 (1.5)	2.6 (0.5)	2.4 (0.8)	10.5 (1.0)	8.3 (1.2)
>8 hours	16.5 (2.1)	12.3 (3.0)	1.7 (0.6)	3.2 (1.7)	9.6 (1.6)	15.8 (4.2)
p (among groups)	<0.01	<0.01	0.13	0.02	<0.01	<0.01
Hours spent on repeated bending, twisting, and reaching at work on a typical workday						
No	1.5 (0.2)	1.4 (0.1)	1.6 (0.2)	0.7 (0.1)	3.1 (0.2)	1.3 (0.1)
Yes*	9.0 (0.4)	7.4 (0.4)	2.1 (0.2)	1.2 (0.2)	7.7 (0.4)	5.6 (0.4)
p (yes *v* no)	<0.01	<0.01	0.05	<0.01	<0.01	<0.01
<2 hours	6.1 (0.7)	5.3 (0.6)	2.4 (0.5)	1.0 (0.3)	6.1 (0.8)	3.6 (0.6)
2–4 hours	9.1 (0.9)	5.3 (0.8)	2.1 (0.4)	0.5 (0.2)	7.0 (0.7)	5.5 (0.8)
4–6 hours	9.2 (0.9)	8.1 (0.9)	1.4 (0.4)	1.2 (0.4)	6.1 (0.8)	6.8 (1.0)
6–8 hours	9.7 (0.7)	10.6 (0.9)	1.9 (0.3)	1.9 (0.4)	9.4 (0.7)	6.6 (0.7)
>8 hours	13.1 (1.4)	10.3 (1.9)	2.2 (0.6)	0.9 (0.6)	10.0 (1.4)	7.7 (2.0)
p (among groups)	<0.01	<0.01	0.27	0.03	<0.01	<0.01

*Including those who were not sure how much time they spent.

Prevalence of back pain

In comparison with studies using workers' compensation claims, the prevalence of back pain among workers estimated by this analysis was much higher. A study on workers' compensation claims from 26 states found that the average number of claims on back injuries was only about 0.86 per 100 workers per year.[1] Data from workers' compensation tend to underestimate the risks for at least two major reasons: many people with back pain do not go to see a doctor, and many back pain patients are not awarded with workers' compensation. A study showed that about half of the people who had back pain did not seek medical care,[33] and another study estimated that only about 10% of low back pain cases received workers' compensation.[34] When those two factors were taken into consideration, the worker compensation data might cover only a very small portion of back pain cases.

Only a few occupations were identified as the major occupations for both genders, which indicated that male and female workers generally had different occupations. Even within the same occupation, the risk of back pain could be very different between male and female workers. The difference in work activities might be one of the reasons. For example, female and male workers in "janitors and cleaners" had very different prevalence of RA back pain. Likewise, male and female "janitors and cleaners" had very different time spent on RSPA at work (174 min/day versus 130 min/day) and time spent on RBTR (304 min/day versus 266 min/day). A similar example was "assemblers". Among male workers, the prevalence of RA back pain was 12.7%, but among female workers, it was only 6.1%. The average time spent on RSPA at work was 199 min/day among men and 131 min/day among women, and the average time spent on RBTR was 376 min/day among men and 280 min/day among women; as in the prevalence of back pain, both were much less among women.

Strengths and limitations of the National Health Interview Survey

In comparison with the other nationwide studies on back pain in the United States,[1 13–15] the 1988 NHIS-OHS had the strength of using a large representative sample with minimal sampling bias. The size of the sample was large enough to provide accurate national estimates and to generate estimates on subpopulations defined by a variety of potential risk factors. For example, national estimates on a specific occupation group defined by three digit BOC codes as presented in this paper cannot be obtained by a small study population or even a large local population, such as thousands of workers in a large plants. However, the data still cannot be used to derive reliable estimates on occupations with small numbers of workers or other types of small subgroups in the population.

The validity of self reported data is a major uncertainty in the NHIS-OHS, which may affect both exposure and outcome data. The outcome of interest, back pain, is a subjective symptom that is hard to validate, because medical imaging and laboratory tests are normal in most cases. Even among people with abnormal medical imaging, the findings may not agree with the existence or severity of symptoms.[35] Furthermore, the existence of such a subjective symptom is hard to invalidate. On the other hand, because there was no incentive for over-reporting and no obvious reason for under-reporting, answers to the questionnaire should generally reflect the true feeling of the case, and thus the outcome measurement was mostly unbiased. Therefore, using a questionnaire as the measurement tool should not be considered a limitation of the study. Other sources of data, such as workers' compensation, might be more objective, but tend to lead to underestimation of the prevalence.

The situation with the exposure data is quite different. There are ways to make better measurements of two major

Table 6 Top 15 high risk major occupations* for back pain attributable to repeated activities at work, the USA, 1988

Occupation (Bureau of Census code)	Number of cases	Prevalence % (SE)
Male workers	6068000	8.9 (0.3)
Carpenters (567)	338000	19.2 (2.2)
Automobile mechanics (505)	173000	17.7 (3.0)
Stock handlers and baggers (877)	72000	17.2 (4.8)
Plumbers, pipefitters, and steamfitters (585)	91000	16.7 (4.0)
Supervisors, n.e.c.† (558)	88000	16.6 (4.1)
Industrial machinery repairers (518)	73000	16.0 (4.5)
Construction labourers (869)	112000	15.9 (3.7)
Industrial truck and tractor equipment operators (856)	76000	15.0 (4.0)
Farmers, except horticultural (473)	169000	14.9 (2.5)
Miscellaneous machine operators, n.e.c. (777)	79000	13.8 (3.7)
Laborers, except construction (889)	159000	13.7 (2.4)
Welders and cutters (783)	84000	13.4 (3.3)
Truck drivers, heavy (804)	268000	13.1 (1.9)
Truck drivers, light (805)	83000	13.0 (3.1)
Assemblers (785)	76000	12.7 (3.1)
Female workers	3426000	5.9 (0.2)
Nursing aides, orderlies, and attendants (447)	217000	15.2 (2.2)
Licensed practical nurses (207)	85000	13.9 (3.3)
Hairdressers and cosmetologists (458)	91000	12.5 (3.1)
Janitors and cleaners (453)	94000	12.4 (2.8)
Maids and housemen (449)	67000	11.9 (2.8)
Labourers, except construction (889)	40000	11.1 (3.6)
Designers (185)	36000	9.3 (3.0)
Health aides, except nursing (446)	32000	9.2 (3.6)
Waiters and waitresses (435)	122000	9.0 (1.7)
Textile sewing machine operators (744)	58000	8.8 (2.5)
Registered nurses (095)	143000	8.6 (1.3)
Production inspectors, checkers, and examiners (796)	31000	8.5 (3.4)
Cooks, except short order (436)	78000	8.4 (1.9)
Cashiers (276)	162000	7.4 (1.3)
Management related occupations, n.e.c. (037)	22000	7.1 (4.2)

*Major occupations were defined as occupations with more than 349000 male workers or 290000 female workers.
†Not elsewhere classified.

risk factors identified in our analysis. For example, the time spent on RBTR at work on a typical workday can be measured more accurately by videotaping. Such approaches, however, are hard to apply to large scale studies.

Recall bias might occur in the survey because back pain cases might report more work activities that they thought to be the cause of their back pain than other workers. Whereas the NHIS-OHS questionnaire put the questions on exposures before the questions of outcomes, which could decrease the degree of such biases to certain levels, it could not eliminate the possibility of obtaining a biased result. This limitation is common to questionnaire surveys and needs further validation studies to evaluate its effects on the risk estimates.

As in assessing the occurrence of back pain, whether or not the back pain was work related was determined by the interviewee without validation. In fact, for a subjective symptom like back pain, whether it is related to work activities is often hard to determine. Again, since there were no incentives for over-reporting and no obvious reason for under-reporting, the answer to the questionnaire should generally reflect the actual belief of the respondent. Although this does not prevent misclassification, differential misclassification should be minimised.

Whereas two types of high risk work activities for back pain were identified by this analysis, information on other occupational risk factors was not elicited by the survey. For example, although whole body vibration[25 36–40] and static work postures[25 28 41–43] have been recognised as risk factors of back pain, neither were included in the NHIS-OHS questionnaire. For the two types of high risk work activities studied, there were positive dose–response relations, but dose–response curves were not linear. The fact that the risk of back pain did not increase proportionately as the dose of a risk factor increased might result from a healthy worker survival effect[44] or effects of other unmeasured risk factors. Under such circumstances, using a continuous variable to represent these risk factors in data analysis will not be able to produce accurate risk estimates. Therefore, in further studies, these factors are better analysed as categorical variables as in the present study.

By the case definition used in the NHIS-OHS questionnaire, back pain patients without any episode lasting for a week or more during the 12 month period before the interview were not counted as cases. A study showed that among those who suffered from low back pain, about one third of men and 17% of women had low back pain for less than eight days altogether in the one year study period.[45] In addition, patients who were unable to work during the entire 12 month period were excluded by the definition of "worker" and thus were not included as cases. Therefore, although the present study has covered the majority of cases, results might not be applicable to a small part of back pain patients.

Because the case definitions used in NHIS-OHS were quite different from those used in other nationwide surveys, it is difficult to compare the results. In addition, the NHIS-OHS is conducted on a cross sectional sample for one time only, and therefore similar surveys are needed to evaluate its reliability and monitor trends of the problem over time. Furthermore, the high risk occupations might have changed since 1988, and a follow up survey is needed to obtain updated information. Nonetheless, it provides the most comprehensive data that are currently available on repeated activities performed at the workplace; the present study has generated many useful data and produced many important findings. Moreover, regarding the effects of repeated motions and bending, twisting, and reaching on back pain, the findings should be valid in spite of

Table 7 Top 15 high risk major occupations* for back pain attributable to a single accident or injury at work, the USA, 1988

Occupation (Bureau of Census code)	Number of cases	Prevalence % (SE)
Male workers	3706000	4.4 (0.2)
Construction labourers (869)	84000	11.9 (3.0)
Truck drivers, heavy (804)	191000	9.3 (1.5)
Electricians (575)	65000	9.3 (3.2)
Farm workers (479)	53000	9.0 (3.5)
Industrial truck and tractor equipment operators (856)	43000	8.6 (3.6)
Carpenters (567)	148000	8.4 (1.5)
Groundskeepers, and gardeners, except farm (486)	57000	8.1 (3.2)
Miscellaneous machine operators, n.e.c.† (777)	44000	7.6 (3.2)
Police and detectives, public service (418)	32000	6.5 (2.5)
Freight, stock, and material handlers, n.e.c. (883)	40000	6.5 (2.2)
Farmers, except horticultural (473)	70000	6.2 (1.6)
Assemblers (785)	34000	5.7 (2.3)
Truck drivers, light (805)	36000	5.6 (2.1)
Plumbers, pipefitters, and steamfitters (585)	31000	5.6 (2.2)
Janitors and cleaners (453)	81000	5.4 (1.4)
Female workers	1731000	2.0 (0.1)
Nursing aides, orderlies, and attendants (447)	107000	7.5 (1.7)
Maids and housemen (449)	8000	6.8 (2.2)
Production inspectors, checkers, and examiners (796)	25000	6.6 (3.0)
Licensed practical nurses (207)	39000	6.4 (2.1)
Labourers, except construction (889)	22000	6.2 (3.2)
Registered nurses (095)	88000	5.3 (1.5)
Designers (185)	19000	4.9 (2.4)
Farmers, except horticultural (473)	8000	2.8 (2.1)
Supervisors, general office (303)	8000	2.7 (2.1)
Social workers (174)	11000	2.7 (1.5)
Cooks, except short order (436)	24000	2.6 (1.2)
Janitors and cleaners (453)	19000	2.5 (1.2)
Supervisors and proprietors, sales occupations (243)	32000	2.5 (0.9)
Waiters and waitresses (435)	34000	2.5 (0.8)
Assemblers (785)	13000	2.3 (1.3)

*Major occupations were defined as occupations with more than 349000 male workers or 290000 female workers.
†Not elsewhere classified.

the fact that the survey was done about a decade ago. The results showed that among the workers whose jobs involved RBTR, about one third spend almost all their working hours on such activities, which would put them at a high risk of developing back pain. We should note that repeated motions as well as bending, twisting, and reaching can be minimised by applying machinery and ergonomic measures in workplaces. Through analysis of data from the NHIS-OHS, high risk occupations were identified for further studies and interventions to prevent work related back pain.

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