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Work-Related Musculoskeletal Disorders in Bricklaying: A Symptom and Job Factors Survey and Guidelines for Improvements

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Workers in the construction trades experience high rates of injury and illness, including work-related musculoskeletal disorders. As the basis for formulating and implementing ergonomics changes to reduce musculoskeletal disorders among bricklayers, a questionnaire survey was conducted regarding work-related musculoskeletal disorders and the troublesome job factors which bricklayers perceived as contributing to those disorders. A two-page questionnaire was mailed out to all members of a Midwestern bricklayers union local. The responses of 39 nonretired bricklayers, having an average age of 45 and an average of 21.8 years of work experience, were analyzed. Results indicated that work-related symptomatic areas, and those accounting for the most reported lost work time and physician visits, were primarily back, neck, and shoulder, and secondarily, elbow and wrist/hand. The survey respondents consistently identified job factors describing awkward postures of the back and shoulder, and handling bricks and mortar in these awkward postures, as the leading causes of their work-related musculoskeletal disorders. The results of this study, along with reports of previous investigations, point to a number of important factors that must be addressed in order to reduce musculoskeletal disorders among bricklayers. These include brick supply and mortar locations, brick placement/scaffold height, brick weight and size, and rate and duration of work. © *1996 AIH.* COOK, T.M.; ROSECRANCE, J.C.; ZIMMERMAN, C.L.: WORK-RELATED MUSCULOSKELETAL DISORDERS IN BRICKLAYING: A SYMPTOM AND JOB FACTORS SURVEY AND GUIDELINES FOR IMPROVEMENTS. APPL. OCCUP. ENVIRON. HYG. 11(11):1335–1339; 1996.

The construction and building trades pose many serious and costly health risks, including risks for musculoskeletal disorders. The U.S. Bureau of Labor[1] estimates that there are more than 226,000 lost-time injuries, requiring restricted work or time off to recover, in construction each year. Karmaus,[2] in a review of previous cross-sectional studies of construction workers, concluded that bricklayers suffer from diseases of the lumbar spine about 1.5 times more frequently than a random sample from the total construction industry. He consequently concluded that bricklayers have about three times as high a risk of suffering from a lumbar spine disorder as the nonconstruction population. A study by the Construction Safety Association of Ontario[3] of 1580 lost-time injuries among bricklayers found that 38 percent were overexertion injuries, the highest among the 21 construction trades they analyzed.

Workers' compensation insurance premiums in construction have been reported to range from 7 percent to well over 100 percent of payroll, depending on the trade.[4] Bricklaying (masonry), along with carpentry and ironworking, have been identified as construction trades having the fastest growing insurance costs over the last several years. Workers' compensation insurance costs for bricklaying in the United States are estimated to average approximately 19 percent of payroll.

As the first phase of a larger project directed at reducing work-related musculoskeletal disorders in the construction trades, a questionnaire survey was sent out to over 7500 unionized construction workers in 11 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 injuries. This report presents the findings regarding bricklayers.

Methods

A two-page questionnaire was mailed to all 211 members of a bricklayers union local in the Midwest covering a three-county area with a population of over 350,000. The survey contained two major sections, one asking about work-related musculoskeletal disorders and the other asking respondents about job factors which they feel may have contributed to their musculoskeletal aches and pains.

The symptom survey section was a modification of the standardized Nordic Questionnaire[5] and consisted of questions referring to nine body areas. A simple body figure with body areas highlighted (3 upper limb, 3 lower limb, 3 trunk) was incorporated to help the respondents answer yes or no to the question, "During the last 12 months have you had a job-related ache, pain, discomfort, etc." in each 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: "During the last 12 months have you been prevented from doing your day's work due to this condition?" and, "During the last 12 months have you seen a physician (M.D., chiropractor, osteopath) for this condition?" If the respondent indicated yes to a "job-related ache, pain, discomfort, etc.,"

TABLE 1. Job Factor Survey Results (n = 39)

Job Factor	Mean Numeric Score (0 to 10 Scale)	No Problem* (0 or 1)	Minor to Moderate Problem* (2 to 7)	Major Problem* (8 to 10)
1. Performing the same task over and over	2.8	43.6	48.7	7.7
2. Working very fast for short periods (lifting, grasping, pulling, etc.)	2.7	43.6	48.7	7.7
3. Having to handle or grasp small objects	1.4	74.4	23.0	2.6
4. Insufficient breaks or pauses during the workday	1.6	64.1	35.9	0
5. Working in awkward or cramped positions	5.3	7.7	71.8	20.5
6. Working in the same position for long periods	5.7	7.7	64.1	28.2
7. Bending or twisting your back in an awkward way	5.9	10.3	51.2	38.5
8. Working near or at your physical limits	4.0	30.8	58.9	10.3
9. Reaching or working over your head or away from your body	5.2	12.8	66.7	20.5
10. Hot, cold, humid, wet conditions	4.6	20.5	61.6	17.9
11. Continuing to work when injured or hurt	4.7	18.5	68.4	13.2
12. Carrying, lifting, or moving heavy materials or equipment	4.6	23.1	59.0	17.9
13. Work scheduling (overtime, irregular shifts, length of workday)	1.7	52.6	47.4	0
14. Using tools (design, weight, vibration, etc.)	2.6	56.4	35.9	7.7
15. Training on how to do the job	1.0	82.1	15.3	2.6

*Percent indicating job factor as problematic.

they fit our case definition of work-related musculoskeletal disorder. This case definition was used for surveillance purposes only and not considered to represent any specific pathology.

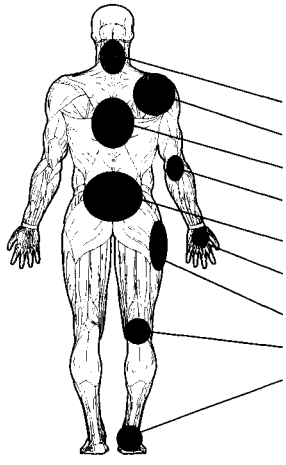
Workers' perceptions of the physically stressful elements in their job were assessed using the job factors portion of the questionnaire. This page of the questionnaire contained a listing of 15 conditions and tasks with the following instructions: "This list describes things at work that could contribute to job-related pain and injury. Please indicate, on a scale of 0 to 10, how much of a problem (if any) each item is for you by circling the appropriate number." Zero was equivalent to a job factor being "no problem," while ten was used to indicate that a job factor was considered a "major problem." The job factor descriptions are contained in Table 1.

Results

Of the total membership, 26.5 percent mailed back completed questionnaires for analysis. The 39 nonretired respondents had an average age of 45 and an average of 21.8 years of experience as bricklayers, and 90 percent had received apprenticeship training. At the time of the survey 92.5 percent of the respondents reported that they were currently working, and the average number of weeks worked in the previous year was reported to be just over 39.

The findings of self-reported musculoskeletal complaints from the 39 nonretired bricklayers responding to the survey are summarized in Figure 1. Low back disorders were clearly the most prevalent musculoskeletal disorders reported by this sample of bricklayers (as well as for all of the 11 trades who participated in the survey). Low back disorders were also reported to account for the most lost work time and the most physician visits. Shoulder disorders were the second most frequently reported work-related problem area and cause for lost work time, and third in physician visits. The neck, hand, and elbow had approximately equivalent prevalence rates (40%) for self-reported musculoskeletal disorders. Work-related neck disorders were the second most commonly reported reason to visit a physician.

Findings related to the job factors that were reported to be problematic for the 39 bricklayers 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



Anatomical Area	Percent With Symptoms	Percent Missing Work	Percent Visiting Physician
Neck	39.5	2.7	25.0
Shoulders	54.1	5.4	13.9
Upper Back	32.4	0	11.4
Elbows	41.0	0	2.7
Low Back	72.5	7.7	34.2
Wrist / Hands	41.0	2.6	5.3
Hips / Thighs	27.8	0	9.1
Knee	39.5	2.7	2.9
Ankles / Feet	30.8	2.6	5.3

FIGURE 1. Results of musculoskeletal symptom survey from 39 working bricklayers.

1 (on the 0 to 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.

Discussion

According to union officials, the union local involved in this study routinely has a response rate of 20 to 25 percent on the questionnaires and other information they solicit from their membership. Using this criterion, the response rate for this survey can be considered typical, but lower than desirable. Union officials confirmed to the investigators that an average age of 45 and average experience of 21.8 years accurately represented their membership. The question of response bias in a study of this kind is a difficult issue to assess. The possibility clearly exists that bricklayers who have had work-related musculoskeletal disorders were more likely to complete and return the questionnaire than those who had not had these disorders. Consequently, the possibility of response bias must be kept in mind when evaluating the absolute percentages of disorders. One of the main purposes of this study, however, was to gather information regarding bricklayer-specific injury profiles. Of primary interest was the relative anatomical distribution of musculoskeletal disorders more than their absolute prevalence. If bricklayers with a specific anatomic disorder were more likely to answer the questionnaire, the possibility of a bias affecting the injury profiles would exist.

Despite the relatively low response rate to this survey, the profile of musculoskeletal complaints found in this study is in agreement with previous reports of musculoskeletal disorders among bricklayers. That profile includes primary disorders in the back and neck region, along with associated disorders in the upper limb (neck, shoulder, elbow, hand). Malchaire and Rezk-Kallah[6] conducted a symptom survey of 33 Dutch bricklayers using a questionnaire which was very similar to the one used in the present study. They reported the following 12-month prevalence for musculoskeletal complaints: low back, 73 percent; shoulder, 24 percent; hand/wrist, 21 percent; neck, 18 percent; and elbow, 9 percent. Back pain was responsible for 30.3 percent of the sick leave occurring during the previous 12 months. Forty-five percent of the cases in their study required medical care. Urlings and Wortel[7] reported that 65 percent of the 23 bricklayers they studied reported experiencing back pain. A questionnaire study of 6305 Nigerian bricklayers[8] found that 97 percent of the respondents in the study reported at least one musculoskeletal disorder, and the severity of the disorders increased with age. In the present study, 94 percent of the bricklayers reported at least one work-related musculoskeletal symptom in the previous 12 months, while 29 percent reported four or more disorders. In a study of 250 bricklayers by Kopf *et al.*,[9] logistic regression analysis of data from a self-reported questionnaire revealed high relative risk estimates [odds ratio (OR)] for pain in the joints of the left wrist (5.27), elbow (2.79), and shoulder (2.15) for bricklayers compared with a matched group of ship repair and harbor workers. Since both groups are likely to report a high prevalence of low back disorders, no increased risk of back pain was found between the bricklayers and the control group.

The profile of troublesome job factors reported by the participants in this study is also supported by previous reports in the literature. That profile includes primarily factors related to awkward postures and materials handling while in awkward postures. Bulthuis *et al.*[10] did a time–activities study of six Dutch male bricklayers, and reported that they spent 26 percent of their work time in 15° or more of back flexion. Luttmann *et al.*[11] conducted a 6-day work sequence and posture analysis of three bricklayers. The study revealed that the time bricklayers spent in a flexed trunk posture of 30° or more was 20 to 25 percent for high walls and up to 75 percent for low walls. Conversely, the time bricklayers spent holding a load in one hand (brick) or both hands (brick, trowel and mortar) ranged from 45 percent for high walls down to 13 percent for low walls.

Occupational and ergonomic factors, such as the sum of lifted tons during working life, job title, and the sum of years of manual work, were reported by Stenlund *et al.*[12] to be risk factors for osteoarthrosis of the acromioclavicular joint among 54 bricklayers. Construction workers who had lifted more than 709 tons had an increased risk of developing severe osteoarthrosis of the left acromioclavicular joint of 7.67 (95% confidence interval, 2.76 to 21.34). Kopf *et al.*[9] reported that a job demand index (consisting of heavy physical work, awkward working positions, repetitive movements, and restriction in the standing posture) was a significant predictor for musculoskeletal pain among bricklayers. When respondents in that study identified three of these four factors as being present in their job, the relative risk estimates (OR) for musculoskeletal pain were 2.38 for low back, 3.46 for left shoulder, 3.38 for left elbow, and 3.33 for left wrist.

The Canadian study[3] of 1580 lost-time injuries among bricklayers found that 70 percent of overexertion injuries involved the back and neck. The authors of this study concluded that the high percentage of overexertion injuries is consistent with "the fact that bricklayers spend considerable time lifting and twisting while laying brick or block. Cost analysis reveals that back injuries to bricklayers are among the most severe in construction." In an attempt to reduce low back disorders and other injuries among bricklayers, the Dutch have been active in the development of materials handling equipment to decrease the musculoskeletal stress on the worker. For example, an adjustable height platform was designed to allow optimal placement of the mortar tub and bricks, thus reducing awkward postures during materials handling.[7] Other innovative devices being designed by the Dutch for brick work include two-wheeled trolleys and powered hoists for transporting bricks, raised work tables, and mortar pumping units.[13]

The present symptom and job factor data, along with previous studies, point to several primary workplace factors that affect musculoskeletal complaints among bricklayers and provide some direction for making ergonomic improvements to reduce these complaints.

Guidelines for Improvements

On the basis of theoretical considerations and data in the literature, the least stressful position for laying bricks is directly in front of the body at waist level in an upright standing posture.[14] Using this location as a reference, the important

parameters that determine musculoskeletal stresses to the back, neck, and upper extremity during bricklaying are: (1) brick supply location (vertical, lateral, and forward distances); (2) mortar location (vertical, lateral, and forward distances); (3) brick placement location (vertical, lateral, and forward distances); (4) weight of the brick/block; (5) grasp size of the brick/block; (6) rate at which the activity is repeated; and (7) duration of the activity relative to the duration and frequency of breaks. The influences and interactions of several of these parameters on producing work-related musculoskeletal disorders among bricklayers have been studied by a limited number of investigators. Lumbar load, as indicated by the moment of force and the force at the lumbosacral disc, was determined by Jager *et al.*[14] for one-handed bricklaying tasks using a dynamic three-dimensional biomechanical model. Analysis using this model supports the findings from other studies that the lower the grasp height, the greater the brick mass (0, 5, 10 kg), and the shorter the placement time, the higher the compressive load on the lumbar spine. Other investigators have looked at the influences of specific parameters as described in the following sections.

Brick Size, Weight, and Design

A study of the effects of brick size and mass on the work load of gypsum bricklayers was conducted by Brouwer *et al.*[15] on four Dutch male bricklayers. As expected, these investigators reported that decreasing the size and mass of the bricks decreased the compressive forces on the discs of the lumbar spine and decreased heart rate. Using half-hollow bricks resulted in a significantly lower overall energy consumption compared with using normal bricks. However, the average building time when laying a course of half-hollow bricks (12.9 minutes) was significantly longer than when building with normal-size bricks (8.6 minutes). These authors concluded that reducing the mass of gypsum bricks decreases the biomechanical and physiological loads associated with building a test wall but lengthens building time. They suggest that a better solution would be to reduce brick mass while maintaining normal size. Both Sweden[16] and Germany[17] have recommended limits for brick and block size and mass. For one-handed work, the German limit is 6 kg for a grasp of between 75 and 115 mm wide and 7.5 kg for a grasp of between 40 and 75 mm wide. For two-handed work, the limit is 25 kg. Blocks weighing more than 25 kg must be lifted mechanically. Additionally, building blocks must be equipped with holes or handles to assist with grasping. The Swedish standard[15] includes a one-handed limit of 3 kg. Blocks weighing more than 3 kg must be handled with two hands. Blocks weighing between 12 and 22 kg can be handled only between knee and shoulder level, and "the scaffolding must be designed accordingly." Blocks over 20 kg must be handled mechanically by vacuum lifts, small cranes, or similar devices.

Brick Supply Height and Mortar Pile Height

According to Jager *et al.*,[14] grasp heights lower than 50 cm (or bricks weighing 10 kg or more) should never be allowed. Their general guideline is that bricks should be prepositioned to permit grasping in erect postures. Vink and Koningsveld[18] studied the energy costs associated with using three different brick supply and mortar pile heights while laying bricks at five different heights. The results of their study indicated that raising the level of the brick pile and mortar barrel 30 or 50 cm decreased the energetic work load significantly for the higher brick rows compared with placing the brick pile and mortar barrel on the floor. This study also showed that raising the brick pile and mortar heights to 50 cm significantly increased the energy cost during bricklaying at the lowest wall levels, although the 30-cm height did not appear to have this effect. The bricklayers in the study subjectively reported that work load and biomechanical back stress were lower during bricklaying at higher wall heights when the set-out pile and mortar barrel were at least 30 cm above the floor. Luttmann *et al.*[11] comment that the brick and mortar supplies should be arranged to allow the bricklayers to grasp them without bending down, and recommend the utilization of scaffolds with continuous hydraulic or mechanical height adjustment. They further recommend the use of a step-type scaffold structure that "would ensure that bricks and mortar are always positioned higher than the bricklayers' standing area."

Scaffold Height

Luttmann *et al.*[11] defined wall height as the difference between the height of the completed wall section and the height of the scaffolding on which a bricklayer stands. Their principal findings were, as wall height increases: (1) bricklayers spend progressively less of their working time with their backs bent into flexion; (2) the number of bricks laid per minute decreases (especially above shoulder height); (3) bricklayers spend progressively more time holding and placing bricks and mortar; and (4) muscle activity in both the back and upper arm increases. The authors conclude that scaffold height should be frequently adapted to the wall height, thus excluding both low and high wall levels. Vink and Koningsveld[18] also concluded that the use of height-adjustable scaffolding would have a major impact on the biomechanical and physiological stresses of bricklaying. In 1990 they reported that such equipment was available but was restricted to use on flat ground and straight walls. They further reported that various prototypes of new equipment had been designed and were under development.

Scheduling, Rest Periods, and Work Structuring

Vink and Koningsveld[18] studied the duration of different tasks of 50 bricklayers and found that bricklaying and mortar laying consumed an average of 58 percent of the bricklayers' total working time. The remaining 42 percent of their time was spent transporting bricks, brick cutting, stirring mortar, setting out bricks or mortar, and rest breaks. Brinkhorst[19] sampled the energy consumption levels of these same 50 bricklayers and reported that they were working at an average rate of 35 to 41 percent of their age-predicted capacity, which is at or above the general guideline of 35 percent for an 8-hour workday.[20] In a laboratory study of ten experienced bricklayers,[17] increasing the work rate by 12 percent caused an energy consumption increase of only 1.5 percent, while decreasing the work rate by 14.4 percent resulted in an energy consumption decrease of only 1.2 percent. Investigators in the Nigerian study of several thousand bricklayers[8] suggest that ergonomic principles be used in planning rest periods, structuring work, and scheduling. While it is difficult to argue against attending to these factors, the authors offer no specific data or suggestions

TABLE 2. Guidelines for Improving Bricklaying

1. The location of the worker should be (frequently) adjusted so that he/she can lay bricks as closely as possible at waist height without extending the arms. (Very low and very high wall locations are clearly the most problem producing.)
2. The location of the bricks should be such that they can be grasped with minimal bending of the trunk and reaching with the arms.
3. The location of the mortar pile should also be such that it can be reached with minimal bending and reaching.
4. Brick weight should be limited.
5. Brick design should allow for modest grasp sizes.
6. Attention must also be paid to rate and duration of work (including overtime) and to the design of tools used by bricklayers.

for actually making such changes. There does not appear to be any information available regarding the effect of modifying these factors among bricklayers other than the general philosophy that rest breaks aid in muscle recovery and delay fatigue.

Summary and Recommendations

The results of the present survey and a review of the literature indicate that a common pattern of work-related musculoskeletal disorders exists among bricklayers. The symptomatic areas, and those accounting for the most lost work time and physician visits, are primarily back, neck, and shoulder, and secondarily, elbow and hand/wrist. Complaints relating to the hip, knee, and foot also exist, but are generally less prevalent and less costly.

In previous studies, bricklayers have consistently identified awkward postures of the back and shoulder and handling bricks and mortar in these awkward postures as a leading cause of their work-related musculoskeletal disorders. The results of the present study identified awkward as well as static postures as problematic job factors contributing to musculoskeletal disorders in bricklayers. Field studies and laboratory investigations have described and, to a limited extent, quantified the parameters that contribute to ergonomic hazards in bricklaying. Based on available information, the guidelines in Table 2 seem warranted as the basis for ergonomic improvements to reduce work-related musculoskeletal disorders among bricklayers.

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