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## Work-related musculoskeletal symptoms among construction workers in the pipe trades

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### Abstract

Workers in the construction trades experience high rates of injuries and illnesses, including work-related musculoskeletal disorders. As the basis for formulating and implementing ergonomic changes to reduce musculoskeletal disorders among workers in the pipe trades, a cross-sectional survey was conducted. The survey instrument assessed the prevalence of work-related musculoskeletal symptoms and identified job factors that may contribute to those symptoms. A two-page questionnaire was mailed out to members of three plumber and pipe/steamfitter unions. Results from 526 (40% response rate) apprentices and journeymen indicated that the highest work-related symptoms and reported lost work time due to those symptoms, were in the back, neck, and knees. Awkward postures and working in the same position for long periods were identified as the leading causes of work-related musculoskeletal symptoms. These results can be used to formulate appropriate intervention strategies for the reduction of musculoskeletal symptoms for construction workers in the pipe trades.

*Keywords:* Musculoskeletal disorders; Occupational injuries; Construction; Symptom survey; Ergonomics

### 1. Introduction

Working in the building and construction trades has been linked to serious and costly health risks, including risks for musculoskeletal disorders. The

U.S. Bureau of Labor (1986) estimates that there are more than 226 000 lost-time injuries, requiring restricted work or lost work time, in construction each year. According to statistics compiled by U.S. insurance brokers, workers' compensation insurance costs for construction workers averages \$28.00 per \$100.00 of payroll and has been increasing at a rate of approximately 10.5% each year over the last 10 years (Marsh and McLen-

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nan, 1993). According to Holmström (1992), unpublished data from Swedish insurance companies between 1988 and 1989 indicated that 72% of all sick leave of more than four weeks duration among construction workers was due to musculoskeletal disorders. An analysis of 360 000 workers' compensation claims in the construction industry over a four year period in ten states of the U.S. revealed that workers in the pipe trades had the highest rate (28%) of overexertion injuries among the construction trades analyzed (U.S. Department of Labor, 1992). Data from the Construction Safety Association of Ontario (1995) revealed that overexertion injuries for construction workers in the pipe trades accounted for 33% of the lost time injuries and were higher than for all construction. Overexertion injuries were most frequently associated with materials handling and involved the back, knees, and hands.

Workers in the pipe trades are often categorized as plumbers, pipefitters, or steamfitters. Although there is a distinction in the type of work performed by workers within each of these categories, their job activities are very similar (Construction Safety Association of Ontario 1995). The workers in this area of construction are craftsmen/women who install pipe systems that carry water, steam, air, or other liquids or gases needed for sanitation, industrial production or other uses. They also replace and repair existing pipe systems and install plumbing fixtures, appliances and heating and refrigeration units. Because the job tasks in the pipe trades often involve materials handling activities such as lifting, carrying, and removing, workers are at risk for musculoskeletal disorders from both acute and repetitive stress. This is especially evident with work that involves heavy materials and strenuous physical activity. For example, based on a sample of 1242 lost time injuries among the plumbers and pipe/steamfitters in Ontario, Canada, it was determined that half of all carrying injuries to plumbers involved handling bathtubs (Construction Safety Association of Ontario, 1995).

As the first phase of a larger project directed at reducing work-related musculoskeletal disorders in the construction trades, a questionnaire survey was mailed to over 8000 unionized construction

workers in 13 different trades from 23 locals in several Midwestern communities. The goal of this first phase of the project was to develop trade-specific musculoskeletal injury profiles as the basis for formulating, implementing, and evaluating ergonomic interventions directed at reducing the prevalence of these problems. This report presents the findings regarding construction workers in the pipe trades.

## 2. Methods

A two-page questionnaire was mailed to all 1674 members of three union locals of the United Association of Plumbers and Pipefitters. Two union locals were located in a geographical area covering three counties with a population of over 350 000. The third local was located in a metropolitan area with a population of approximately 180 000. Each union local had at least 500 members. All surveys were mailed during the first week in June followed by a reminder postcard exactly 1 week later. The surveys were accompanied by a support letter endorsed by the President of the local Building and Construction Trades Council. To increase the probability of a returned questionnaire, a drawing for \$100.00 was offered to construction workers that returned a completed questionnaire. Although each survey was numerically coded for the \$100.00 drawing, the union locals would not permit any names to be identified with the questionnaires. Thus, it was impossible to determine who returned a questionnaire or to obtain information regarding non-respondents.

The survey contained three sections. The first section consisted of ten questions dealing with type of trade, years in trade, yearly working time, apprentice training, working status, handedness, gender, age, height, and weight.

The second section of the survey was a modification of the standardized Nordic Questionnaire (Kuroinka and Johnsson, 1987) and consisted of questions referring to nine body areas. An anatomical figure with body areas highlighted (three upper limb, three lower limb, three trunk) was incorporated to help the respondents answer 'yes or no' to the question, 'During the last 12 months

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have you had a job-related ache, pain, discomfort?, etc.' in any of nine different body segments. If the respondents indicated that a work-related musculoskeletal symptom had occurred, they were then asked to answer 'yes or no' to two additional questions, (1) 'During the last 12 months have you been prevented from doing your day's work due to this condition?' and (2) 'During the last 12 months have you seen a physician (M.D., Chiropractor, Osteopath) for this condition?'

The third section of the questionnaire concerned the workers' perceptions of the physically stressful elements in their job. This portion of the questionnaire contained a listing of fifteen conditions and tasks with the following instructions, 'This list describes things at work that could contribute to job-related pain and injury. Please indicate, on a scale of 0-10, how much of a problem (if any) each item is for you by circling the appropriate number.' Zero to one was equiva-

lent to a job factor being 'No Problem', a score of 2-7 was rated a 'Minimal to Moderate Problem', while an 8-10 was used to indicate that a job factor was considered a 'Major Problem.' The job factor descriptions are contained in Table 1.

### 3. Results

Six hundred and seventy-seven completed questionnaires were returned for an overall response rate of 40.4%. The response rate for each of the three unions varied between 35 and 46%. Data for the present study was analyzed for only active working plumbers and pipe/steamfitters (i.e. not including retirees) which numbered 526. The 526 workers had an average age of 43.2 (S.D., 9.5) years, an average of 19.7 (S.D., 9.5) years of experience in the trade, 91.4% had received apprenticeship training, and 99% were male. Fig. 1a and 1b illustrate the grouped distribution of age

Table 1  
Job factor survey results ( $N = 526$ )

Job factor	Mean numeric score 0-10 (0 or 1)	No moderate problem* (2-7)	Minimal to problem <sup>a</sup> (8-10)	Major
1. Performing the same task over and over.	2.8	41.4	51.5	7.1
2. Working very fast for short periods (lifting, grasping, pulling, etc.).	3.6	30.2	58.2	11.6
3. Having to handle or grasp small objects.	1.7	64.5	32.0	3.5
4. Insufficient breaks or pauses during the work day.	2.1	55.0	38.3	6.7
5. Working in awkward or cramped positions.	5.7	8.5	58.7	32.8
6. Working in the same position for long periods.	6.0	6.4	59.9	33.7
7. Bending or twisting your back in an awkward way.	5.9	11.2	50.6	38.2
8. Working near or at your physical limits.	4.4	20.3	60.3	19.4
9. Reaching or working over your head or away from your body.	4.7	19.7	58.9	21.4
10. Hot, cold, humid, wet conditions	4.5	20.8	57.8	21.4
11. Continuing to work when injured or hurt.	4.9	16.8	57.9	25.3
12. Carrying, lifting, or moving heavy materials or equipment.	5.1	15.5	56.1	28.4
13. Work scheduling (overtime, irregular shifts, length of workday).	2.9	41.2	47.8	11.0
14. Using tools (design, weight, vibration, etc.).	2.8	38.3	54.7	7.0
15. Training on how to do the job.	1.3	69.1	28.0	2.9

<sup>a</sup>Percent indicating job factor is problematic at indicated degree.

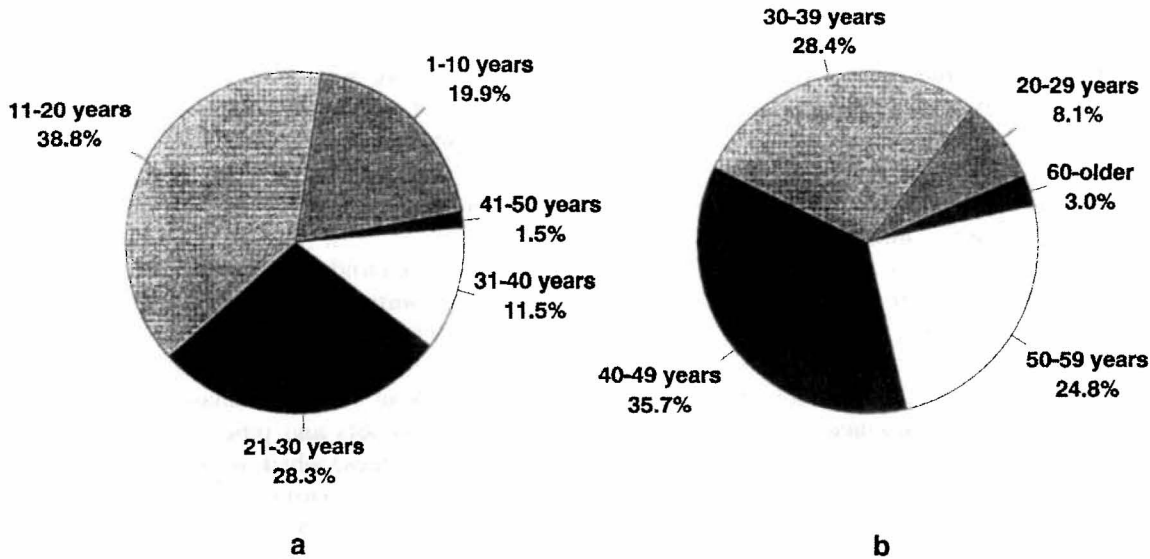


Fig. 1. (a) Distribution of years employed in trade. (b) Distribution of plumbers and fitters by age group.

and experience in the trade for the respondents. At the time of the survey, the respondents reported that they worked an average of 47.2 (S.D., 7.0) weeks in the previous year. The respondents had an average height and weight of 179.5 cm (S.D. 8.1) and 88.5 kg (S.D. 14.9), respectively, 87% were right handed.

The prevalence of self-reported musculoskeletal complaints by body area for the 526 actively working plumbers and pipe/steamfitters responding to the survey are summarized in Fig. 2. Low back symptoms were clearly the most prevalent musculoskeletal problem reported by this sample of construction workers in the pipe trades. Low back symptoms were also reported to account for the most lost work time and the most physician visits. More than one third of all respondents indicated that they had seen a physician for low back problems in the previous year, 11.5% reported missing work because of low back symptoms.

The knees were the second most frequently reported work-related problem area. Although over half of the respondents indicated work-related knee symptoms, only 6% of the construction workers reported seeing a physician for a knee ailment. The neck, wrist/hand, and shoulder ar-

ms had approximately equivalent prevalence rates (41-43%) for self-reported musculoskeletal problems. Following the low back, the upper back and neck were reported to be the second and third most prevalent body areas with symptoms leading to physician visits and missed work.

In the present study, 88.4% of the plumbers and fitters reported at least one work-related musculoskeletal symptom in the previous 12 months. As a result of work-related musculoskeletal symptoms, 25.1% of the tradesmen/women reported missing work and 51.5% reported seeing their physician in the previous 12 months.

Findings related to the job factors which were reported to be problematic for the plumbers and pipe/steamfitters who responded to this survey are shown in Table 1. In addition to containing the mean numerical score, Table 1 presents the responses divided into three categories: (1) those scoring the job factor as a 0 or 1 (on the 0-10 scale), thus indicating that the job factor was not a problem for them; (2) those scoring the job factor from 2 to 7, indicating a minor-to-moderate problem; and (3) those scoring the job factor from 8 to 10, indicating their assessment that the job factor was a major problem for them.

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#### 4. Discussi

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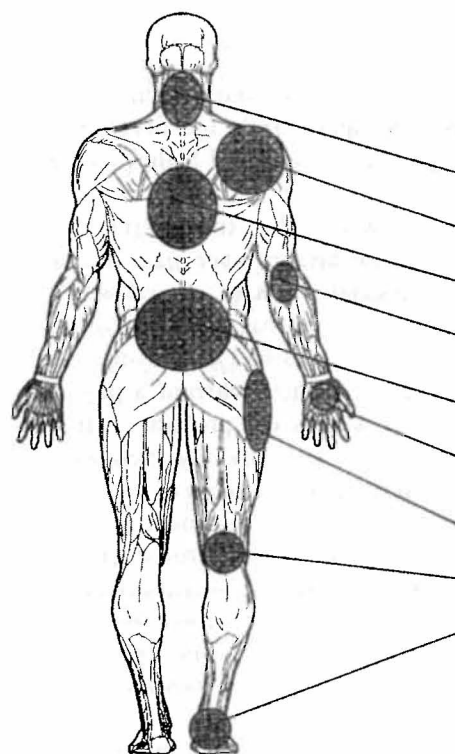
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Anatomical Area	Percent With Symptoms	Percent Missing Work	Percent Visiting Physician
Neck	24.7	0.7	1.7
Shoulders	18.9	0.4	1.0
Upper Back	28.7	0.7	1.3
Elbows	8.0	0.2	0.6
Low Back	45.0	2.8	2.9
Wrist / Hands	29.6	1.0	2.3
Hips / Thighs	4.7	0.2	0.6
Knee	10.9	1.0	1.7
Ankles / Feet	10.7	0.5	1.6

Fig. 2. Results of musculoskeletal symptom survey from 526 plumbers and pipefitters.

The job factors with the highest percentage of workers indicating it was a major problem contributing to job-related injury were #7 'bending or twisting the back in an awkward way,' #6 'working in the same position for long periods,' and #5 'working in awkward or cramped positions.' These three job factors also had the highest mean numeric score which ranged from 5.7 to 6.0. The only other job factor that had a mean score above 5.0 was #12 'carrying, lifting, or moving heavy materials or equipment.' Twenty-eight percent of the respondents indicated that the materials handling job factor (#12) was a major problem contributing to work-related pain and injury.

**4. Discussion**

This survey of construction workers in the pipe trades revealed that a large proportion (88.4%) of active tradesmen/women reported experiencing musculoskeletal symptoms in the previous year.

This finding is consistent with earlier cross sectional studies based on questionnaire data that have revealed a high prevalence of musculoskeletal complaints among construction workers (Holmström, 1992; Cook and Zimmermann, 1992; Cameron et al., 1993; Engholm and Englund, 1993; Hunting et al., 1994). Using a survey instrument similar to the one used in the present study, 92% of 1773 Swedish construction workers reported musculoskeletal symptoms during the past 12 months in at least one body area (Holmström, 1992). The average age and years in the trade of the Swedish workers was 39.5 and 17.5 years, respectively, which was similar to the sample population in the present study. In the Swedish study, the low back and knees were the most prevalent symptomatic body areas at 72 and 52%, respectively.

In a survey of 526 unionized construction workers from various trades, Cook and Zimmermann (1992) reported on the prevalence of work-related

musculoskeletal symptoms described as an ache, pain or discomfort. Their sample population had a mean age of 41 years with 16.75 years experience in the trade. The highest prevalence of symptoms was reported in the low back at 75%. The body areas with the next highest prevalence of symptoms were the neck, knees, and wrist/hands at approximately 40% each. Cook and Zimmermann (1992) noted that the proportional prevalence of musculoskeletal symptoms for the different body areas varied from trade to trade. Holmströmm et al. (1995) suggested that occupational groups within the construction industry are exposed to various kinds of physical workloads involving different parts of the body. The different types of work may account for the differences in pain localization reported among the construction trades.

In the present study of 526 experienced plumbers and fitters, we found symptom prevalences slightly lower in the low back as compared to studies of all construction trades using similar questionnaire instruments. The prevalence of knee symptoms for plumbers and pipe/steamfitters were the same as those reported by Holmströmm (1992), but higher than those reported by Cook and Zimmermann (1992) for all construction trades. In terms of lost work time injuries, the Construction Safety Association of Ontario (1995) reported that low back and knees were the body parts most frequently injured among workers in the pipe trades. Although not directly comparable, the Ontario findings are in agreement with those in the present study in terms of involved anatomical areas for plumbers and fitters.

In a survey of construction workers from various trades, Engholm and Englund (1993) reported the prevalence of knee symptoms were highest in floorlayers and workers in the pipe trades. Workers in the pipe trades were more than 1.5 times (odds ratio) as likely to report knee symptoms in comparison to carpenters (reference group of 19677). Other investigators have reported that pipefitters have a 3.5 and 4.4 times higher risk for developing non-specific and meniscus knee joint lesions, respectively, than workers not exposed to the same job stresses (Ritz and Brunnholz, 1988).

In the present study, low back symptoms accounted for the majority of reported physician visits and missed work compared to other body areas. The upper back and neck were the areas with the second and third highest symptom prevalences resulting in physician visits and missed work. Although the knees ranked second for symptom prevalence, knee pain did not result in many physician visits or missed work relative to other anatomical areas. Thus, although more than half of the workers had knee symptoms, few were significant enough to warrant a physician visit or prevent work. It is also probable that construction workers are able to modify their working activities to contend with knee pain to a greater extent than they can for back or neck pain.

There is little data regarding specific work factors that contribute to musculoskeletal symptoms and disorders in construction workers. Generally, 'extreme work postures' and 'work with the muscles being static' are job factors that are thought to contribute to the occurrence of musculoskeletal symptoms in construction workers (Ritz and Brunnholz, 1988). Holmströmm (1992) reported that frequent handling of machines (especially hand-held machines) was associated with increased prevalence rates of low back pain and neck-shoulder trouble. In the same study, frequent handling of materials did not significantly increase either neck-shoulder or low back pain prevalence rates. Cook and Zimmermann (1992) reported that approximately 70% of construction workers responding to their survey indicated that static positions and awkward postures were problems that lead to musculoskeletal pain or injury. During a 3-year period in Ontario, Canada, one third of all lost time injuries among plumbers and fitters were a result of lifting, carrying, or installing (Construction Safety Association of Ontario, 1995). The results of the job factors survey in the present study generally agree with previous reports of hazardous activities in construction. Plumbers and pipe/steamfitters in our study reported that activities involving awkward postures, static muscle contractions, and materials handling (carrying, lifting, moving) were the most problematic for them.

According to the survey, approximately 20–25% of plumbers and fitters reported low back symptoms. This criterion can be compared to other occupational studies in the pipe trade to the involvement of experience and membership in the Union's N. The survey working time lost due to the two most reported symptoms during the survey, the average approximate relationship profile questionnaire worked an average of our sample tradesmen experience sampled.

The questionnaire is a measure of the prevalence of low back symptoms among plumbers and fitters. The prevalence of low back symptoms is higher among plumbers and fitters than non-plumbers and fitters. The prevalence of low back symptoms is higher among plumbers and fitters than non-plumbers and fitters. The prevalence of low back symptoms is higher among plumbers and fitters than non-plumbers and fitters.

One of the reasons for this is that plumbers and fitters are exposed to a higher level of physical activity and stress than other trades. A primary cause of low back symptoms is the lifting and moving of heavy materials. This is little known.

According to union officials, the unions involved in this study routinely have a response rate of 20-25% on the questionnaires and other information they solicit from their membership. Using this criterion, the response rate for this survey can be considered better than average for this population, but less than ideal for a cross-sectional study. Business managers from the two pipe trade locals involved in this study confirmed to the investigators that the mean age and trade experience of our respondents approximated their membership characteristics. According to the Union's Membership Profile during the year of the survey (1995), the average age of an actively working tradesman was 44.0 and 44.9 years for the two locals, respectively, and each local reported that the workers worked an average of 47 weeks during the year. Including apprentice training, the average worker had been in the trade for approximately 20 years according to the membership profile. Those responding to the present questionnaire had an average age of 43.2 years, worked an average of 47 weeks, and had an average of 19.7 years in the trade. Thus, although our sample only represented 40% of the tradesmen, the respondents were similar in age, experience, and work exposure to the population sampled.

The question of response bias in a study of this nature is a difficult issue to assess. If symptomatic plumbers and pipe/steamfitters were more likely than non-symptomatic workers to complete and return the questionnaire, this would increase the observed symptom prevalence. However, if severely symptomatic workers left the trade because of musculoskeletal disorders, the reported symptom prevalence would have been smaller (healthy worker effect). Consequently, the possibility of selection and participation biases must be kept in mind when evaluating absolute symptom prevalence.

One of the main purposes of this study, however, was to gather information regarding symptom and injury profiles specific to the pipe trades. A primary objective was to assess the relative anatomical distribution of musculoskeletal symptoms rather than the absolute prevalence. There is little reason to believe that the relative dis-

tribution of symptoms among the anatomical areas studied was biased, although the possibility of such bias exists. Additionally, the relative ranking of problematic job factors for workers in the pipe trades may not have been significantly different with a greater response rate.

## 5. Conclusions

For construction workers in the pipe trades, the low back was reported to account for the majority of work-related musculoskeletal symptoms, physician visits and missed work. One third of all plumbers and pipe/steamfitters that responded to the survey reported visiting a physician in the last 12 months for low back pain. One half of the respondents reported knee pain but few resulted in physician visits or missed work. Upper back and neck pain often led to physician visits and missed work relative to other body areas. Bending or twisting the back, awkward positions, static positions, and materials handling were reported as the most problematic job factors for plumbers and pipe/steamfitters.

Trade specific injury and job factor profiles should be investigated prior to formulating and implementing ergonomic interventions in the construction trades. These profiles can be used to assist with efficient and targeted intervention strategies. The next logical step in the ergonomic intervention process is to determine how specific tasks, processes, or tools can be modified to reduce the problematic job factors and decrease work-related musculoskeletal disorders. Further study is needed to develop efficacious interventions for the construction industry.

## Acknowledgements

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**Abstract**

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