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Ergonomic Exposures of Construction Workers: An Analysis of the U.S. Department of Labor Employment and Training Administration Database on Job Demands

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The U.S. Department of Labor Employment and Training Administration (DOL/ETA) has for many years been collecting quantitative data based on field observations of the job demands of over 13,000 different occupations. Eleven of the 34 variables which DOL/ETA coded for seem to relate to ergonomics. For example, strength required by the job was assessed on a five-point scale from sedentary to very heavy. Construction jobs were identified by reference to classification by DOL/ETA and a contractor association manual. Data were sorted to compare construction job requirements with nonconstruction job requirements. These data show construction jobs to be significantly more ergonomically challenging than nonconstruction jobs. However, few differences seem to exist with regard to some variables, such as reaching, fingering, and handling, where nonconstruction jobs appear equally demanding. Limitations of the data set are also discussed. SCHNEIDER, S.; GRIFFIN, M.; CHOWDHURY, R.: ERGONOMIC EXPOSURES OF CONSTRUCTION WORKERS: AN ANALYSIS OF THE U.S. DEPARTMENT OF LABOR EMPLOYMENT AND TRAINING ADMINISTRATION DATABASE ON JOB DEMANDS. APPL. OCCUP. ENVIRON. HYG. 13(4):238–241; 1998. © 1998 AIH.

Construction work is physically demanding. It requires a lot of manual handling of heavy materials and often requires work to be performed in awkward postures.(1) One would therefore expect construction workers to suffer disproportionately from musculoskeletal disorders. The latest statistics from the Bureau of Labor Statistics (BLS) annual survey show that among construction workers, 37 percent of all lost-time injuries were due to sprains and strains in 1994.(2) The rate of sprain and strain injuries in construction that year was 179.9 per 10,000 full-time workers, the second highest rate for all industries (second only to transportation) and over 50 percent higher than the rate for all industries (119.3).

Very little research quantifying occupational exposures of construction workers has been done. Little monitoring of chemical exposures (other than lead and asbestos) or noise has been done, and quantification of ergonomic exposures has just begun in the past few years. However, other sources of information exist where some of these variables have been quantified for other purposes, and the data may be useful to industrial hygienists and ergonomists. In particular, the U.S. Department of Labor's Employment and Training Administration (DOL/ETA) has for many years been collecting quantitative data based on field observations of the job demands of many different occupations.(3) The purpose of this database is to help management place job applicants and injured workers in the most appropriate jobs, in particular, those that they are physically capable of performing. Vocational and rehabilitation counselors have used this database. For 13,115 occupations, a description of the work is provided. This comprises the Dictionary of Occupational Titles. Each occupation's data are then coded for selected characteristics. Many, though not all, have relevance to occupational health.

Methods

The DOL/ETA database on occupations and job characteristics was obtained from the North Carolina Employment Security Commission, which keeps it for DOL. In the database, occupations are coded as to the industry to which they belong. Occupations that are found in many industries are classified as "any industry." There were 415 occupations classified as construction industry occupations. In addition, several other occupations occur in both the construction industry and other sectors, such as welding, and were classified as "all industries." The Associated General Contractors of America (AGC) has used this database to generate a book of job descriptions for their industry. The book, *Generic Job Descriptions for Construction Industry*, identified those occupations deemed to be construction related, including those appearing in other sectors.(4) This is a total of 429 occupations. Of these 429 construction occupations in the AGC book, 55 (e.g., secretaries and architects) were clearly not doing construction work in the ergonomic sense of the word. So this analysis was performed by looking at exposures to the 374 construction occupations identified by the AGC after deletion of the 55 nonconstruction occupations from their data set.

The DOL/ETA database includes information on 34 variables. Twenty were called physical demand variables. The other 14 were called environmental variables. Of these 34 variables, 11 were chosen as ergonomic variables because they represented exposures that may be related to musculoskeletal disorders. The variables are all listed in Table 1. The ergonomic variables are defined by DOL/ETA as follows:

1. Strength: A composite of assessments of body position (standing, walking, and sitting), weight/force (including lifting, carrying, pushing, and pulling), and use of controls (hand-arm and foot-leg). Each occupation was placed into

TABLE 1. Exposure Variables Collected by the DOL/ETA Survey

Ergonomic Exposure Variables	Other Physical Demand Variables	Environmental Condition Variables
Strength	Accommodation	Exposure to weather
Climbing	Color vision	Extreme cold
Balancing	Feeling	Extreme heat
Stooping	Talking	Wet and/or humid
Kneeling	Hearing	Noise intensity level
Crouching	Tasting/smelling	Atmospheric conditions
Crawling	Near acuity	Proximity to mechanical moving parts
Reaching	Far acuity	Exposure to electrical shock
Handling	Depth perception	Working in high, exposed places
Fingering	Field of vision	Exposure to radiation
Vibration		Working with explosives
		Exposure to toxic, caustic chemicals
		Other environmental conditions

one of five categories: sedentary work, light work, medium work, heavy work, and very heavy work. These are further defined in Table 2. As an example, a job that required lifting 20 to 50 pounds occasionally, 10 to 25 pounds frequently, or less than 10 pounds constantly would be classified as a medium-strength job.

2. Climbing: Ascending or descending ladders, stairs scaffolding, ramps, poles, and the like, using feet and legs or hands and arms. Body agility is emphasized.
3. Balancing: Maintaining body equilibrium to prevent falls when walking, standing, crouching, or running on narrow, slippery, or erratically moving surfaces, or maintaining body equilibrium when performing gymnastic feats.
4. Stooping: Bending body downward and forward by bending spine at the waist, requiring full use of the lower extremities and back muscles.
5. Kneeling: Bending legs at knees to come to rest on knee or knees.
6. Bending body downward and forward by bending legs and spine.
7. Crawling: Moving about on hands and knees or hands and feet.
8. Reaching: Extending hand(s) and arm(s) in any direction.
9. Handling: Seizing, holding, grasping, turning, or otherwise working with hand or hands. Fingers minimally involved.
10. Fingering: Picking, pinching, or otherwise working primarily with the fingers rather than the whole hand or arm, as in handling.

TABLE 2. Limits of Weights (in Pounds) Lifted/Carried or Force Exerted by Job Rating

Rating	Occasionally	Frequently	Constantly
Sedentary	*–10	*	N/A
Light	*–20	*–10	*
Medium	20–50	10–25	*–10
Heavy	50–100	25–50	10–20
Very heavy	100+	50+	20+

*Negligible weight.
N/A, not applicable.
Source: U.S. DOL ETA.[3]

11. Vibration: Exposure to a shaking object or surface.

The last ten variables were coded on a four-point scale based on how frequently this activity occurred: not present, occasionally (up to one-third of the time), frequently (from one-third to two-thirds of the time), or constantly (two-thirds or more of the time).

For each variable a frequency distribution was created which shows the percentage of occupations where this variable was not present or was present occasionally, frequently, or constantly. Since the percentage of occupations constantly exposed was very small, this category was combined with the frequently category. Comparisons can then be made between the distribution of occupations in construction versus those nonconstruction occupations. Figure 1 shows the results for the variable strength, and Table 3 shows the results for all other ergonomic exposure variables. The difference between the construction and nonconstruction distributions was tested for significance using a chi-square test.

Results

The DOL/ETA database shows that construction occupations require significantly more strength than nonconstruction occupations (see Figure 1). Over 30 percent of construction occupations are considered heavy or very heavy jobs, compared with less than 10 percent of nonconstruction occupations. Another 44 percent require medium strength compared with less than 30 percent of nonconstruction occupations.

Table 3 shows that construction jobs require significantly more balancing, climbing, crouching, stooping, kneeling, and crawling than nonconstruction jobs, but there is little or no difference between construction and nonconstruction jobs in the amount of fingering, handling, reaching, and vibration exposure.

The differences between the distributions for construction and nonconstruction occupations were tested for significance using a chi-square test, and all but one were significant at the $p = 0.001$ level (for fingering, the differences were significant at the $p = 0.007$ level). Statistical significance of these differences, though, is more a function of the large sample sizes (over 12,000 for nonconstruction occupations and 374 for

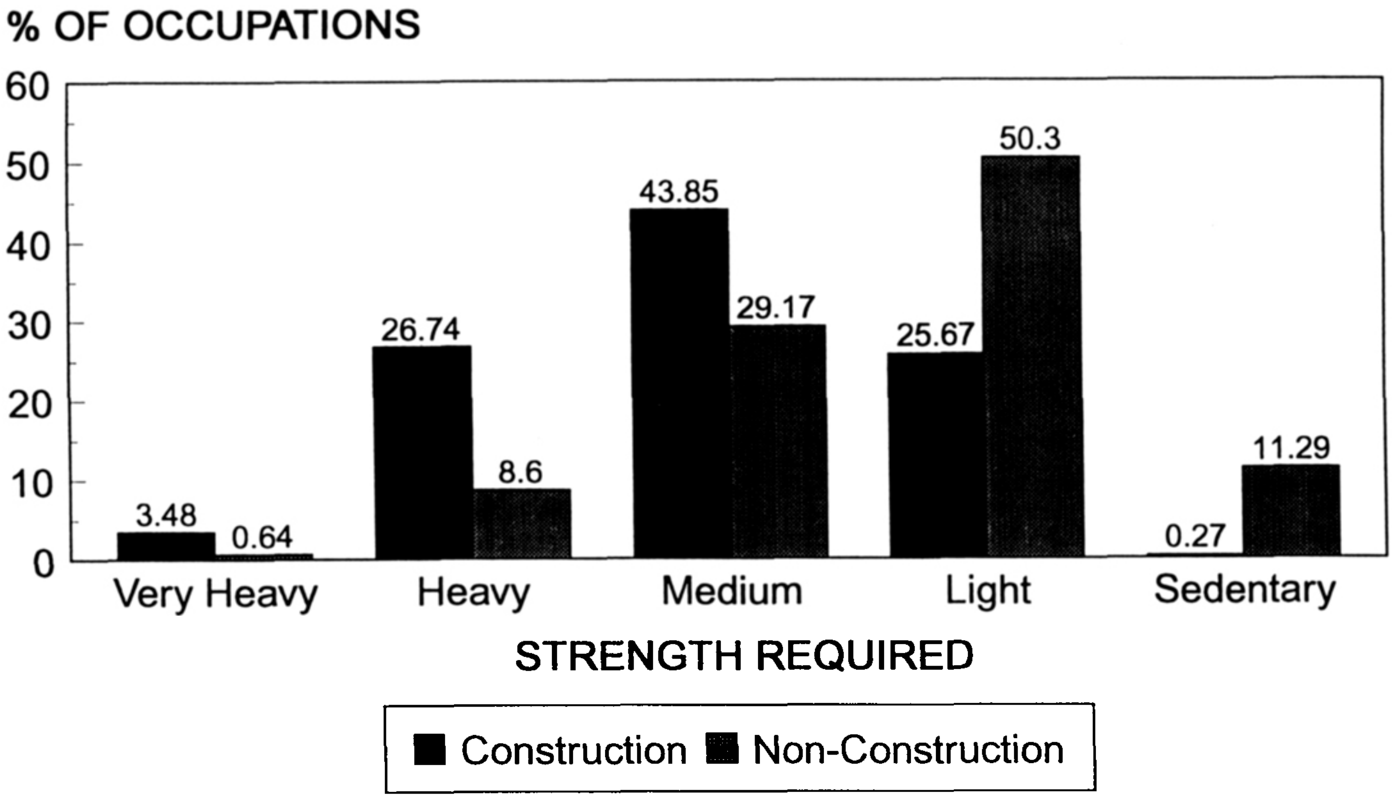

FIGURE 1. Strength required by industry. Source: U.S. DOL/ETA.

construction ones), so even small differences achieve significance. It is clear from the distributions that some differences are much greater than others.

Discussion

Construction work is difficult work involving heavy materials, and as a result musculoskeletal injuries are common in construction.[1] Therefore, it is not surprising that many construction occupations require a lot of strength. It is also not surprising that construction jobs require considerably more strength than nonconstruction jobs. The National Institute for Occupational Safety and Health (NIOSH) revised lifting equation suggests that under ideal conditions no more than 51 pounds should be lifted at one time.[5] Using that criterion, occupations classified as heavy or very heavy would automatically exceed the NIOSH limits. Medium-strength jobs (those requiring occasional lifts of 20 to 50 pounds, frequent lifts of 10 to 25 pounds, and constant lifting of 10 pounds or less) are also likely to exceed the NIOSH limits. By this measure, at least 30 percent and perhaps as many as 74 percent of construction jobs require strength beyond that recommended by NIOSH. The same is true for only 9 percent and perhaps as many as 40 percent of nonconstruction jobs.

Balancing and climbing require agility and strength, respectively. They could be related to musculoskeletal injuries in that loss of balance can result in falls and/or what BLS calls "bodily

TABLE 3. Frequency Exposure Variables Were Found in Construction Versus Nonconstruction Occupations (in Percent)

Ergonomic Exposure	Constantly/Frequently		Occasionally		Not Present	
	Construction	Nonconstruction	Construction	Nonconstruction	Construction	Nonconstruction
Balancing	10.16	1.58	31.28	4.55	58.56	93.87
Climbing	16.84	2.75	45.99	9.07	37.17	88.18
Crouching	27.27	5.47	38.77	14.89	33.96	79.63
Stooping	34.76	10.94	41.44	22.94	23.08	66.12
Kneeling	26.20	3.02	39.04	9.82	34.76	87.17
Crawling	2.41	0.47	12.03	2.23	85.56	97.30
Fingering	60.16	54.88	26.74	28.97	13.10	16.15
Handling	97.60	92.08	2.41	7.13	0	0.79
Reaching	97.06	91.49	2.41	7.63	0.53	0.87
Exposure to vibration	1.34	0.21	0.53	0.27	98.13	99.52

reaction," where the body must quickly compensate for loss of balance, possibly resulting in sprain and strain injuries. Climbing is very fatiguing and thus could result in muscle strains as well. Construction workers such as steel erectors must use balance frequently while walking on structural steel to connect it. Climbing ladders is often required of many construction workers, particularly in building construction before elevators are installed and operational. Both climbing and balancing are significantly more common among construction occupations than nonconstruction occupations.

Crouching, stooping, kneeling, or crawling are also much more common among construction occupations than nonconstruction occupations. Workers like carpet layers, floor layers, concrete floor workers, and roofers must spend much of their day on their knees or stooped over. These postures can result in lower extremity cumulative trauma disorders (CTDs) of the knees, ankles, and hips. Symptoms in these areas are common in many construction workers.[6]

Fingering, handling, and reaching, which are common in many industries, are found in about the same frequency in construction as in nonconstruction jobs. Frequent use of the hands and fingers can result in CTDs like carpal tunnel syndrome and tendonitis. Reaching, particularly overhead, can result in shoulder CTDs.

Surprisingly, vibration was present in only a few construction and nonconstruction jobs. The problem probably lies in the definition of exposure. Power tool use, which does produce hand-arm vibration, probably was not considered as a vibration exposure.[7] Otherwise, vibration exposure would have been considered more widespread among construction workers. A similar problem occurred in the data set when the authors looked at exposure to cold. Exposure to cold was counted only if weather did not cause it. This would include, for example, handling cold materials, as in a food meat locker. Weather exposure was a separate variable. As a result, in the data set construction occupations were not more exposed to cold than nonconstruction occupations.

Limitations

The main limitation of this study was that the quality of the data is unknown. The data for some occupations were quite old, having been collected in the 1970s. The data for some occupations were based on several site visits, whereas the data for others were based on a single visit or only a few visits. It is likely that the construction occupations had fewer site visits (because of the difficulty in access to job sites) and older samples than other nonconstruction jobs. However, the fact that the data conform to our common perceptions of the risks associated with construction jobs and that the comparisons with nonconstruction occupations seem valid indicate that this limitation may not be a significant one.

The other limitation is that the data refer solely to occupations. Some obscure or uncommon occupations with high risk exposures could act to skew the data. A better approach would be to weight the data based on the number of workers who work in each occupation and create a weighted sum for construction occupations and one for nonconstruction occupations. We hope to do this at a future date, depending on the availability of census data by occupation for these 13,000 occupations.

Conclusions

The DOL/ETA database on job demands is a rich source of information on ergonomic exposures. The data show that construction occupations have higher exposures than nonconstruction occupations with regard to strength requirements, stooping, crawling, crouching, kneeling, climbing, and balancing. Construction occupations are not more exposed to fingering, handling, and reaching than nonconstruction occupations. Vibration exposures do not seem higher among construction workers, but that may be the result of a poor exposure definition. Future research with this data set is planned to (1) look at nonergonomic variables like noise exposure, (2) weight occupations based on census data, and (3) develop a composite index for ergonomic exposures to identify high risk occupations based on the number of exposures and the degree of exposure to each variable. It is hoped that this data set can be used to help focus future research efforts and interventions by identifying those occupations with the highest exposures to ergonomic risk factors.

Acknowledgments

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