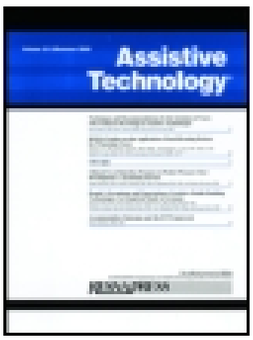

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Ergonomic Job Design to Accommodate and Prevent Musculoskeletal Disabilities

Thomas R. Waters Ph.D. and C.P.E. & Leslie A. MacDonald Sc.D.

PERSPECTIVE

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Ergonomic Job Design to Accommodate and Prevent Musculoskeletal Disabilities

Thomas R. Waters, Ph.D., C.P.E., and Leslie A. MacDonald, Sc.D.

National Institute for Occupational Safety and Health, Cincinnati, Ohio

Work-related musculoskeletal disorders (MSDs) account for a major portion of the cost of work-related injury and illness in the United States. Many of these injuries and illnesses lead to temporary or permanent disability. It is generally accepted that the incidence of MSDs increases when the demands of the job exceed the capabilities of the worker. As the workforce ages and physical capabilities decline, it is anticipated that many more Americans will request disability-related leave resulting from musculoskeletal disorders because they are unable to meet the demands of the job. To prevent these disabilities and to accommodate a wider range of people in the workforce, physical job demands may have to be reduced so that a larger portion of the population will be capable of working. Providing engineering controls or alternative work arrangements allows for accommodation of workers with a wide range of capabilities and can assist in rehabilitation and early return to work following injury.

Key Words: Musculoskeletal disorders—Ergonomic interventions—Obesity—Aging—Job accommodation—Diversity.

Work-related musculoskeletal disorders (MSDs), such as low back pain, tendonitis, hand-arm vibration syndrome, and carpal tunnel syndrome, account for a major component of the cost of work-related injury, illness, and disability in the United States. The costs associated with work-related musculoskeletal disorders are estimated to be as high as $100 billion annually, with occupational low back pain accounting for an estimated 34% of the total costs of all occupational injuries and illnesses combined (Leigh, Markowitz, Fahs, Shin, & Landrigan, 1997). The problem is a major one both in terms of health and of economics. Disability arising from these occupational disorders is a serious concern. About 16.5% of the adult population in the United States reports having a disability, with musculoskeletal disorders cited most frequently. Review of data from the National Health Interview Survey reveals that 90% of the 36.9 million individuals who report musculoskeletal injuries each year seek medical attention, more than half (52%) of the injuries lead to activity restrictions, and one fifth (20%) of the injuries result in at least a half-day of bed disability (Praemer, Furner, & Rice, 1999). Arthritis, rheumatism, and back or spine problems are the leading causes of disability in the United States, accounting for more than 30.6% of all disabilities (Centers for Disease Control and Prevention, 1994). Given current population projections, it is estimated that in the year 2020 arthritis alone will affect more than 18% of all persons in the United States (nearly 60 million persons) and will limit the major activities of nearly 4% (11.6 million) (U.S. Department of Health and Human Services, 2000). Although a number of MSD symptoms, such as low back pain, usually abate within about 6 weeks of onset, a small percentage develop into chronic disorders that will end in temporary or permanent disability.

In general terms, disability for an individual is defined by the Americans with Disabilities Act (ADA) of 1990 as a "physical or mental impairment that substantially limits one or more of the major life activities of such individual." Work disability, however, is defined as a limitation in the amount or kind of gainful work that can be performed because of a chronic condition or impairment (Snook & Webster, 1987). Work disability is classified ac-

Address correspondence and reprint requests to Dr. Thomas R. Waters, Chief, Human Factors and Ergonomics Research Section, National Institute for Occupational Safety and Health, 4676 Columbia Parkway (MS C-24), Cincinnati, Ohio 45226.

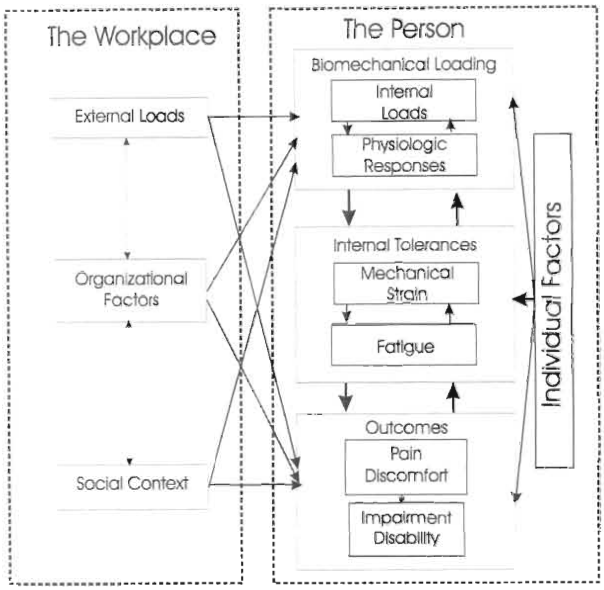

FIG. 1. Conceptual model of potential risk factors for musculoskeletal disorders.

cording to the severity of the disorder and duration of functional limitation. Temporary work disability usually lasts a few months, whereas permanent disability may last a lifetime. Partial work disability describes cases in which the worker can perform some of the job functions, but not all. Total work disability describes cases in which the worker cannot perform the job functions.

There is strong evidence that temporary or permanent work disability due to MSDs may result from occupational exposure to physically demanding jobs, highly repetitive jobs, or both, even for short periods (National Institute for Occupational Safety and Health, 1997; Snook & Webster, 1987). Figure 1 depicts a conceptual model of the possible roles and influences that various factors may play in the development of musculoskeletal disorders (National Research Council, 2001). When the external loads exceed the strength and tolerance capabilities of the individual, the risk of injury increases. Osteoarthritis, rheumatism, and other chronically disabling diseases affecting millions of older Americans may be related to exposure to highly repetitive and physically demanding jobs during their working careers.

CHANGING NATURE OF THE WORKFORCE

A significant concern for prevention of disability from MSDs is the changing nature of the workforce. In general, the labor force is becoming older, heavier, increasingly female, and less physically fit (Judy & D'Amico, 1997; Mokdad et al., 1999).

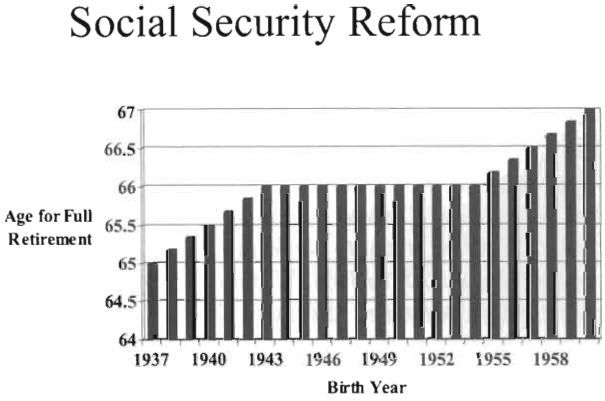

FIG. 2. Increase in age for receiving full retirement benefit according to year of birth.

All of these factors tend to reduce the physical capacity or tolerance of the exposed population.

The Bureau of National Affairs estimated that between 1986 and 2000, the number of workers aged 35 to 47 increased by 38%, and the number between ages 48 and 53 jumped 67%. Estimates from Japan indicate that 25% of its population will be older than 65 years of age by the year 2020. From 1995 to 2050, life expectancy is estimated to rise from 76 to 82 years of age. It is likely that the number of individuals working beyond the age of 65 will increase dramatically. Older people are continuing to stay in the workforce because of heightened economic pressures, rising age requirements for receiving Social Security payments, and increasing life expectancy. The reduced earning power accompanying the transition from a dynamic income to a more fixed income (associated with retirement) or a move from a higher paying job into a lower paying one probably accounts for the increased economic pressure. In addition, as can be seen in Figure 2, the age requirement for receiving full Social Security retirement benefits increases from 65 to 67 years of age, depending on the year of birth (U.S. Social Security Administration, 2001). Therefore, workers can be expected to continue working for more years, often in lower paying jobs that may require more physical effort than previous jobs. However, research indicates that older workers will experience significant decrements in physical capacity, psychomotor skills, and neurobehavioral function. It has also been shown that increasing age negatively affects how muscles and joints respond to applied loads, thereby increasing the risk of degeneration or weakening of the tissues that can maintain the capacity to withstand applied loads (Chaffin, Andersson, & Martin, 1999). To prevent disabilities for many of these older workers, job demands will have to be reduced to

levels significantly lower than those acceptable for more fit, younger, and stronger workers.

Another factor in prevention of disability is the changing gender balance of the labor force. Since 1967, the percentage of women participating in the labor force has increased from 41% to 60%. Six in ten women now work outside the home, and the percentage of women working full time has increased from 52% to 70%. Women are also working more hours per week than ever before, with many women working an average of 50 or more hours per week. Although little information is available regarding the relative risk of MSDs for women compared with men working in jobs with gender-normalized strength and aerobic demands, it is known that women have lower average strength and aerobic capacity than men. Regardless of the potential differences in relative risk for men and women, physical job demands will have to be reduced to better match the capabilities of the changing workforce.

There is additional concern about the problem of obesity and lack of fitness or conditioning for many U.S. workers. In a recent study of obesity, it was found that the prevalence of obesity increased from 12% in 1991 to 18% in 1998, and it was noted that "it is rare that chronic conditions, such as obesity, spread with the speed and dispersion characteristics of a communicable disease" (Mokdad et al., 1999, p. 1519). It is interesting to note, however, that this study also found that self-reported physical activity did not change significantly over the same period. Recent media reports have claimed that almost every American will be obese by the year 2023 if current trends in the prevalence of obesity continue. Workers who are overweight and have physically demanding material-handling jobs are likely to be at increased risk for an MSD because of the additional internal forces resulting from lifting their own body weight. For example, when an overweight individual bends over to lift a load, the forces created in the spine are greater than what they would be for an individual of normal weight because of the additional biomechanical loads needed to lift the extra body weight (Chaffin et al., 1999). These additional musculoskeletal forces could conceivably turn a safe job into a high-risk job for an otherwise healthy individual. Also, being overweight, older, and physically inactive has been shown to increase risk for carpal tunnel syndrome (Nathan & Kenistion, 1993).

CHANGING NATURE OF WORK

Rapid changes in the nature of work are increasing stress at work and are increasing the threat to workers' health and safety. In a recent National Institute for Occupational Safety and Health (NIOSH) publication, it was reported that 40% of workers believe their job is "very or extremely stressful" and that health care expenditures are nearly 50% greater for workers who report high levels of stress (National Institute for Occupational Safety and Health, 1999). Also, working families have less time for socialization because an increasing percentage of families require both parents to participate in the workforce. Other factors that may play an important role in the impact of work on disability include added responsibility of caring for an elderly or disabled relative, increasing demands for higher levels of work skill and education by employers in some job sectors, and increasingly specialized and routinized work in other job sectors.

PREVENTION

Ergonomics, the science of designing jobs to fit workers, provides the best opportunity to prevent disabling musculoskeletal disorders, both in the short term and long term. Although the objectives of an ergonomics program may be to improve efficiency and increase quality and productivity of the work being done, and at the same time reduce risk of injury or illness of the workers, a natural outcome of an ergonomics program will be to increase the size and diversity of the pool of workers who can perform the work. Ergonomics practice examines the physical demands of the job and seeks to reduce them so that they do not exceed the capabilities of the worker. A wide range of assessment tools are available for estimating the physical demands of jobs. These tools provide a method for estimating the magnitude of MSD risk associated with specific job factors, such as the applied force required to perform the job, amount of weight lifted, frequency of activity, posture, duration of exposure, and dynamic requirements. The results of a large study of industrial workers' compensation claims showed that to prevent low back disorders associated with manual material-handling tasks, the demands of the job should be reduced to a level that would be acceptable to approximately 75% of the workers who perform the job (Snook, 1978). This criterion has been used as a job design limit for healthy workers in several ergonomic recommendations (Snook & Ciriello, 1991; Waters, Anderson, & Garg, 1994; Waters, Anderson, Garg, & Fine, 1993).

A number of studies have shown that prevention efforts are best achieved by properly designing the

work activity using engineering approaches. The engineering approach involves modifying the tasks and tools using ergonomic design principles to reduce biomechanical stressors and associated exertion. Ergonomic design examines the job layout and work process or procedure to reduce potentially high-risk movements (e.g., bending and twisting), awkward postures, high forces, and repetitive motions. Like universal design principles that consider the needs of the widest array of users, ergonomic job design seeks to make safe work practices a natural result of the tool and workplace design. Although engineering approaches are preferred, administrative controls also have been used to prevent MSDs. These approaches include education and training programs, job rotation, worker placement, worker strength or fitness training, and use of protective equipment.

ACCOMMODATION

The Americans with Disabilities Act mandates that employers with 15 or more employees make reasonable accommodation to allow qualified workers with disabilities to participate in the workforce. Ergonomics can play a crucial role in accommodating workers with physical disabilities in the workplace when strength is an issue. In many cases, workers with disabilities can perform a moderate level of physical work, but the job requirements must be sufficiently reduced to meet their capabilities. Unfortunately, many jobs in industry are designed so that only a small percentage of workers can safely perform them, thereby excluding many workers with and without physical disabilities. To accommodate the widest range of workers, the maximum physical job demands will have to be reduced significantly below what is currently considered acceptable.

Ergonomic design also must recognize that functional impairments of workers with physical disabilities and injuries will require special consideration beyond strength requirements. For example, functional impairment may affect body mechanics, including both kinematics (body posture and movement velocity and acceleration) and kinetics (muscle and joint forces and patterns of muscle activity). Workers with physical disabilities typically move more slowly and have reduced flexibility, reach capabilities, and muscle coordination. All of these functional states can modify the biomechanical loads on the soft tissues of the body and increase risk of injury at equivalent levels of externally applied loads.

REHABILITATION AND RETURN-TO-WORK ISSUES

Research has shown that getting workers back to work after an injury is the best approach to preventing long-term disability (Garg & Moore, 1992). The most effective return-to-work programs provide a wide range of options for employment that includes availability of jobs with varied physical and mental demands, modified or reduced physical work requirements, and alternative work schedules (e.g., part-time work and job sharing), as well as adaptive or redesigned equipment. Organizational changes may also be effective in modifying the job requirements or reducing the work demands. These can include slowing down the pace of work, changing the sequence or pattern of the work process, rotating workers between jobs, and job enlargement.

PSYCHOLOGICAL AND SOCIAL ISSUES

An individual with a disability may be exposed to significantly different psychological and social conditions than someone without a disability, even within the same work environment. When functional impairment arises from a work-related injury or illness, the legitimacy of the condition may be questioned by the employer, coworkers and even worksite medical staff, especially when diagnostic signs are ambiguous. Even when diagnostic signs are conclusive, the employer may deny the work-relatedness of an injury or illness. It is not surprising, therefore, that claims for back injuries are the single largest impairment category of on-the-job discrimination cases under the ADA, representing nearly one in six complaints (Santiago, 2000). Back injury claims outnumber those related to blindness, hearing impairment, paralysis, and heart trouble combined. Because of concern that injury and illness claims will be viewed as fraudulent and a potential risk to continued employment, injured workers may fail to report their condition to the employer and thus hamper prospects for early intervention that could mitigate long-term disability.

Other, subtler social factors can reduce the effectiveness of some workplace accommodations. Restricted-duty work assignments are an increasingly common accommodation for injured workers as a result of stepped-up efforts by employers to reduce lost work time and associated costs. The experience of accommodation through temporary or sometimes indefinite reassignments to new restricted-duty tasks can have undesirable consequences, such as social displacement at a time

when injured workers are grappling with adjustment to functional loss and most need supportive social ties. Anticipation of such displacement may also motivate injured workers to conceal injuries and illnesses from employers and to self-medicate.

Adjustment to impairment includes the difficult psychological hurdle of facing and redefining expectations of performance in light of functional limitations or loss. This adjustment can be especially challenging for many workers impaired by work-related MSDs, especially those workers who were formerly recognized by their coworkers and employer as high performers. Supervisors are often evaluated on the basis of their work group's ability to achieve targeted performance goals, and they may therefore respond harshly or even punitively to employees who can no longer meet the demands of the job. Leslie Kanes Weisman (1999) noted that "at any point in our lives, personal self-esteem, identity, and well-being are deeply affected by our ability to function in our physical surroundings with a sense of comfort, independence, and control."

Therefore, efforts are needed to ensure a responsive organizational environment for both disability prevention and accommodation. Coordination and information sharing among key functional groups within an organization, such as Human Resources, Health and Safety Management, Process Engineering, Accounting, Facilities, and supervisors, may provide an important framework for establishing timely and effective solutions to prevent worker injury and illness or to accommodate an existing condition.

SUMMARY AND CONCLUSIONS

At present, disability from work-related MSDs is a significant and costly problem to society that may become more prevalent. The changing nature of the labor force is increasing the importance of using ergonomics to prevent work-related disabilities. These changes include (1) increase in the age of the typical worker, (2) increase in the percentage of women in the labor force, (3) increase in the percentage of obese individuals, (4) increase in exposure to stress factors, and (5) reduction in worker physical fitness. These changes are significant because they increase the risk of MSDs and disability for workers in the future.

Some of the benefits of ergonomic job design to prevent disability include:

(1) Wider range of jobs available for individuals with disabilities.
(2) Larger number of qualified workers to choose to employ.
(3) Acceptable jobs for rehabilitation and return to work following injury.
(4) Reduced injuries and long-term disability.
(5) Cost savings associated with reduced health problems for workers without disabilities.

Another benefit of proactive application of ergonomics to prevent disability is that employers are more likely to be in compliance with provisions of the ADA that require reasonable accommodation for workers with disabilities. Furthermore, employers are legally required under the General Duty Clause of the Occupational Safety and Health Act to provide a workplace free from recognized hazards. These requirements call attention to the need for the more widespread application of universal design or ergonomic design principles to the physical design of the work environment as well as to the job requirements. By leveling the playing field, these design efforts promote and support diversity and social equality by enabling individuals with a wide range of capabilities to meaningfully participate in productive employment, and by promoting longer term employment options for the aging population. Universal or ergonomic design principles will also benefit the entire workforce through the abatement of physical job stressors and thus the effective prevention of work-related MSDs. Ergonomic design or redesign of jobs should focus on abilities, not disabilities. It is crucial to increase efforts to prevent disability and to accommodate workers who have functional limitations by providing more flexible workplaces in which a wide range of individuals can participate.

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