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The Prevalence of Overexertion Injuries in the U.S. Metal-Nonmetal Mining Industry

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THE PREVALENCE OF OVEREXERTION INJURIES IN THE U.S. METAL-NONMETAL MINING INDUSTRY

By Debra A. Griffith[1]

ABSTRACT

The U.S. Bureau of Mines currently is researching the relationship between the level of back strength and the probability of low-back injury. This report is a review of the literature and statistics on overexertion injuries.

Overexertion continues to be a significant source of injury in metal and nonmetal mining, accounting for approximately 24 pct of all injuries yearly. These injuries, particularly to the lower back, can be very expensive in human and monetary terms. An examination of the accident data on overexertion injuries is necessary to provide a background for research into prevention and/or amelioration of those injuries. The job categories outlined in the Accident Data Analysis data base most affected are "Mechanic/Electrician" and "Mill/Plant Worker." The age group most affected is "30-39" years, and the experience group most affected is "0-.99" years. The most prevalent type of overexertion injury is "Strain/Sprain," and the trunk is the body part most often involved in an overexertion injury.

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INTRODUCTION

Overexertion is a major source of injury in metal-nonmetal mining in the United States, accounting for approximately 24 pct of all injuries yearly. Between 1986 and 1991, these overexertion injuries accounted for 275,330 days of lost time. These injuries, particularly to the lower back, are expensive in human and monetary terms. As part of the safety mission of the U.S. Bureau of Mines (USBM), an examination of the accident data on overexertion injuries is necessary to provide a background for research into prevention and/or amelioration of those injuries.

Overexertion is defined as the state in which internally created forces exceed the strength of a tissue (*1*).[2] Chaffin and Andersson (*2*) summed up the 1981 National Institute for Occupational Safety and Health (NIOSH) findings on overexertion injuries thusly:

- One-third of the U.S. workforce is required to exert significant strength as part of their jobs.
- Sixty pct of people suffering from lower-back pain list "overexertion" as the cause.
- Overexertion injuries of all types happen to about 500,000 workers per year.
- In overexertion injuries with low-back pain and significant lost time, fewer than one-third of the patients eventually return to work.
- Overexertion injuries account for about 25 pct of all reported occupational injuries in the United States.
- Approximately two-thirds of overexertion injuries involved lifting and about 20 pct pushing or pulling.

These percentages are also consistent with figures for Great Britain. Its version of the Mine Safety and Health Administration (MSHA), the District Inspector of Factories, has kept records since 1924 of accidents that have resulted in more than 3 days of lost time (*3*). The percentage of accidents due to material handling has remained very constant at between 20 and 28 pct despite considerable efforts to enforce correct lifting strategies. In the late 1970's, the percentage of injuries due to overexertion stabilized at about 26 pct.

In California, 27 pct of all compensable injuries and illnesses in 1973 were due to overexertion (*4*). The 1976 Workers Compensation records for the State of Arkansas also had a similar figure. Their overexertion figure was 24 pct. Twenty-nine pct of the overexertion injuries were strains and/or sprains. Sixty-one pct of the back injuries listed overexertion as the cause. Seven pct of the overexertion injuries became permanently disabling (*5*). Sixty-one pct of the back-pain cases in Wisconsin in 1973 listed "overexertion" as the primary cause (*6*), agreeing with the Arkansas findings. Sanders and Peay (*7*) also reported that 52 pct of back injuries experienced in the low-seam coal industry over a 3-year period involved overexertion. Mansfield (*8*) reported 1983 Bureau of Labor Statistics' statistics that show 28.2 pct of disabling work injuries were the result of overexertion.

Sanders and Peay (*7*) reported on a 1983 study by Chi and DiCanio that listed the following elements as making up the costs associated with an injury: (1) loss of personal income; (2) compensation of wages from state, Federal, and union funds for disabling injuries; (3) benefits for injuries resulting in death or permanent disability; (4) medical treatment and hospital care; (5) immediate and post-accident production losses as a result of a fatality or amputation injury; and (6) investigation costs of a fatal accident.

Other costs that should be considered would include the time to fill out and submit the accident report forms, the cost of finding a replacement worker in the case of extended time-off, and training time for the individual upon return to the workplace. Chi and DiCanio estimated the cost of a disabling injury in mining for the years 1975 to 1981 to be $177,000 (*7*). The average total cost for an overexertion injury in underground coal mining between the years 1977 and 1982 was $7,086 (*9*). Bonfiglio (*10*) estimates the cost to industry of musculoskeletal injuries as greater than $30 billion per year. In 1974, over $1 billion was spent on Workers Compensation and medical payments alone (*11*).

In 1976, Grinnold did a study following 549 workers who had been classified as partially permanently disabled (*12*). Less than one-third of those workers returned to any kind of work, and Workers Compensation replaced less than one-third of their income. No comparable research has been done in the mining community.

Musculoskeletal injuries, especially to the lower back, do not have a clear-cut cause and effect relationship and the extent of the trauma is seldom defined. Interpretation of the injury depends on the mechanism of injury which, because of inexperienced, incomplete, or subjective reporting, is difficult to analyze. This is certainly true of the MSHA reporting system that relies on the interpretation of the workers' supervisor and not a physician. This is backed up by the statements of Sanders and Peay (*7*) that: "The entire accident-reporting process, from accident occurrence to reporting, is at best an unreliable process that almost always fails to capture all the accidents that actually occur. In addition, the data collected about the accidents are often inaccurate and incomplete." Hirsch (*11*) states: "Clearly, human suffering and high economic burdens are greatest in industries which require manual handling of objects... Whether such acts are the primary

[2]Italic numbers in parentheses refer to items in the list of references at the end of this report.

cause or simply aggravate a pre-existing susceptibility to injury of the musculo-skeletal system is often debated." Andersson (*1*) has also stated that: "...not enough is known about the mechanisms leading to these injuries."

Manual material handling is associated with causing or aggravating preexisting musculoskeletal disorders in a large number of workers. The jobs with the highest frequencies of injury are historically mechanics, handlers, production machine operators, and trainees (*13*). Approximately 25 pct of all industrial accidents in the United States are associated with manual materials handling. Of those, 50 pct are to the back and 30 pct are shoulder, arm, or abdominal strains and sprains. Forty-two pct of all industrial accidents result in lost time, and 25 pct have more than 5 days of lost time associated with them (*13*). More than 40 pct of back injuries are attributable to a sudden loss of stability or an unexpected shift in the weight of an object that is being handled. This was borne out by a study done in 1988 by Troup, Davies, and Manning (*14*). They found that back injuries may arise from load weight changes, slips, falls, blows, or stuck loads, and frequently may lead to chronic disabilities. Back pain can have musculoskeletal or secondary causes, and is seldom well-localized. One of the most common back injuries is sudden pain while stooping to lift. In these cases, it is difficult to distinguish between long-term and short-term effects. Andersson (*15*) reviewed 30 years of epidemiological data and found six primary work factors for the development of back pain. These factors are (1) heavy physical work, (2) static work postures, (3) frequent bending and twisting, (4) lifting and forceful movements, (5) repetitive work, and (6) vibration.

There are a variety of personal factors, such as age and experience level, gender, and strength, that also have been explored as possibly increasing the risk of back injury. These factors are discussed below.

Age has been considered to be a factor in the development of overexertion injuries. The literature indicates that the greatest incidence of low-back pain is found in the 30 to 50 year old group. Butani's research bears this out in the mining community for both the coal and metal-nonmetal industries (*16*). She found that workers in the group 30 to 39 years of age were at a higher than average risk for back injury, while workers over 50 years old were the least susceptible to back injuries. The over-50 group also had the second-lowest number of lost work days associated with back injury. It is difficult to say if the lesser incidence of low-back pain in older people is due to their being less exposed to hazardous conditions, for whatever reason, or to their being "survivors." There is a very complex process at work, as it is recognized that heavy work can cause accelerated rates of injury. It may be that younger workers are not able to recognize or control hazards as well as older workers. Since age and experience level are so closely correlated with accidents in mining, it is difficult to separate them. Symptoms of overexertion may be noticed in the first few weeks on a new job. This is usually because the worker is unaccustomed to the work. New workers may be at a greater risk of developing overexertion injuries because of their inexperience at the work tasks. During the learning period on a new job, the worker may exhibit inefficient application of force and overly aggressive work methods that may be responsible for increased symptoms (*13*).

When assessing the impact of gender on the risk of developing overexertion injuries, it is important to make a distinction between gender and strength. While, on average, women have 50 to 70 pct of the muscular strength of men, one must remember that there is a wide range of strength values for either gender, and there is considerable overlap. Studies on nurses have concluded that women are much more likely to develop low-back injuries than are men, but these studies are flawed, in that they neglected to account for the majority of nurses being women. The weights lifted in nursing are also much higher on average than the weights lifted on a regular basis in industry. Butani and Bartholomew have indicated that there is a statistically significant difference between the genders, with the women incurring proportionately fewer injuries than do men, but that the differences were practically insignificant (*17*).

Tissue strength can be influenced by such factors as age, fatigue, and concomitant diseases; thus, the loading level at which an injury occurs can vary greatly (*1*).

Workers may be strong, but the job strength demands may exceed their strength level. The workers then would be "overstressed." Chaffin, Herrin, Keyserling, and Garg (*18*) found that the incidence rate of back pain is about three times higher in overstressed than in understressed workers.

Anthropometry has not been linked to overexertion injuries, except in extreme cases (*1*).

Snook, Campanelli, and Hart (*19*) looked at 191 low-back injuries in a wide variety of companies and industries. They compared companies that used medical preselection and/or safe lifting training with companies that used neither and found no difference in the number of back injuries incurred. They suggested that one-third of back injuries will occur no matter what, and felt that job redesign may provide a partial control for low-back injuries. Snook (*20*) feels that longitudinal studies provide the most reliable estimates of hazards and risks in the development of back injuries. Mansfield (*8*) states that an individual who has injured his or her back at least once is four times more likely to suffer an additional back injury than an individual with no back injury history.

METHODS

The Accident Data Analysis (ADA) data base, maintained at Spokane Research Center, was electronically accessed to retrieve metal and nonmetal mining accident data for the years 1987 to 1991. Only accidents listing overexertion as the type of accident were analyzed. This data base contains the information for all reportable mining accidents from 1972 to 1991. The data for 1991 were incomplete at the time of this study.

In some cases, this report will refer to the risk values or the incidence rates associated with different variables. The risk value is calculated by the ADA system, and is found by multiplying the number of accidents by the number of lost workdays, then dividing by the sum of all accidents multiplied by all lost workdays. This procedure is outlined in the ADA manual "Accident Data Analysis: A User's Guide." The Incidence Rate (IR) is found by using the equation

$$IR = \frac{\text{number of accidents} \times 200{,}000}{\text{number of affected workers} \times 2{,}000}.$$

("Affected workers" refer to the workers who experienced the set of accidents. For example, the IR for accidents to women in mining would be the number of accidents to women in mining divided by the number of women in mining.)

Current census data on the number of workers by job classification in the metal and nonmetal mining workforce were unavailable, so the information contained in Butani and Bartholomew's 1988 report, "Characterization of the 1986 Metal and Nonmetal Mining Workforce" was used. It must be understood that for the purposes of this analysis the assumption has been made that the rate of growth of the workforce and changes in its gender composition have remained at zero. The validity of Sanders and Peay's suggestion that the proportion of women in mining will near 10 pct in the future cannot be determined (*7*). There is some evidence that the average age of miners is decreasing (*7*). In some cases, the categories that were used by Butani and Bartholomew (*17*) are inconsistent with ADA.

RESULTS

During the years 1987 to 1991, there were 14,737 overexertion injuries reported to MSHA in metal and nonmetal mining in the United States. The actual number of injuries may be even higher if, as suggested by Sanders and Peay (*7*), there is significant report "filtering." Overexertion injuries continue to account for approximately 24 pct of all injuries in metal and nonmetal mining yearly, as seen in figure 1. This is consistent with the findings of NIOSH (*21*), the National Safety Council (*4*), and the Bureau of Labor Statistics (*5*) regarding all industries.

The most prevalent nature of injury within the general class of overexertion injuries indicated by ADA is "Strain/Sprain." Again, this is consistent over all 5 years, as we can see in figure 2.

Over the 5 years, the location with the greatest number of overexertion injuries is "Prep Plants" (also called "Mill/Plant") with 50.45 pct of the reported overexertion injuries (see figure 3). The incidence rate (IR) for the "Prep Plants" is 11.9. The second greatest number of overexertion injuries is "Strip/Open Pit" with 35.40 pct of the reported overexertion injuries. This area has an IR of 6.3. These proportions hold true for each individual year. Over the 5 years, these two locations account for 226,178 days of lost time and 85.9 pct of all overexertion injuries. Based on the IRs, this report focused attention on the "Prep Plants" area first when attempting to reduce overexertion injuries.

Women account for 3.24 pct of the overexertion injuries over the 5 years, and men for 96.76 pct of the overexertion injuries. Given the relatively few women in mining (4,523 in 1986), this seems reasonable. When looking at the IRs it is noted that women had an IR of 10.7 for overexertion injuries, and men had an IR of 8.9. The women may have a higher IR because the work being done is soliciting a greater strength requirement than they are capable of supplying; however, the IR for men is not much smaller. The findings of Butani and Bartholomew (*17*), regarding the gender difference in IR, appear to be supported. The three locations with the highest frequency of overexertion injury, based on gender, are "Mill/Plant," "Strip/Open Pit," and "Underground." This is the same for men and women. "Office Facilities" is the fourth highest for females, but seventh highest for men.

The age group with the highest percentage of overexertion injuries is "30-34," 18.10 pct. The IR was 10.6.

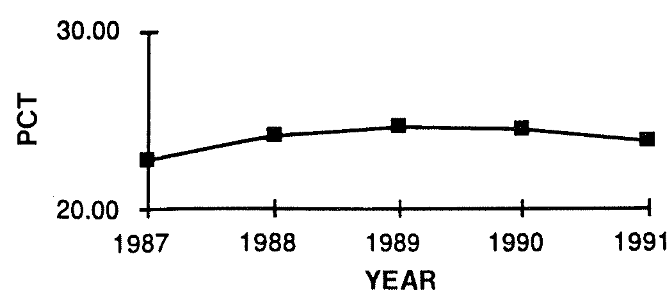

Figure 1.—Percentage of all injuries due to overexertion on a yearly basis.

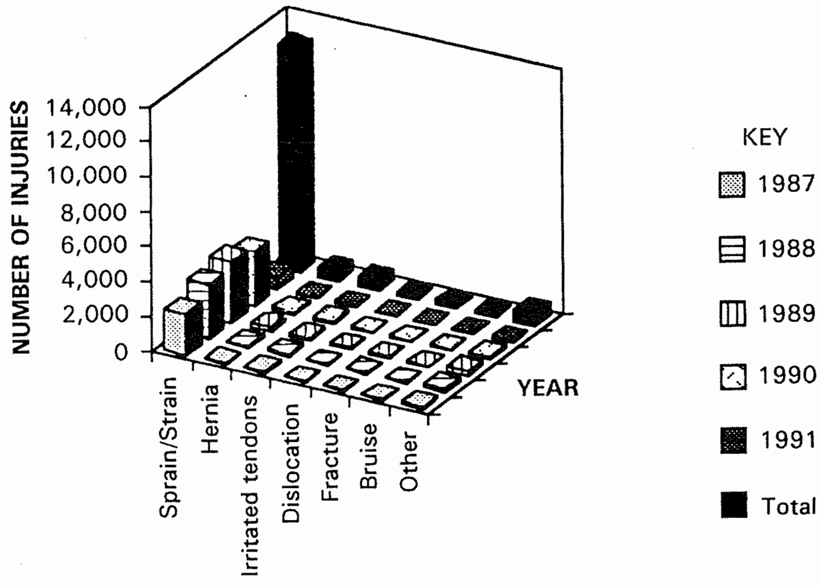

Figure 2.—Nature of overexertion injury.

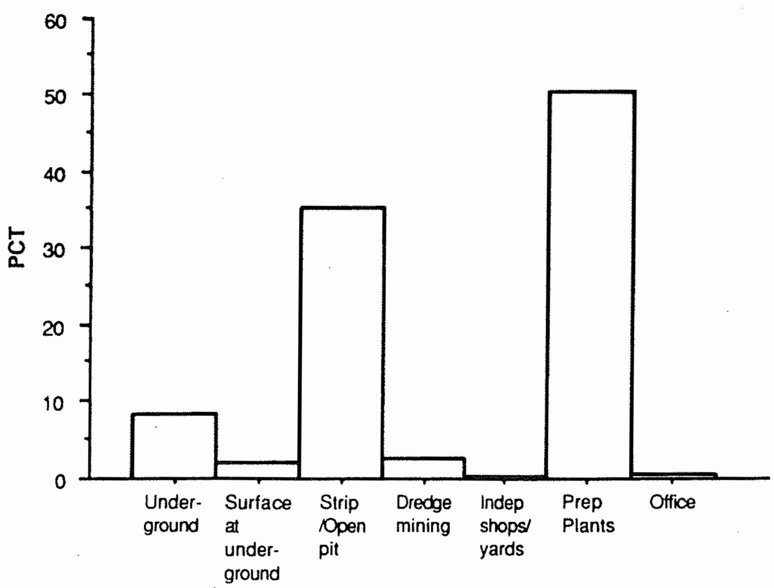

Figure 3.—Overexertion injuries by location.

The second highest percentage of overexertion injuries is "35-39," 17.51 pct. The IR in the "35-39" age group was 10.5. The third highest percentage of overexertion injuries is "40-44," 13.36 pct. The IR was about 9.0. Together, the age range "30-44" accounts for 48.97 pct of the overexertion injuries over the 5 years, and a total of 134,913 days of lost time. Interestingly, the age group "61 & Over," accounts for only 1.96 pct of the overexertion injuries and 6,290 days of lost time. The "50+" age group had an IR of 5.8. This again is in agreement with the findings of Butani (*16*). The workers in the "50+" age group may be survivors or they may have been assigned to areas that do not present the opportunity for overexertion injuries to occur.

The frequency of overexertion injuries by month is well-distributed over all 12 months. The risk value for January is the highest of the 12 months, at 12.2 pct.

The mining experience level associated with the highest frequency of overexertion injuries is "0-.99" years. 28.31 pct of the overexertion injuries occurred in workers with less than 1 year of mining experience. This group had an IR of 32.6. The next highest IR (11.7) is for "1-5" years of experience. Compare this to the group with "25-30" years of experience which has an IR of 5.8, and the "30+" experience years group (IR = 4.6). If we combine groups, the "≤ 5" years of experience group had an IR of 17.3 and the "≥ 25" years of experience group had an IR of 5.1.

Over the 5 years, the top four sources of injury were "Metal Items" (drill steel, roof bolts, steel rail, molten metal, metal covers and guards, wheels, and metal not elsewhere classified) with 23.11 pct of injuries; "Containers" (bags, barrels, kegs, drums, boxes, crates, fiberglass, plastic, glass, fabric, rubber, and containers not elsewhere classified) with 14.17 pct of injuries; "Miscellaneous" with 7.39 pct of injuries; and "Handtools" with 12.20 pct of injuries. Altogether these four categories were named as the source of injury in 56.88 pct of the overexertion injuries (table 1).

The body part most often involved in overexertion injuries was the trunk, with 73.39 pct of the injuries. The MSHA risk value associated with a trunk injury is .743. The second most commonly involved body part was the leg and/or foot, with 11.13 pct of the injuries (fig. 4). The MSHA risk value associated with a leg and/or foot injury is .094. As noted, the risk is approximately eight times greater for an overexertion injury to the trunk.

The occupation with the highest number of overexertion injuries was a tie between "Mechanics/Electricians," with 21.22 pct (IR = 12.1), and "Mill/Plant Workers," with 21.19 pct (IR = 12.1). The next highest number of overexertion injuries was experienced by "Laborers," with 14.09 pct (IR = 25.8). Of 108 occupations, these three accounted for 56.50 pct of all overexertion injuries, and the top ten occupations accounted for 77.75 pct of overexertion injuries. In figure 5, the occupations have been recategorized by the ADA program into the occupation categories used by the Health Safety Analysis Center. Here "Mechanics/Electricians" and "Mill/Plant Workers" are still the top two categories in terms of the number of overexertion injuries. "Laborers" are now fifth, with "Surface Miners" moving to the third spot and "Other" becoming the fourth highest. Since the category "Other" contains so many unrelated jobs, analysis emphasis should still be given to the other four categories.

Of all 108 occupations, 91 pct listed back overexertion injuries as the number one overexertion injury category, and 2 pct listed it as the second leading overexertion injury category.

Table 1.—Sources of injury

Source	Frequency (severity)	Total lost time, days	Risk value, pct
Metal items	3,452	64,437	0.234
Containers	2,117	41,629	.151
Miscellaneous	1,104	33,053	.120
Handtools	1,823	28,842	.105
Mineral items	1,426	26,220	.095
Machines	974	15,673	.057
Electrical or power appliance	676	10,999	.040
Vehicles	578	10,171	.037
Structures	631	9,404	.034
Hoists/supports	348	8,740	.032
Surface ground	518	6,232	.023
Timber/wood	389	6,146	.022
Powered hand tools	331	5,399	.020
Conveyors	341	5,137	.019
Heat/cold	57	1,216	.004
UG work area	85	1,112	.004
Coal/oil products	45	625	.002
Clothing	19	295	.001
Total (all cases)	14,937	275,330	

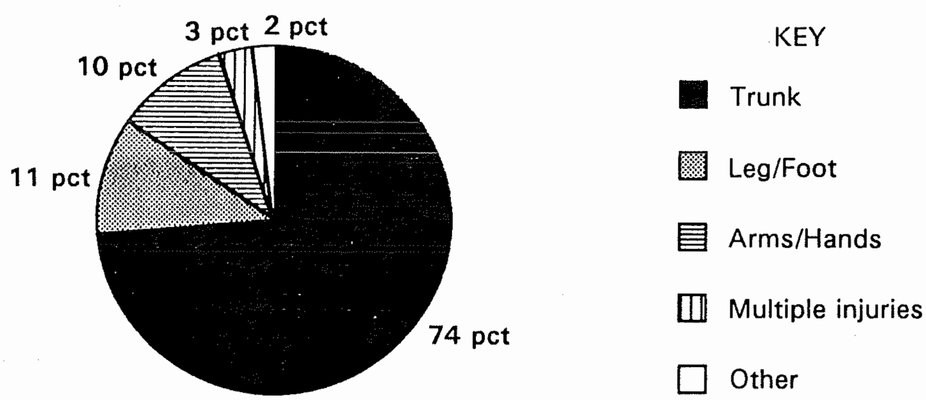

Figure 4.—Injuries by body part.

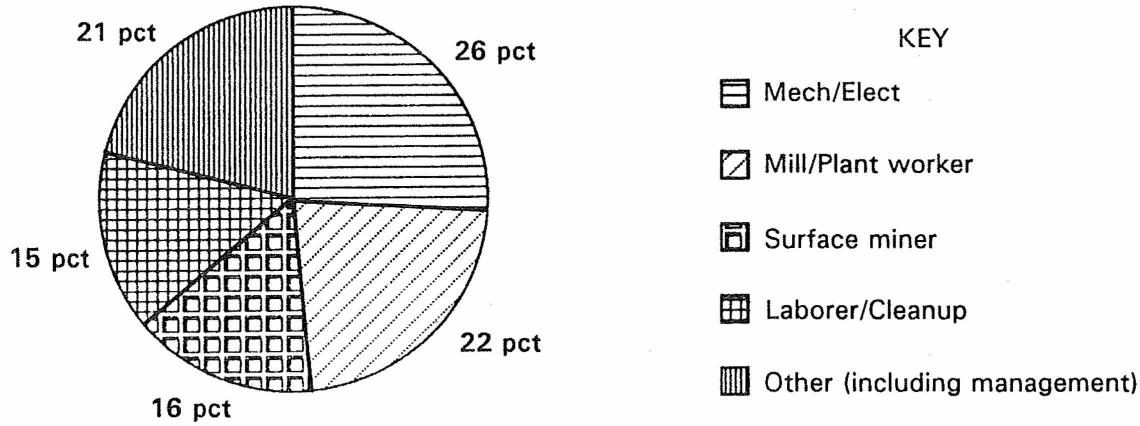

Figure 5.—Injuries by occupation.

In analyzing the bivariate analysis report generated by the ADA program, it could be seen that the occupation category "Mechanics/Electricians" involved in the activity "Moving Materials" (or manual material handling) had the highest risk value (.127) of incurring an overexertion injury, and have 10.8 pct of the injuries. "Mill/Plant Workers" who are involved in manual material handling have the second highest risk value (.118), while having 13 pct of the overexertion injuries. If one examines the trivariate analysis of occupation, activity, and body part injured, the outcome is much the same. "Mechanics/Electricians" involved in the activity "Moving Materials" have a risk value of .115 for incurring a trunk overexertion injury, and make up 9.2 pct of the overexertion injuries. "Mill/Plant Workers" who are involved in manual material handling have the second highest risk value (.101) for incurring a trunk overexertion injury, while having 10.2 pct of the overexertion injuries.

DISCUSSION AND SUMMARY

The percentage of injuries attributable to overexertion within the metal and nonmetal mining industry has remained very constant over the last 5 years, despite the efforts to instill safe lifting procedures by industry. This would serve to validate the opinion of Snook, Campanelli, and Hart (*19*) that: "...the only currently effective control for low back injuries is the ergonomic approach...," or the redesign of jobs to reduce or eliminate manual materials handling; however, they felt this would be only partially effective and suggested that strength testing may be an avenue of worker selection worth investigating. While worker selection is inconsistent with the principles of human-factors engineering, strength testing would enable knowing if there is, indeed, a relationship between back strength and the probability of low-back injury. Such a project currently is underway at the Twin Cities Research Center of the USBM.

Since back injuries in the work place rarely are caused by direct trauma, and are typically the result of overexertion (*1*) and cumulative trauma, longitudinal studies, in the manner of the Framingham Heart Study, are necessary to understand fully the mechanisms involved. This report notes that the group most affected by overexertion injuries, overall and to the trunk in particular, are the "Mechanics," "Electricians," and "Mill/Plant" workers who are involved in manual materials handling.

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