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Occupational Ergonomic Issues in Highway Construction Surveyed in Wisconsin, United States

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Abstract: This study discusses the workplace ergonomic issues in highway construction, and the safe work practices associated with the prevention of ergonomic-related injuries and illnesses in the construction field. In order to achieve the study objectives, a survey was designed and sent to Wisconsin based construction contractors. To design an adequate questionnaire, the research team first conducted a pilot study. The findings from the pilot survey provided a clear direction in creating the final survey. The survey results indicated that hand and finger injuries due to cutting operations and back injuries due to the manual handling of heavy materials to be the most frequent construction task/injury combination. All of the construction firms surveyed had a safety program; however, most of the contractors did not have a site-specific ergonomics program. The construction workers were usually walking/working on the ground, ladder and scaffold, and spent significant amount of time for the manual lifting or carrying heavy materials. The findings from this study may assist safety and health professionals in the construction industry in making effective changes for improving health and productivity.

Key words: Construction, Workers, Ergonomics, Injury and illness, Occupational health, Questionnaire

The construction industry is one of the largest industries in the Unites States, historically accounting for about 10% of the nation's gross national product and employing some 10 million workers[1]. The boom in construction is so widespread that project delays and shortage in materials and labor are common[2]. In 2002, about 1 in 5 construction workers worked 45 h or more a week. Construction workers may occasionally work evenings, weekends, and holidays to finish a job or take care of an emergency[3]. This incredible growth has brought many inexperienced workers into the field[2], which may be contributing to its relatively a high-injury rate compared to the manufacturing and service sectors. According to the U.S. Bureau of Labor Statistics (BLS), the construction industry had the highest incidence rate of any U.S. industry from 1992 to 2002, for all recorded cases.

Working in the building and construction trades has been linked to serious and costly health risks, including risks for musculoskeletal disorders[4]. For years the construction industry has been associated with increased rates of work-related musculoskeletal disorders (WMSDs), a condition involving the soft tissues of the body, including muscles, tendons, nerves, cartilage, and other supporting structures, that is caused by exposure to work-related factors[5]. The U.S. Bureau of Labor Statistics[6] estimates that there are more than 226,000 lost-time injuries, requiring restricted work or lost work time, in construction each year. Work-related musculoskeletal disorders and injuries are very important and costly national health problem as they account for nearly 70 million physician office visits in the United States annually and an estimated 130 million total health

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care counters including outpatient, hospital, and emergency room visits[7]. Conservative estimates of the economic burden imposed by WMSDs in the United States, as measured by compensation costs, lost wages, and lost productivity, are between $45 and $54 billion annually[8]. Some experts estimate an even higher economic burden reaching up to $210 billion for low back pain alone[9].

The existing data show construction workers to be at significant risk of musculoskeletal injury, specifically related to the work they do[10]. In a recent survey, 40 percent of construction workers said "working while hurt" is a major problem. Working while hurt reduces productivity[11]. Many of the injuries that occur in the construction industry are due to the manual material handling that is required in the construction industry[12]. Another contributing factor is that the workers' bodies must be in awkward postures (such as bending or twisting the trunk). These positions can be work below the knees, work above the head, on their backs[10]. In construction, the job is always changing. There are new situations each day as the job or project progresses. These jobs can range from above the shoulder work, to below the knees work, and a variety in between. The surfaces that workers work on change all the time and also change throughout the day[12].

The objective of this study is to report the current workplace ergonomic issues in highway construction, and the current safety practices associated with the prevention of ergonomic injuries and illnesses in the construction field.

To achieve the study objectives, the authors first researched injury and illness trends in the U.S. construction fields. This research was conducted through many different sources: books, electronic copies of books, scholarly journals articles, magazines, abstracts from safety conferences, and web sites. Upon the completion of the literature reviews, a pilot survey was developed, and then distributed to the construction contractors. The pilot survey was sent out via e-mails to 27 Wisconsin construction companies. These contractors involved in the reconstruction of a major highway interchange project in Wisconsin, which is in the upper Midwestern United States. Based upon the responses of these contractors, the survey instrument was further refined. This draft survey also was intended to determine what and all possible concerns that need to be worked out. Each question in the pilot survey was constructed or developed to gain a better understanding of what was really going on in the construction world today.

Of the 27 construction companies asked to participate, 9 completed the pilot survey. The background of the 9 companies was varied. The youngest company has been in business for 30 yr, and the oldest company has been in business for 118 yr. All except for one of the companies are unionized. All 9 companies had a safety program. The number of non-fatal injuries varied greatly by company from as little as 2%, to as many as 36% of employees. The most common type of injury was sprains/strains followed by cuts and back injury. According to these companies, these accidents typically happen for various reasons including: overexertion, motion/position, slip/trip, and tools/machinery. More than 50% of the companies said the most frequently injured part was the finger/hand. When the companies' injuries most frequently occurred was less than three months of their hires (the new employees). Three of the 9 companies surveyed had an ergonomics program. Many different factors drive these ergonomics programs such as: personnel reports, input from outside sources, types of injuries, illness, participation from field employees, loss, and trends.

This pilot survey was very helpful in the fact it enlightened the authors on the finer points of conduction a final survey. The biggest point would be to have more exact questions; meaning that the responses are more catered to analytical results. This could be achieved by: (1) providing the respondent with specific responses to choose from (e.g., multiple choice questions), (2) have the table/questions based in excel thus allowing for a more simple process, (3) making the survey more user friendly/ easier to complete, and (4) if one has to use an open ended question ask for more specifics (example one response or their top choice do not allow multiple responses).

The findings from the pilot study gave the authors a clear direction in creating the final survey. To determine what changes needed to be made we looked at the pilot survey. When rewriting the new questions we considered what kind of ergonomic issues the construction industry might face on a daily basis. By doing this we can identify what issues need to be addressed in a new ergonomics program. Also, after looking at the wording of the questions we believed that the word ergonomics might have confused some of the individuals that were filling out the survey. The new questions that we added had to do with the different ergonomics issues that a construction site might face. These issues were vibration, stretching/exercising programs, back belts, and training program for lifting. A copy of the questionnaire is attached in the Appendix. The final revised questionnaire was sent out to 41 construction contracting companies. These contractors involved in a major highway and bridge construction project in Wisconsin. The entire construction project is a billion dollar effort to reconstruct a cornerstone of southeastern Wisconsin's highway system. It involves

Table 1. Workforce and type of work of participating construction contractors

Contractor	Type of contractor	Number of employees
1	Building, heavy highway/bridges	3,000
2	Utility construction/services	1,465
3	Highway, road construction	1,000
4	Highway, road construction	800
5	Building, general contractor	750
6	Heavy highway	650
7	Building, general contractor	500
8	Building, general contractor	400
9	Heavy highway	400
10	Heavy highway	380
11	Electrical contracting	250
12	Concrete precast structures	200
13	Electrical contracting	200
14	Highway, road construction	117
15	Steel erection	80
16	Building, general contractor	60
17	Steel erection	55
18	Landscaping, signs	35
19	Street lighting, traffic signals	32
20	Highway, road construction	25
21	Heavy highway	15
Total number of employees represented in the 21 returned surveys		10,414

many contractors/subcontractors and construction workers over the life of the project (4 yr anticipated at present). The questionnaire was distributed over a time period of 5–6 wk. Distribution methodology involved faxing or e-mailing the survey to companies and having them filled out by a safety manager/director.

Of the 41 construction companies asked to participate, 21 completed the survey. This represents a response rate of 51%. The size of the participating companies greatly varied, with some employing as few as 15 workers, and others as many as 3,000. Table 1 provides data on the workforce and the type of work of the participating construction contractors. The average time that the companies had been in business was 57 yr, and 86% of respondents (18 of 21 companies) were unionized. Looking at the gender distribution of the companies surveyed, the percentage of male employees had a wide margin over female employees. The women population represented 12% of the total number of workers.

The companies were asked whether or not safety programs were maintained at their companies. All of the firms surveyed (21 of 21) had a written safety program, and 67% of the respondents have had a safety program for more than ten years. However, only 48% of the respondents (10 of 21) had an ergonomics program. Sixty-seven percent of the respondents (14 of 21) said they had a lifting training program. Fifty-two percent (11 of 21) had weight restrictions on single-person lifting. Twenty-nine percent of the respondents (6 of 21) encouraged the use of back belts. When the companies were asked if their employees did stretches prior to the beginning of their shift, 48% of respondents (10 of 21) said that they implemented the stretching program. When the companies were asked if they measured the handle of the tool when purchasing new tools, 76% (16 of 21) said that they considered ergonomic handle of the new tool before purchasing. Forty-three percent of respondents (9 of 21) indicated that they employed personal protective equipment (e.g. anti-vibration gloves) for vibrations.

Companies were asked to pick from a list as well as to list common injuries that occur on their work sites. Participants could also list other injuries that were not included selections in the given list. Choices included sprain/strain, back injury, fractures, burns, cuts, and Carpal Tunnel Syndrome. Other types of injuries specified included contusions and eye injuries. Sprain/strain was the majority of the selected injuries totaling 38% (17 of 45 total cases) of the listed types of injuries. Back injury followed with 27%, and cuts made up 22% of the selected injuries. The other types of injuries reported contusions (7%), eye injury (2%), fractures (2%), and burns (2%) respectively.

Options included in the source of injury section included

overexertion, motion/position, slip/trip, tools/machinery, and chemicals. Participants again were able to specify other types of sources that were not included in the given list and these included sharp edges and struck by. The most prevalent source of injury was overexertion totaling 30% (11 of 37 total cases) of the selected sources, followed by motion/position (27%) and slip/trip (24%), respectively. Other sources included tools/machinery (14%), sharp edges (3%), struck by (3%), and chemicals (0%).

The survey also contained a section in which participants were asked to rank the frequency at which certain parts of the body were affected with injury and illness. Seven parts of the body were listed: (1) knees; (2) hand/fingers; (3) back; (4) shoulders; (5) eyes; (6) foot/ankle; (7) head/neck. The participants were asked to rank the relative frequency on a scale of 1 to 7, with 1 being the most frequent. Back injuries had the highest ranking with a mean response value of 2.8, while hand/fingers injuries had the second highest ranking with a mean response value of 3.0. Shoulder and foot/ankle had the third and fourth highest ranking with a mean value of 3.6 and 3.7, respectively. The other three parts of the body were assessed rankings of 4.3 (knees), 4.5 (head/neck), and 4.8 (eyes).

The first question in this section designed to examine various characteristics of the walking/working surface that construction workers will commonly walk/work on. Other questions concerning manual lifting/carrying were also important to the study in determining information about common loads carried and load handling techniques when working on construction sites. Relevant issues included time spent on lifting/carrying per day, number of repetitions performed per day, distances traveled while handling loads, weight of the loads carried, and method of carrying the common loads. It should be noted here that the questionnaire respondents (i.e., safety managers/directors) had very extensive knowledge and fieldwork experiences in the construction operations, and actively interacted with their field workers in hourly and/or daily bases. The safety managers/directors have been with their company for 5 to 11 yr, and majority of them performed in construction activities related to their skilled trade.

The participants were asked to pick from a list as well as to list common working surface conditions of their construction field workers. These surfaces included roof, ladder, scaffold, and ground. Other types of working surfaces that were specified included building decks, aerial/scissor lifts, concrete pour beds, floor level, and steel girders. Ground made up the most common type of surface that the construction workers work/walk on; totaling 38% (19 of 50 total cases) of the listed types of surface conditions. The next common type of work surface recorded ladders (24%), followed by scaffold (10%) and roof (10%) respectively. The other types of working surfaces included building decks (6%), steel girders (4%), aerial/scissor lifts (4%), concrete pour beds (2%), and floor level (2%).

Responses from the survey determined that the most favorable accumulated time designated to manual lifting/carrying per day was within the range of 3–4 h. Sixty-two percent of the respondents (13 of 21 companies) chose this range as the most common. Other choices and response rates included 1–2 h (24%), 5–6 h (10%), less than 1 h (5%), and 7–8 h (0%), respectively. Forty-eight percent of the respondents (10 of 21 companies) selected a range of 3.35 m (11 ft) to 9.14 m (30 ft) as the most common distance traveled for a manual carry. Other choices and responses included a range of 9.45 m (31 ft) to 15.24 m (50 ft) (33%), 15.54 m (51 ft) to 21.34 m (70 ft) (10%), less than 3.05 m (10 ft) (10%), and more than 21.34 m (70 ft) (0%), respectively. The approximate weight of the most common types of load was designated to weigh 14.0 kg (31 lbs) to 22.6 kg (50 lbs). Forty-eight percent of the respondents (10 of 21 companies) agreed on that choice. Other choices and response rates included 9.5 kg (21 lbs) to 13.6 kg (30 lbs) (33%), 5.0 kg (11 lbs) to 9.1 kg (20 lbs) (10%), more than 23.1 kg (51 lbs) (10%), and less than 4.5 kg (10 lbs) (0%), respectively.

This study findings support that work in construction has high potential risks for musculoskeletal disorders and injuries. The survey indicates that strains/sprains are the most prevalent types of injury resulting in the back being the part of the body mainly affected. The majority of these injuries are due to overexertion in lifting/carrying heavy materials. The findings from the present survey are similar to those of other construction safety and health surveys. Data from the self-reported work-related illness (SWI) surveys in Great Britain estimated that 199,000 people ever employed suffered from an illness caused or made worse by a job in the construction industry. The surveys also showed construction as having among the highest prevalence rates for musculoskeletal disorders including back pain, joint injuries and repetitive strain injuries[13].

Additionally, the manual materials handling (MMH) findings from the present survey are very similar to those of other objective ergonomic evaluation of construction work. A study by Paguet, Punnett, and Buchholz (1999) on an ergonomic assessment of MMH activities reported that the highway construction workers were frequently observed in heavy manual materials handling activities involving at least

13.5 kg[14].

Some of the construction companies in the present study encouraged the use of back belts. These companies should note that the U.S. National Institute for Occupational Safety and Health (NIOSH) does not recommend the use of back belts to prevent injuries among workers who have never been injured[15]. Lifting hazards can very from job site to job site, thus lifting training programs must be site-specific. Before attempting to develop the training program the foreman and/or company safety personnel should evaluate the job site a materials that will be used throughout the construction project. Proper site set up from the beginning of the project could prevent back injuries[11]. Adequate amounts of the proper mechanical material handling equipment such as forklifts and hand carts should be available so that workers do not feel they have to move everything manually. The employees should be trained on what material handling equipment is on-site, how they work and any other types that they could request if they feel it is necessary. Training on the specific types of materials that will be used throughout the job and the hazards associated with them are also needed.

Majority of the construction contractors surveyed considered ergonomic handle of the new tool before purchasing. It is believed that something as simple as the handle could help to improve the safety and health of the employees while on the job[11]. Excessive hand and arm vibrations were another concern for the construction contractors. This is because there tends to be extensive usage of power tools on a daily basis. Without the proper protection, construction workers may develop injuries and diseases in the hands and arms, which can be painful and/or disabling. The most common type of personal protective equipment used when handing vibrating tools was anti-vibration gloves. These may help to lower the amount of vibration that affects the worker on a day-to-day basis. However, the construction contractors should note that the NIOSH does not offer recommended anti-vibration gloves to prevent injuries associated with vibrations. Using equipment that may produce less of a vibration would be the best solution before using personal protective equipment. Tool manufactures are also critical links in the ergonomics process. There is a great need for ergonomically designed hand tools for men and women in the construction trades. Poorly designed hand tools increase the amount of vibration transmitted to the hands, increase the forces required to operate the tool, and increase the awkward postures and positions taken when using them[12].

The current study also highlights that significant number of construction companies implemented the stretching program. Stretching has been part of a normal workout routine for many years, but it is now becoming part of the work routine for construction workers. The U.S. Occupational Safety and Health Administration (OSHA) has recommended that when working in a bent over position for the worker to take short and frequent breaks to stretch out the back muscles to help reduce injuries[16]. Construction companies are now taking this a step further by having their workers stretch before beginning work to loosen up the muscles. It is, however, important to note that the most positive support for exercise continues to be in the studies in which exercise was included as part of a more comprehensive ergonomics program approach to controlling musculoskeletal disorders, including engineering control (e.g., workstation and tool redesign) and administrative control (e.g., method training, job enlargement, job rotation and work scheduling)[17].

Findings of the survey also point out that most of the construction contractors did not have a site-specific ergonomics program. The application of ergonomic principles and methods is of primary importance for reducing the burden of occupationally related injuries and illnesses among construction workers[12]. The construction workplace is always changing which makes it hard to reduce ergonomics injuries when new risks are created each day. The solutions would have to be industry-wide to really have an effect[18]. The solutions would also have to be for each construction discipline to have a long sustained effect in each construction discipline[19]. To do this, there would have to be task-based exposure for each construction discipline. This may also include long-term studies before and after possible implementation of solutions[14]. Another hurdle to overcome is criticism from fellow employees. One must change the view of safety or ergonomics in general, and teach everyone the advantages of ergonomics[20]. With the implementation of an effective comprehensive ergonomics program, not only may the construction company's health and safety improve, but also the company's profits by decreasing the worksites related injuries and illnesses. However, it should be noted here that the results of the present study might be different from the other parts of the country when the survey is limited to one region. A larger sample representing the U.S. construction industry will be administered to develop a national database. Overall, the findings of this field report may still provide helpful insights into safety practices associated with the prevention of ergonomic injuries and illnesses in construction.

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Appendix. Survey Instrument

Background

What are the primary types of work that your company does? _____
How long have you been in business? _____
How many employees do you employ? _____ Gender: Male _____% Female_____%
Are you unionized? _____ If so, what is the union? _____
What are your title and your job function in this company? Title _____ Job function _____
How long have you worked in the above job? _____ years
Have you performed in the construction skilled trade(s)? Yes _____ No _____

Safety programs

Do you have a safety program? _____ If yes, do you have a written safety program _____
How long has your safety program been implemented? _____
Do you have an ergonomics program? Yes_____ No_____
Do your employees do stretches prior to the beginning of their shift? Yes_____ No_____
Do you consider the handle of power tools when purchasing new equipment? Yes___ No__
Do you have a lifting training program? Yes_____ No_____
Do you have weight restrictions on single-person lifting? Yes_____ No_____
Do you encourage back belts? Yes_____ No_____
Do you have work practices or personal protective equipment for vibrations? Yes___ No___

Injuries and illnesses

What are the most common types of injury or illness in your line of work?
(Please circle all applicable)

Sprain/Strain Back injury Fractures Burns Cuts Carpal Tunnel Syndrome
Others _____

How do these injuries or illnesses typically happen? (Please circle all applicable)

Overexertion Motion/Position Slip/Trip Tools/Machinery Chemicals
Others _____

Please rank these parts of the body as to the frequency at which injuries and illnesses occur to them: (1-most frequent, 7-least frequent)

____Knees ____Hand/fingers ____Back ____Shoulders
____Eyes ____Foot/Ankle ____Head/Neck

Work conditions

What types of surface conditions are the workers commonly work/walking on?
(Please circle all applicable)

Roof Ladder Scaffold Ground
Other (Please list):_____

Circle the one appropriate value in each row for your company (manual materials handling):

Accumulated time for manual lifting/carrying during a day per employee	< 1 h	1–2 h	3–4 h	5–6 h	7–8 h
Total distance traveled for each manual carry	<10 ft	11–30 ft	31–50 ft	51–70 ft	>70 ft
Approximate weight of the load the individual lifts/carries manually	<10 lbs	11–20 lbs	21–30 lbs	31–50 lbs	>51 lbs