

Musculoskeletal Injuries in Construction: A Review of the Literature

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The first step in addressing any problem is recognition of the problem and a measure of its size and scope. There have been few reviews to date of the evidence of a musculoskeletal disorders problem in construction, particularly in the United States. Construction contractors in the United States have questioned the existence of a musculoskeletal disorders problem in construction, so a review of the evidence is warranted. The types of evidence reviewed include: 1) historical evidence, 2) injury data, 3) workers' compensation data, 4) medical exam data, 5) survey data, and 6) exposure data. Injury data generally represent injuries that the employers have identified as work-related and recorded or reported. Workers' compensation data are from cases that have been filed by workers for compensation and quite often represent only "closed" cases where compensation has been awarded. Medical exam data are from physical examinations of workers. Symptom survey data are the most inclusive and show the number of workers who self-report musculoskeletal problems. Exposure data include measurements made of exposure to musculoskeletal risk factors. The existing data show construction workers to be at significant risk of musculoskeletal injury, specifically related to the work they do. Their risk of musculoskeletal injury is much higher than that of other workers who have less heavy work, about 50 percent higher than all other workers. Several trades have been extensively studied, while others have been studied to a lesser extent. While the exact relationship between exposures and injuries is complex and often multifaceted, it would be difficult to deny the existence of the problem and the fact that these injuries are, to a great extent, related to the work that construction workers perform.

Keywords Construction, Musculoskeletal Disorders, Ergonomics, Surveillance

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struction contractors in the United States have questioned the existence of a musculoskeletal disorders problem in construction,⁽¹⁾ so a review of the evidence is warranted. The types of evidence available include: 1) historical evidence, 2) injury data, 3) workers' compensation data, 4) medical exam data, 5) symptom survey data, and 6) exposure data. Historical data is evidence from the historic record (in this case from ancient Egypt). Injury data generally represent injuries that the employers have identified as work-related and recorded or reported. Workers' compensation data are from cases that have been filed by workers for compensation and quite often represent only "closed" cases where compensation has been awarded. Medical exam data are from physical examinations of workers. Symptom survey data (from surveys of workers asking if or how often they have musculoskeletal symptoms) are the most inclusive and show the number of workers who self-report musculoskeletal problems. Exposure data include measurements made of exposure to musculoskeletal risk factors.

HISTORICAL EVIDENCE

Musculoskeletal injuries have probably been common in construction as long as people have been constructing buildings. The first recorded musculoskeletal injury in construction is probably the Edwin Smith papyrus.⁽²⁾ Imhotep, who lived about 2780 B.C., was an administrator concerned with a major construction project, an architect, and one of the most famous Egyptian physicians. The Edwin Smith papyrus, which has been attributed to Imhotep, includes cases that are likely to be musculoskeletal injuries during the building of the pyramids. The final case in the document deals with "instructions concerning a sprain of the vertebra [in] his spinal column." The document gives advice regarding diagnosis of a back injury. Advice regarding treatment of the injury, however, is incomplete due to missing sections of the document.

INJURY DATA

BLS Data

The U.S. Bureau of Labor Statistics (BLS) produces an annual survey of occupational injuries and illnesses each year. The

TABLE I

Lost time injury data for musculoskeletal disorders in construction

	% Sprains & strains	% Overexertion	% Lifting	% Back
BLS 98	37.5	20.3	11.7	21.0
Ontario 87-89	24.0	28.0	12.0	22.0
USACE 84-88	29.9	10.6		18.0

Annual Survey samples thousands of businesses and produces injury statistics including injury rates by industry classification. Musculoskeletal injuries are classified by BLS as “illnesses due to repeated trauma” for injuries like carpal tunnel syndrome. But back injuries, which far outnumber repeated trauma injuries in the BLS data, are classified as “injuries.” They can be characterized as injuries due to “sprains and strains.” Injuries are often thought of as occurring at a particular instance while “illnesses” is the term used to classify chronic injuries that accumulate over time. For the purposes of this review, they will all be referred to as “injuries.” There is no distinction made here between acute and chronic injuries. Such a distinction may, in fact, be artificial because many acute injuries could be the result of a chronic injury that is triggered by a peak exposure or episode. Likewise, a chronic injury may be instigated or initiated by an acute episode. This distinction is perpetuated primarily due to the nature of the workers’ compensation system that requires a specific date the injury occurred for payment and processing of claims.

Compensation for chronic injuries is particularly problematic in the construction industry since workers are changing jobs constantly. The employer who is responsible for compensation is the one who was the last employer when the injury occurred. Thus, a specific date is required and the chronic nature of injuries is masked.

For each data set there are several ways to look at musculoskeletal injuries. First there is the percentage of injuries that are classified by nature as “sprains and strains.” Carpal tunnel syndrome and tendonitis are other musculoskeletal injuries separately classified by BLS. Second is classification by “event,” what percentage were due to “overexertion,” “lifting,” or “bodily

reaction.” BLS defines “overexertion” as “an outside source of injury or illness, such as a heavy container, against which excessive physical effort was directed, such as lifting or carrying, when the injury or illness occurred.” “Bodily reaction” is another “event or exposure” associated with musculoskeletal disorders. Bodily reaction is defined by BLS as generally including “cases involving musculoskeletal or internal injury or illness resulting from the assumption of an unnatural position, or from voluntary movements like climbing, or involuntary motions induced by sudden noise, flight, or efforts to recover from slips or loss of balance (not resulting in falls).”⁽³⁾ Third is an examination of what percentage of injuries occurred to the back, as the majority of back injuries are muscle sprains and only a small number are fractures or more acute injuries. Lastly, there are incidence “rates” or the number of injuries per 100 or 10,000 full-time workers.

The BLS surveyed about 280,000 employers, about 15,000 (or 5 percent) of whom are in construction. The survey asks about injuries that employers deem “work-related.” Some information is also captured regarding the nature and cause of the injury. In 1998, there were an estimated 178,341 lost workday injuries in construction in the United States.⁽⁴⁾ This review is confined to “lost-workday injuries.” In the United States injuries are only recorded as “lost-workday” injuries when the worker has lost at least one full day of work. If a worker is injured, leaves work, but returns the next day, it is not considered a lost-workday injury. Table I shows that about one-quarter to over one-third of all lost-workday injuries were sprains and strains. About one-fifth were due to overexertion, and about one-eighth due to lifting. About 20 percent were back injuries.

In terms of incidence rates⁽⁵⁾ (see Table II), construction has the second highest rate of sprain and strain injuries in the United States. In 1998 there were 122.6 lost-workday injuries due to sprains and strains in construction for every 10,000 full-time workers, or almost 1.23 per 100 workers. While injury rates in construction have dropped from 1992 to 1998, they are still significantly higher than in all private industry for sprains and strains, back injuries, and overexertion injuries. Construction rates are lower than those in all industries for carpal tunnel syndrome and tendonitis, but this may be due to underreporting.

TABLE II

Incidence rates for lost-workday injuries for musculoskeletal disorders in construction (lost-workday injuries per 10,000 full-time workers)

	Sprains/strains	Tendonitis	Carpal Tunnel	Back	Overexertion
BLS 98					
Construction	122.6	1.8	1.8	68.8	66.3
Manufacturing	86.6	6.2	4.0	49.4	58.5
All industries	85.6	3.0	1.9	49.6	53.8
BLS 94					
Construction	179.9	3.2	2.0	119.4	110.9
All industries	119.3	4.8	3.1	75.1	76.0

The only industry with a higher rate of sprain and strain injuries was "transportation," which represents the trucking industry (with a rate of 162.0 lost workday injuries per 10,000 full-time employees in 1998). The rate in construction was 43 percent higher than in all industries combined (85.6 per 10,000 full-time workers) and 42 percent higher than in manufacturing (86.6 per 10,000 full-time workers). The rates vary significantly by type of construction, with masonry work having the highest rate for sprains and strains (173.3 per 10,000) and residential building work having the lowest rate (83.7 per 10,000).

The incidence rate data on carpal tunnel syndrome and tendonitis among construction workers also show residential construction to have the highest rate of tendonitis (6.6 per 10,000) and carpentry work to have the highest rate of carpal tunnel syndrome within the industry (4.3 per 10,000).

BLS has also done a follow-back survey of injured construction laborers.⁽⁶⁾ Construction laborers, according to this report, are injured about $2\frac{1}{2}$ times more often than the general workforce. They perform a wide variety of tasks on construction sites, involving some of the most manually intensive work performed in construction. This study surveyed 658 injured construction laborers from 27 states (53% response rate). On-the-road vehicle accidents (other than at the construction site), assaults, and fatalities were excluded from the survey. Muscle sprains and strains accounted for almost 4 out of 10 injuries (38% of injuries). Twenty-two percent of all injuries were overexertion injuries. Another 3 percent were due to "bodily reaction." About half (51%) of overexertion injuries were sprains and strains.

The leading causes of overexertion injuries were manually lifting, carrying, or moving objects (55%) and shoveling and digging (10%). About one in five injuries (19%) were to the back. The most common factors contributing to the injury, according to the workers, were lifting, pushing, or moving an object that was too heavy or bulky (22%); and working too fast (21%). The most common activity at the time of the accident was manually lifting, carrying, or moving (29%). Four percent of accidents also occurred during mechanically lifting, carrying, and moving items.

Ontario Injury Data

The Construction Safety Association of Ontario has published an *Injury Atlas* which shows the percentage distribution of construction lost-time injuries broken down by type of injury (e.g., sprain and strain), part of body injured (e.g., back), accident type (e.g., overexertion), activity at time of injury (e.g., lifting), and percentage due to materials handling.⁽⁷⁾ This is based on 53,803 individual records and 55,367 occurrences over the three-year period 1987–1989. From the accompanying figures you can see that about 28 percent of accidents were due to overexertion (range for trades = 18–42%). Overexertion was the number one type of accident overall and for 15 of the 21 trades. Twenty-two percent of all lost-workday injuries in construction were to the back (range = 2–33%). The back was the number one part of the body injured for all trades and overall. Sprains and strains

were the most common type of injury for all trades and overall, representing 24 percent of all lost-workday injuries in construction overall (range = 21–37%). From 21 to 58 percent of all injuries were attributed to materials handling, depending on the trade, and 12 percent occurred during lifting (range = 8–23%). Lifting was the number one activity during the accident for 14 of the 21 trades. Sheet metal and flooring workers have the biggest problem with overexertion injuries. Back problems are most common among bricklayers and flooring workers. Sprains and strains were most common among reinforced steel workers, bricklayers, and pipe trades. Manual handling injuries were highest among reinforced steel workers, flooring workers, heating and refrigeration mechanics, millwrights, and laborers (residential). Lifting injuries were most common among reinforced steel workers, flooring workers, and bricklayers.

U.S. Army Corps of Engineers Data

The United States Army Corps of Engineers (ACE) oversees an enormous amount of construction in the United States each year. Most of it is heavy and highway construction, but it also includes residential facilities and other buildings. Lost time injury data for 1984–1988 were recently summarized and published.⁽⁸⁾ It shows that ACE jobs are much safer than construction jobs in the private sector, with an annual injury rate of 1.34–1.52 lost-workday injuries per 100 full-time workers. Sprain and strain injuries accounted for 29.9 percent of all lost-time injuries. During the initial phases of construction (site preparation and excavation) sprains and strains accounted for over 60 percent of lost-time injuries. Overexertion injuries (10.6% of the total) and bodily reaction injuries (6.8% of the total) were almost all sprains and strains. In comparison, data from state workers' compensation records (the BLS Supplementary Data System) showed 24 percent of injuries were due to overexertion and 7 percent were due to bodily reaction. Seventy-nine percent of all back injuries for the ACE were sprains and strains. Sprains and strains also accounted for 37 percent of all ACE trunk (except back) injuries and 16 percent of ACE upper extremity injuries.

Workers' Compensation Data

Workers' compensation cases regarding sprain and strain injuries should be a conservative measure of the problem in that not all cases get compensated and those that do are likely to be the worst cases. Most states require a five- to seven-day waiting period before filing for compensation.

In the construction industry, contractors generally get workers' compensation through private carriers, although many are self-insured, and an increasing number are "self-employed" and working without insurance. Many are also in state-run "assigned risk pools" where, because of their high injury rates, they cannot afford insurance and are pooled together with other companies by the state. In a few states, workers' compensation is run through the state, which is the sole carrier. In such states (like Oregon and Washington) it is easier to get data on injury rates.

Until recently, the Bureau of Labor Statistics has collected workers' compensation data from states and compiled them into the Supplementary Data System (SDS). In 1992, the BLS published an analysis of 359,765 construction accidents occurring in 10 states between 1985 and 1988.⁽⁹⁾ The analysis showed an accident rate of 7.02–7.20 cases per 100 full-time employees. Sprains and strains were the most frequent type of injury, 36 percent of the total, and more than twice as frequent as the next leading cause (cuts, lacerations, and punctures). Back injuries were the most common, with 21 percent of the total. Overexertion was listed as the most frequent cause of injuries, accounting for 24 percent of the total. When broken down by trade, it shows some trades to be more affected than others by overexertion injuries. Below is the percentage of injuries that were due to overexertion for each trade:

• All construction trades combined	24%
• Construction laborers	26%
• Carpenters	29%
• Electricians	23%
• Plumbers, pipe fitters, & steamfitters	28%
• Helpers, construction trades	22%
• Roofers	22%
• Drywall installers	26%
• Construction supervisors	27%

These data appear to be very similar to and confirm the BLS *Annual Survey* data discussed above. Data from Oregon and Washington workers' compensation cases is also presented below (see Table III). Both states are the sole insurance provider for workers' compensation in their states.

Hsiao and Stanevich also performed an analysis of the SDS data from 1987 using census figures to calculate injury rates.⁽¹⁰⁾ They used the data to rank the 30 construction occupations with the largest number of claims. The occupations with most frequent injuries were construction laborers (25.8%), carpenters (14.8%), electricians (5.9%), and plumbers (5.6%). An analysis by type of injury revealed that overexertion injuries, struck by, and falls from elevation constituted over 50 percent of the injuries. Roofers and drywall installers had the highest rates of injuries from overexertion and falls from elevation.

A November 1993 analysis by the state Department of Consumer and Business Affairs entitled, *Overexertion and Bodily Reaction Events Among Oregon Workers in the Construction*

Industry—1987–1991⁽¹¹⁾ showed musculoskeletal injuries to be very high in this industry. Overexertion and bodily reaction claims accepted were about 41–45 percent of all claims in construction (versus about 50 percent of claims in all industry). The rate was 2.3–3.6 claims per 100 employed workers versus 1.3–1.9 for all industries. In 1991 the median cost of an overexertion or bodily reaction injury (closed cases) in construction was \$3,519 versus \$2,536 for all industries, about 35 percent higher than all industries. Sprains and strains represented 28.6–33.8 percent of all claims in construction. Carpal tunnel syndrome represented 1.2–2.5 percent of all claims in construction.

A review of all workers' compensation claims for musculoskeletal disorders (MSD) in Washington State from 1992–1994 showed 17–39 percent of all claims in construction were for MSD.⁽¹²⁾ In this report musculoskeletal disorders includes the following nature of injury codes: dislocation (190); hernia and rupture (250–259); inflammation/irritation of joints, tendons, and muscles (260); strains/sprains (310); and diseases of nerves/peripheral ganglia and carpal tunnel syndrome (562). The incidence rate for construction occupations ranged from 4.57 MSD per 100 full-time equivalent workers (FTE, e.g., 200,000 hours) among Elevator Installation to 33.87 MSD per 100 FTE for Building Construction. Twenty-five "risk classifications" in construction had incidence rates over 10 MSD per 100 FTE, compared with an average for all risk classifications of 3.7 MSD per 100 FTE. The number of lost workdays for MSD per 100 FTE (severity index) ranged from 126.39 for Elevator Installation to 3336.18 for Reinforcing Steel Installation. Twenty-three construction risk classifications had severity indices of over 500 LWD for MSD per 100 FTE, compared with 147 LWD for MSD per 100 FTE for all risk classifications. The total cost of MSD (including medical, hospital, pharmacy, time loss, permanent partial disability, pension, and loss of earning power) in construction in Washington State was over \$122.7 million during those 3 years, or about \$41 million each year. Wallboard Installation, Roofing, and Concrete Construction were among the top 10 risk classifications rated by incidence rate (for those with more than 200 claims). Wood Frame and Building Construction, Building Construction NOC (not elsewhere classified) and Painting were in the top 10 most costly classifications. Wood Frame and Building Construction was the 4th highest classification in terms of number of MSD claims.

An analysis of workers' compensation claims among union carpenters in Washington State from 1989–1992 found the

TABLE III
Workers' compensation data for musculoskeletal disorders in construction

	% Sprains & strains	% Overexertion	% Bodily reaction	% Lifting	% Back
SDS 85–88 (10 states, 4 years)	36	4	7	21	
OR 87–91	28.6–33.8	32.9	9.5	9.2–12.4	15–21.9
WA 88	34			15.5	

highest rate of claims was for sprain and strain injuries (10.54 per 200,000 hours worked as a union carpenter) and back injuries represented the highest rate of claims by body part (5.26 per 200,000 hours). This study was based on a review of 9505 claims.⁽¹³⁾ A follow-up study on 3050 claims for musculoskeletal injuries among this group found an overall rate of 15.6 claims per 200,000 hours. Drywall workers were shown to have the highest risk of musculoskeletal injuries among the various subtrades of union carpenters.⁽¹⁴⁾

A similar study has been made of construction laborers in Washington State.⁽¹⁵⁾ Workers' compensation data show that 31.5 percent of 8615 workers' compensation claims by union construction laborers in Washington State between 1990-1994 were for sprains and strains (this analysis only includes claims made during months when hours were worked on union jobs). Over one quarter (28.6%) of the claims were for either overexertion (24.9%) or bodily reaction (3.7%).

MEDICAL DATA

Musculoskeletal disorders are difficult to diagnose. Pain is hard to measure and quantify objectively. So perhaps it is not surprising that there are few studies looking at the prevalence of musculoskeletal disorders based on medical examinations. This is particularly true in construction, where workers rarely get medical surveillance through their job. Carpal tunnel syndrome (CTS) is perhaps the exception in that there are specific tests (e.g., nerve conduction velocity) recognized for diagnosis. One study has been published looking at the prevalence of carpal tunnel syndrome among carpenters using medical tests.⁽¹⁶⁾ Seventy-eight percent of cases (carpenters with hand/wrist symptoms) and 34 percent of controls (those without symptoms) had electrodiagnostic findings consistent with carpal tunnel syndrome. Even 21 percent of asymptomatic controls (asymptomatic on day of nerve testing) had electrodiagnostic confirmation of CTS.

An ongoing study is testing sheet metal worker and electrician apprentices, who are just beginning their career in construction, for CTS.⁽¹⁷⁾ With testing of over 200 apprentices, the authors found 10.6 percent have carpal tunnel syndrome in at least one hand, and the prevalence increases with each year of apprenticeship. This is beginning to confirm the survey data showing increased prevalence of CTS among construction workers.

SURVEY DATA

NHIS Data

In 1988 the National Health Interview Survey (NHIS) included an occupational health supplement on a sample of 30,074 current workers. Respondents were asked about the existence of work-related back pain due to injuries or repeated exposures (pain every day for 1 week or more) during the past 12 months. They were also asked about the occurrence of prolonged hand discomfort (7 or more consecutive days or 20 or more total days within the past 12 months), which was not specifically work-related.

Table IV shows data from the National Health Interview Survey comparing the prevalence of musculoskeletal symptoms among construction workers and among all workers.⁽¹⁸⁾ Construction workers had significantly higher rates of back pain and hand discomfort than other workers. Carpenters had the highest rate of back pain due to injuries at work (8.7%) and electricians (7.1%) and plumbers and pipe fitters (6.7%) followed. The highest rates for back pain from repeated activities at work were found among brick/stone masons (25.5%), roofers (19.2%), and carpenters (8.7%).

Severe hand discomfort in the NHIS occurred in 15.9 percent of construction workers versus 10.7 percent of all U.S. workers. The rate of severe hand discomfort was highest among structural metal workers (47.5%), plumbers and pipe fitters (23.8%), and carpet installers (20.2%). The excess risk of back pain and hand discomfort among construction workers was statistically significant at the 0.05 level, although some of the trade-specific rates were not significantly different due to small sample sizes.

Another study of the NHIS data found the rate for back pain due to injuries at work on any job among males during the previous year was highest for construction laborers (1-year prevalence of 22.6%, relative risk of 2.1, compared to all male workers) and carpenters (1-year prevalence of 22.2%, relative risk 2.1, compared to all male workers), representing an estimated 159,000 and 392,000 cases nationwide, respectively.⁽¹⁹⁾ Construction supervisors (not elsewhere classified) and plumbers, pipe fitters, and steamfitters were also among the top 15 high-risk occupations for back pain at work, with prevalence rates of 18.7 percent and 18.4 percent, respectively, and relative risks of 1.7.

In the NHIS, self-reported carpal tunnel syndrome was found in 1.55 percent of all workers, but 2.1% of construction

TABLE IV

Symptom survey data for musculoskeletal disorders from the 1988 National Health Interview Survey occupational health follow-back

	Back pain due to injury	Back pain repeated activity	Severe hand discomfort	Self-reported carpal tunnel
NHIS 1988				
Const	5.3%	10.1%	15.9%	2.11%
All	2.5%	4.5%	10.7%	1.27%

workers.⁽²⁰⁾ Construction was the fourth highest industry for self-reported CTS (after food industry, 2.46%; repair services, 2.4%; and transportation, except railroad and trucking, 2.34%), and the third highest looking only at males.

Other Symptom Survey Data

Excess rates of back pain have also been found among construction workers in studies in the Netherlands,⁽²¹⁾ Ontario,⁽²²⁾ and Sweden.⁽²³⁾ Hildebrandt found that Dutch construction workers had the highest prevalence of back pain (35.5%) of any industry other than building materials (38%) and "other industries" (40.7%).⁽²¹⁾

Liira et al. found a prevalence of 8.5 percent of Construction workers in Ontario with "long-term back problems" compared with 7.8 percent of the overall population (sample size = 38,540) (the difference was not statistically significant), but construction was the third highest industry for chronic back pain, behind Transportation (11.4%, but with a high sampling variability) and Processing (9.0%).⁽²²⁾ Those not working also had a very high rate of back pain (10.8%). Construction workers were also found to have the highest exposures to frequent heavy lifting, frequent bending, and lifting and working with the back in an awkward posture, and the second highest exposure to "frequent lifting of light objects (<50 pounds)." Frequent lifting of light objects, frequent bending and lifting, and working with back in awkward postures showed strong odds ratios (OR) for chronic back pain (1.46, 1.65, and 2.33, respectively, statistically significant, age, sex, and smoking adjusted), as did operating vibrating equipment or vehicles (OR = 1.84; construction workers had the second highest exposures, after transport workers).

Holmström found that a 1-year prevalence of back pain among 1773 randomly selected Swedish construction workers to be 54 percent, with the 1-year prevalence of severe lower back pain at 7 percent, both statistically significant.⁽²³⁾

A symptom survey of sheet metal workers has also been published.⁽²⁴⁾ The survey of 47 active and retired workers (one-third of the population) showed 64 percent had at least one musculoskeletal symptom. The prevalence of symptomatic Cumulative Trauma Disorder was 21 percent for neck and elbow CTDs, 32 percent for shoulder CTDs, and 30 percent for hand CTDs. The proportion of time spent hanging duct was strongly associated with neck (odds ratio 7.5) and shoulder (odds ratio 2.7) symptoms, but the small sample size precluded statistical significance.

Iowa Symptom Survey Data

In 1994 researchers at the University of Iowa mailed a survey to over 7,000 construction workers in Iowa through their local unions.⁽²⁵⁾ About 2100 were returned. They were asked about the prevalence of "job-related" problems by body part during the past 12 months. Of these workers, 71.7 percent reported problems with their lower back, 48.9 percent with their knees, 45.2 percent with their hand/wrists, 42.4 percent with their

shoulders, and 41.6 percent with their neck. Of these workers, about one-third (32.9%) said they had seen a physician or health-care provider because of job-related lower back pain in the past year. Because of job-related neck problems, 20.7 percent had seen a healthcare provider, as had 16.9 percent because of job-related problems of the upper back, and 13.1 percent because of job-related shoulder problems. Almost 12 percent stated that they had missed work because of a job-related lower back problem in the past year. Percentages missing work because of job-related problems of other body parts were 4.1 percent neck, 3.7 percent knees, 3.1 percent upper back, 2.7 percent ankles/feet, and 2.7 percent neck. Because of the large number of nonrespondents, these data may overestimate the prevalence of symptoms due to response bias.

NYC Symptom Survey Data on Construction Laborers

A similar survey was used with construction laborers in New York City in 1999.⁽²⁶⁾ Four hundred and forty-four surveys were distributed at a local union meeting and 300 were completed. Most workers (61%) were age 30–49, with 11 percent in their 20s and 13 percent in their 50s (12% unreported and 2% > 60). The average number of years at the trade was 12.5. Workers worked an average of 42.6 weeks per year and for 3.75 contractors/year. This group reported the following prevalences for pain during the past 12 months: absence from work, seeing a healthcare provider and pain in the last 7 days (see Table V).

Bygghälsan Symptom Survey Data from Sweden

The largest survey of construction worker symptom prevalence was in Sweden.⁽²⁷⁾ Bygghälsan, the Swedish Construction Industry Research Institute, surveyed close to 94,000 construction workers on prevalence of musculoskeletal symptoms during regular medical checkups between 1969 and 1989. They were asked how often during the past 12 months they had "disorders" of the various body parts. Frequency was categorized as: never, rarely, sometimes, often, and very often. The results

TABLE V
Musculoskeletal disorders in construction laborers in NYC—symptom survey data

Part of body	Pain last 12 mo %	Missed wk %	Seen a HCP %	Pain last 7 days %
Neck	41	6	13	22
Shoulders	42	5	10	21
Upper back	31	5	8	14
Elbows	25	3	4	12
Low back	65	12	18	33
Wrist/Hands	41	3	5	21
Hip/Thighs	18	4	5	11
Knees	41	8	9	22
Feet	33	5	8	19

Percentages reporting pain or missing work were fairly similar to figures from the Iowa study.⁽²⁵⁾

TABLE VI

Musculoskeletal disorders in construction—Swedish symptom survey data by body part

Body part	Never	Rarely	Sometimes	Often	Very often
Neck	37.8	18.5	26.2	10.3	7.3
Shoulder	35.3	16.2	26.2	12.7	9.6
Elbow	59.6	15.6	14.2	5.9	4.7
Wrist/Hand	51.2	18.6	19.2	6.6	4.4
Upper back	50.2	24.1	17.7	5.2	2.8
Lower back	23.5	14.9	35.8	15.7	10.0
Elbow	65.5	15.6	11.5	4.3	3.1
Knee	36.2	15.4	28.0	12.2	8.3
Ankle/Foot	62.2	17.4	12.2	4.6	3.6

of those identifying frequent pain, by body part, were as shown in Table VI.

Comparisons were made between trades to identify those trades with the highest injury problems for each body part and by age (scaffold erectors and roofers seem to have the highest rates for many disorders). Most disorders increased in frequency with age, but some, like back disorders, peaked in the 40- or 50-year-olds, probably due to workers dropping out of the trade. The risk of injury was compared with white-collar workers who worked for the same construction companies. An OR of 1 means they are at no higher risk of injury than the white-collar workers. An OR of 10 means they are 10 times more likely to have musculoskeletal problems. Table VII shows the OR for those trades with the highest risk of problems by body part.

For lower back injuries, the risk of injury is directly related to both the amount of heavy lifting done and the amount of stooping. Shoulder injuries are directly related to the amount

TABLE VII

Musculoskeletal disorders in construction—Swedish symptom survey data—odds ratios by trade

Part of body	Trades at highest risk	Odds ratio
Neck	Crane Operators, Painters, Insulators	5.7–5.5
Shoulder	Scaffold Erectors, Insulators, Painters	10.3–6.0
Elbow	Scaffold Erectors, Roofers, Sheet Metal Workers	9.4–5.2
Hand/Wrist	Scaffold Erectors, Sheet Metal Workers, Insulators	12.9–6.4
Upper back	Insulators, Scaffold Erectors, Crane Operators	3.4–3.2
Low back	Roofers, Floor Layers, Scaffold Erectors	7.35–4.4
MP	Roofers, Scaffold Erectors, Rock Workers	4.0–3.3
Knee	Floor Layers, Plumbers, Roofers	7.5–6.2
Ankle/Foot	Roofers, Sheet Metal Workers, Repairers	2.7–2.4

TABLE VIII

Musculoskeletal disorders in construction—Swedish symptom survey data—odds ratios for amount of heavy lifting

Amount of heavy lifting	Odds ratio for lower back injuries
Unknown	1.3
Rather rarely	0.99
Sometimes	1.13
Rather often	1.45
Often	1.5

of work overhead. And knee injuries are directly related to the amount of kneeling and stooping. Table VIII shows the odds ratios for lower back injuries depending on the amount of heavy lifting done.

EXPOSURE DATA

In a recent paper by Schneider et al., the authors analyzed a database of over 13,000 job analyses done by the United States Department of Labor. It showed that construction occupations are much more physically demanding than other occupations, particularly with regard to strength required. Over 30 percent of construction occupations were rated as heavy or very heavy, compared with only about 9 percent of non-construction occupations. Heavy or very heavy jobs require lifting more than 100 pounds occasionally, 50–100 pounds occasionally or frequently, 25–50 pounds frequently, or over 10 pounds constantly.⁽²⁸⁾

REVIEWS

Holmström et al. reviewed evidence of musculoskeletal injuries among construction workers in Sweden and the risk factors that may contribute to their injury rates.⁽²⁹⁾ They point out, for example, that 72 percent of sick leaves longer than 4 weeks in the construction industry in Sweden during 1988–1989 were due to musculoskeletal disorders and that early retirements due to these disorders were more common among construction workers. Comparisons between construction workers and office workers showed musculoskeletal symptoms much more prevalent among the construction workers. Musculoskeletal disorders showed a clear relationship to heavy work and vibration exposures, frequent use of handheld tools, repetitive work, and awkward postures (e.g., work above shoulder level and shoulder problems, kneeling and knee disorders, working in bent-forward posture and sciatica). Work organizational factors like jobs that have high demands or stress and few resources also showed an association with lower back pain. Holmström et al. state that the studies suggest “a stronger influence of physical factors than psychosocial factors on the occurrence of musculoskeletal disorders in construction workers.” Age was a strong risk factor for musculoskeletal disorders in construction workers as well. Smoking, height, weight, poor physical fitness, less leisure time,

and diminished muscle strength were also associated in some studies with musculoskeletal disorders in construction workers.

Some musculoskeletal problems of construction workers are well documented in the literature. Perhaps the best known example is "carpet layer's knee."⁽³⁰⁾ In the past several years, NIOSH has published several studies of knee injuries among carpet layers. The researchers found that while carpet layers were less than 0.06 percent of the workforce in the United States, they submit 6.2 percent of all the compensation claims for knee injuries.⁽²⁹⁾ Knee injuries were attributed to the large amount of kneeling and the use of a knee kicker. NIOSH encouraged workers to switch to use of a power stretcher as much as possible. Knee disorders were also reviewed by Kivimaki et al.⁽³¹⁾ The researchers found considerably more knee disorders among carpet and floor layers than among painters.

Concrete Reinforcement workers were well studied in the 1970s in Finland by Wickström et al.⁽³²⁾ In a series of studies, the researchers showed high rates of lumbago and sciatica among Concrete Reinforcement workers. This was attributed to the awkward postures required for the work (forward bending). Concrete Reinforcement workers were also compared with a group of painters and found to have significantly more musculoskeletal problems. This group of workers was studied longitudinally for several years.

Bricklayers have been studied extensively by Jager,⁽³³⁾ Luttmann,⁽³⁴⁾ Jorgensen,⁽³⁵⁾ Vink,⁽³⁶⁾ and others, particularly in the laboratory. Together they give a pretty clear picture of the ergonomic loads on bricklayers and possible interventions. The ergonomic hazards facing bricklayers have been reviewed by Cook et al.⁽³⁷⁾ and by Schierhorn.⁽³⁸⁾

Other trades or subtrades (like scaffold erectors⁽³⁹⁾) have also been studied to lesser extents. A review of the amount of research done, a gaps analysis, on ergonomic problems by trade has also been published recently.⁽⁴⁰⁾

CONCLUSIONS

The existing data show construction workers to be at significant risk of musculoskeletal injury, specifically related to the work they do. Their risk of musculoskeletal injury is much higher than that of other workers who have less heavy work, about 50 percent higher than all other workers. Several trades have been extensively studied, while others have been studied to a lesser extent. While the exact relationship between exposures and injuries is complex and often multifaceted, it would be difficult to deny the existence of the problem and the fact that these injuries are, to a great extent, related to the work that construction workers perform.

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