REVIEWS, CASE HISTORIES, AND RESEARCH

Using Ergonomics in the Prevention of Musculoskeletal Cumulative Trauma Injuries in Agriculture: Learning from the Mistakes of Others

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ABSTRACT. Cumulative traumatic disorders, or CTDs, are among the most pressing occupational health issues facing employers today. Research has identified the risk factors associated with CTDs and there is now a body of literature that supports the use of specific measures-ergonomic measures, as well as other control strategies-to reduce these injuries. To date, little work has been done on applying these principles to agriculture, although as an industry, it shares the known risk factors and job demands with other high risk settings that have successfully utilized this research literature. However, agricultural employers will soon be required to institute control strategies-and they are largely unprepared to initiate such strategies. This paper outlines the lessons gleaned from successful efforts and makes an argument for applying those lessons to agriculture.

KEYWORDS. Ergonomics, agriculture, CTDs

Employers are currently being faced with a serious, but preventable, occupational health problem-cumulative trauma disorders, or CTDs. CTDs are defined here as chronic musculoskeletal disorders of tendon, muscle, joint structures and nerves such as tendonitis, chronic muscle strain, carpal tunnel syndrome, and a variety of neck and back problems, including degenerative disc disease. In agriculture, as well as in other contemporary industries, CTDs represent a problem that is rapidly increasing and accounting for a larger and larger share of all injury costs. CTDs are the kinds of injuries that are very likely to recur and, because these injuries develop accumulatively with time, there is growing evidence that if left untreated or if treated ineffectively, most can lead to permanent disability.[1] A lack of understanding about how work tasks and tools contribute to these musculoskeletal CTDs is a major barrier to developing solutions. As serious as this problem is acknowledged to be, it is also clear that the true size of the work-generated CTD problem remains unknown.[2]

To address the rapidly increasing rates of injuries, the Federal Occupational Safety and Health Administration (OSHA) has begun the process of developing regulations that will require employers to take an aggressive approach to preventing CTDs. These regulations will take the form of an ergonomics standard that is expected to stress prevention through engineering and administrative controls,

over other solutions. Legislation enacted last year in California requires that a similar standard be in place by January 1995. In California, agriculture is big business; it is also one of the industries that has been targeted for special attention in implementing this standard.

For many years, agriculture has ranked among the most hazardous occupations in this country. Traditionally, the attitude of farmers has been that hard physical work was simply part of their jobs. Now there is a growing body of research that describes the risks and the methods of preventing CTDs, stressing ergonomic approaches to eliminating the worksite hazards that contribute to CTDs. This research has been used in some industrial settings to institute regulations for the control of CTDs.[3] This paper proposes to review the research, identify the essential elements of the successful efforts in general industry, and then apply the lessons learned to the task of preventing CTDs in agriculture by looking at a specific industry case example. In California and across the United States, agricultural employers will soon be required to find ergonomic solutions to this expensive health problem. We suggest that the means for reducing the human and work product losses connected with cumulative musculoskeletal injuries is available. What is already working in other settings may provide a guide for future prevention planning in agriculture.

THE SIZE AND NATURE OF THE MUSCULOSKELETAL CTD PROBLEM

Musculoskeletal CTDs are a group of injuries that involve the structures of the hands, wrists, elbows, shoulders, neck and back resulting "... from repeated biomechanical stress due to ergonomic hazards ..."[3] Work-related CTDs have been increasing over the last decade and now account for a majority of workers' compensation costs. The Bureau of Labor Statistics reported that the numbers of CTD cases are increasing faster than any other occupational illness category: in 1980, CTDs comprised 18% of all occupational illnesses reported; by 1987, CTDs had increased to 38% of that total; by 1989, the number of cases accounted for more than half of all work-related illness cases.[4] In California, claims filed as "cumula-

tive injuries'' comprise a share that is twice the size of any other specific injury category.[5]

Back injuries are the most frequently occurring musculoskeletal injury and low-back pain is the most frequently cited cause of disability in persons aged 45 or less.[6] Repeated back injuries may lead to chronic disability.[7] Low-back injuries result in more lost work time than non-back injuries,[8] and account for a significant portion of all workers' compensation costs.[9,10,11,12] As a result of a recent national survey, the Bureau of National Affairs[13] estimates that there are 22.4 million cases of back pain in the United States, about half of which are thought to be caused by a work activity or an on-the-job injury. A review of workers' compensation records for 26 states[14] revealed that 20% of claims were filed for back injuries. A similar percentage was reported by Spengler et al.[10] in another study of work-connected injuries. In this study, these injuries accounted for approximately 80% of all the workers' compensation costs.

As understanding of the CTD problem has grown, so too has the list of associated ergonomic risk factors. In a classic cross-sectional study, Silverstein et al.[15,16] demonstrated a relationship between occupational exposures (specifically those with high force-high repetitious tasks) and CTD diagnoses. For example, reviews about hand and wrist-related CTDs[17,18,19,20,21] agree that cumulative musculoskeletal injuries are consistently associated with ''. . . repetitive wrist/finger movement with loading of tendons in the carpal tunnel; forceful contraction of these tendons; extreme wrist flexion or extension, awkward posture, or pinch; mechanical stress to the median nerve in the base of the palm, vibration; and poorly fitting gloves.''[21]

Specific research on back injuries has demonstrated observable damage in cadavers related to occupational history, as well as a significant association between spinal changes and family reports of history of back pain.[22] Reviews of the literature on back injuries and low-back pain indicate that heavy physical work, repeated lifting and twisting are consistently associated with greater risk.[6,7,23,24,25] Clemmer et al.[8] found that those with the heaviest labor duties had the largest numbers of injuries, as well as the largest number of low-

back injuries. Other studies found that over half of back injuries reported were caused by lifting activities.[26,27]

TRACING THE SEARCH FOR SOLUTIONS IN GENERAL INDUSTRY

Historically, industrial prevention efforts have emphasized prescreening and training. Some researchers, for example, Ryan and Zwerling[28] and Zwerling et al.[29] have reported that a history of back injuries can predict those who will suffer future such injuries. Other researchers,[30,31,32] however, raise questions about whether it is possible to screen out poor risks. In the past, interventions aimed at reducing musculoskeletal injuries,[33,34] have predominately concentrated on training to change worker safety behavior.[35,36,37,38,39] These interventions have generally failed to show any statistically significant effect on the incidence of injuries. As discussed below, training as a single intervention, is regarded as the least effective way to reduce injuries.[40,41]

By contrast, interventions that focus on eliminating or reducing hazards themselves have been shown to be more consistently effective. Most of the documented examples of the prevention of CTDs come from manufacturing industries in which ergonomics programs have yielded reductions in worker discomfort, lost-time injuries, and increases in productivity. After Chrysler instituted their ergonomics program, for example, there was an 80% decrease in lost-work days at a new Jeep Cherokee plant and requiring one-third less floor space and one-third less personnel than a comparable plant. These changes resulted in a net return on investment of approximately $2 million annually (Society of Manufacturing Engineers; Ergonomics Videotape). Similarly, Volkswagen of America launched a program concentrated on ergonomic improvements to high risk tasks within its auto assembly operation which resulted in 50% reduction in the need for surgical intervention for carpal tunnel cases in the early to moderate stages. It is generally accepted that a comprehensive approach with a central role for ergonomic change can produce a "... reduction in incidence of low-back pain ... reduction in severity of low-back pain ... improved productivity and reduction in cost ..."[25]

Given the evidence that cumulative musculoskeletal injuries are caused by repeated biomechanical stress to the same tissues over months and years, general guidelines for workplace control of these disorders have emerged.[3] These guidelines suggest that reducing repetitive hand motions, avoiding awkward postures, minimizing grip or pinch forces, and using lifting guidelines will effectively reduce the incidence of CTDs in the work setting. While, clearly, the best and most efficient way to reduce these injuries is through the planned elimination of ergonomic hazards, these guidelines do not limit the approaches that are taken. In fact, the elimination of CTD hazards requires the involvement of many different levels of the organization.[12] Indeed, management commitment to injury control[35] and multilevel control activities–including a company-wide task force, employee involvement, appropriate training and engineering interventions[42]–have demonstrated that CTD injuries can be effectively reduced.

Three different levels of control strategies have been used by industry–engineering, administrative, and behavioral controls. *Engineering controls* target the elimination of occupational hazards. Engineering the ergonomic hazards out of work processes is clearly the most desirable form of control–once in place, its success is not dependent on the actions of the individual worker. Instead of looking to individual behavioral change, engineering successes rely on identifying the specific mechanical source of a problem and then planning and evaluating the design of work stations, tasks, and tools. The engineering approach has not succeeded, however, without active management commitment, employee input, and an interactive system for initiating and then assessing the effectiveness of the changes in the workplace.

Administrative controls, the next level of preference in the design of prevention programs, seek to limit the worker's exposure to hazards by using techniques such as pre-placement screening, job rotation, or work/rest breaks. In this category, policy planners also include the medical management of CTDs: early detection of symptoms through the survey of employees and through the review of medical records; timely referral of injured workers to well-trained, experienced occupational health professionals; training of supervisors and workers in the need for follow-up on identified problems.

Behavioral controls, as stated above, are the least likely to reduce CTDs when used alone, because it is difficult to change individual work practices. Activities as safe work practices and the use of personal protective equipment by employees are considered to be behavioral controls. Generally, the initiation of these controls is handled by providing workers with training sessions or tailgate or field meetings. As we have argued previously,[43] this level of control strategy has been strengthened in some industrial settings by moving beyond training to employee *education*. Instead of limiting sessions to lectures on general safety or on the specific practices related to the individual worker's job duties, an educational approach requires the building of a management-employee team that works together to identify on-going problems and to institute changes that redress those problems. In a California Department of Insurance, Policy, Research and Special Projects[5] analysis, organizations with the lowest compensation costs, were those that actively required management involvement, employee input, and a proactive approach to addressing ergonomic hazards. By redesigning the job, changing employer policy about injury control, and tying medical surveillance and management to these worksite changes, the cumulative musculoskeletal injuries can be reduced.

APPLYING ERGONOMIC PRINCIPLES IN AGRICULTURE

Musculoskeletal symptoms and injury patterns are found in agricultural work,[44] an occupation that has the dubious distinction of being one of the most hazardous in the nation.[45,46,47,48,49] According to the California Department of Industrial Relations,[50] almost half of California's 1991 occupational injuries occurred in the agricultural production area. Analyses of agricultural safety and health[44,51] confirm that agricultural work involves those risk factors associated with cumulative musculoskeletal problems, including: forceful exertions, prolonged static postures, awkward postures that include continued bending at the waist, twisting at the waist especially while lifting, handling excessive or asymmetrical weights, and repetition of these damaging activities.

Much of the work accomplished to date on ergonomic prevention

of CTDs has been done in stationary nonagricultural industries with stable workforces. While there is no doubt that the same ergonomic principles apply in agricultural work, direct application of specific interventions to agricultural jobs and agricultural workplaces is likely to prove difficult. For example, many agricultural jobs involve multiple duties at multiple locations both on a daily as well as seasonal basis. Further, agricultural workplaces and equipment are widely varied and usually specific to the crops involved. Because much agricultural work has been historically excluded from many OSHA requirements the supportive technology found in other industries is likely to be missing. Finally, agriculture and agricultural workers differ from many other industries in terms of occupational culture. Not only do farmers and farm workers think of their work as nonindustrial and uniquely specific in its context, a clear majority of farm workers in the United States are from Mexico or other Latin American countries and cultures. For the most part, agricultural employers and workers tend to regard examples from other industries as not relevant and nontransferrable to work which they regard as unique. Although some areas in agriculture have instituted ergonomic changes, principally in milking operations, little change has occurred in work tasks performed by the major portion of the agricultural workforce.

To specifically illustrate the ways in which ergonomic principles can be used in agriculture, we present an example from the nursery industry. Nurseries are typical of much of the agricultural work in California. An analysis of five years of injury data from California's nurseries[52] reveals that the vast majority of the injuries are diagnosed as ''sprains and strains.'' Experience and research support the idea that these are not single-event incidents but an accumulation of damage, too often blamed on ''overexertion'' in an effort to fix the resulting injury claims to some specific incident.

ERGONOMICS IN THE NURSERY INDUSTRY

Furthermore, the nursery industry provides an excellent bridging opportunity from stationary manufacturing where most ergonomic intervention has been focused, to agriculture which is characterized by greater physical mobility and task variation. Nursery work is

clearly identified as agricultural and shares many features of employment and task types with field agriculture. Indeed several California nursery crops, plants and flowers, rank fifth in state farm income. At the same time, nursery work reflects many features of stationary industries, especially warehousing. For this reason many previously validated ergonomic principles and applications can be applied to nurseries.

According to the AgSafe analysis,[52] the overall California nursery industry employed an average of 31,000 workers per year and experienced an average of 1634 reported nonfatal disabling injuries per year. A resulting rate of about 5.3 injuries per 100 workers, ranks the nursery industry roughly equivalent to general farming. Approximately 49% of all reported nonfatal disabling injuries were categorized as sprains and strains, of which 46% were said to be back injuries. This pattern is typical of virtually all agricultural commodity areas analyzed.

Researchers[53,54] have shown that risk factors can be mitigated in this kind of agricultural work through the application of ergonomic principles. Wick[53] was able to identify a list of ergonomic factors that contributed to the musculoskeletal injury symptoms of lemon orchard workers after carefully analyzing video tapes of their work. For some of the problems he identified, new work tools were recommended, such as work gloves of lighter, more flexible material that could still protect the worker's hand from thorns, and a picking bag that fit the worker as a vest rather than falling off one shoulder. For some of the problems, such as the fruit load the workers carried when climbing a ladder, Wick recommended a change in the way the work was performed–changing the order in which the worker picked the fruit, so that the bag would be heaviest when the worker was in the least stressful picking posture (i.e., picking at waist-level). Additionally, Miles[55] designed an easily portable cart that could be used to transport picked fruit from the base of each tree to the orchard's central loading area. Use of the cart reduces the workers' musculoskeletal symptoms by eliminating the need to carry maximum weight to make the best income and piece work system.

Miles[55] has applied the same identification, analysis, and evaluation techniques to study work processes in southern California nurseries. He has identified inexpensive ways to make nursery sites

ergonomically safer. His recommendations include the development of new tools to enable workers to safely handle multiple small plants, remodeling work stations to accommodate individual worker height and reach, and reorganization of work tasks.

One of his simplest ergonomic changes involves placing tables in the loading dock, so that plants delivered from various parts of the nursery fields to this area, can be off-loaded onto waist-high platforms. The present work pattern requires employees to place the newly arrived plants on the ground. This means that workers are repeatedly bending, stooping, and lifting the potted plants when they are delivered to this area and then repeating this process when the plants must be loaded onto delivery trucks. It is clear from these examples that ergonomic analysis and change need not be a complicated or an expensive process. Most of all, it involves a new way of seeing tools, tasks and workplaces which are now taken for granted.

Agricultural work involves demanding physical tasks, it often involves repetitious motions, and work organization and equipment are often traditional in design and layout. This initial review of the nursery industry suggests that there are a wide range of tasks and tools which can be readily improved throughout agricultural practice. At the same time, many jobs, field vegetable harvest for example, which involve hand labor and stooped posture will require more in-depth analysis and design work. Both the likely gains from immediately addressable tasks and the probable difficulty of other tasks suggest a new and greater priority for the application of ergonomic methods in agriculture.

SUMMARY AND CONCLUSIONS

Musculoskeletal CTDs are a growing problem across all industries, including the agricultural industry. Research now suggests that musculoskeletal CTDs are preventable. There is growing evidence that specific work-related factors are associated with these injuries. Elimination or reduction of ergonomic hazards promises greater success in controlling cumulative musculoskeletal injuries than worker training alone or prescreening. Although comprehensive ergonomic programs have demonstrated success in multiple

industries, agriculture lags behind in the application of ergonomic principles to work processes.

The most successful approach emphasizes ergonomic control of hazards that combines engineering, administrative, and behavioral approaches into a comprehensive program of problem identification and problem-solving. There is a need and a challenge to demonstrate to agricultural employers and workers that comprehensive programs can not only prove effective in reducing risk exposure and injury, but also prove practical in terms of productivity benefits. By focusing on the adaptation of previously validated interventions to an agricultural industry sector, there is an opportunity to add to the understanding of CTDs and to develop interest by industry leaders in ergonomic prevention methods. In any case, new and increased priority for the application of ergonomic analytic methods across agricultural tasks and tools is indicated.

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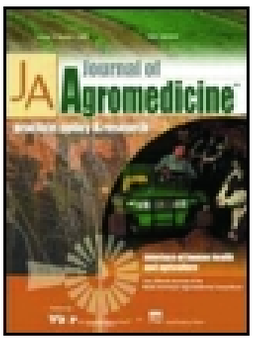

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