

# Musculoskeletal Disorders

*A comparison of two national research agendas*

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**W**ORK-RELATED MUSCULOSKELETAL disorders (MSDs) account for a major component of the cost of work-related illness in the U.S. MSDs include low back pain, tendonitis, hand-arm vibration syndrome and carpal tunnel syndrome. The enormous scope of the problem is confirmed by the Bureau of Labor Statistics (BLS), which reports that for those cases involving days away from work in 1999, approximately one third of the total—532,636 cases—were the result of overexertion or repetitive motion. This article explains the method for the development of the musculoskeletal research portion of NIOSH's National Occupational Research Agenda (NORA) and compares the result with the National Research Council (NRC) research agenda.

During the past decade, approximately 4,000 published articles have focused on work-related MSDs (National Library of Medicine). The findings presented in many of these publications have been summarized in various literature reviews [Andersson; Bernard; Buckle and Devereux; Ferguson and Marras; Frank, et al (a), (b), (c); Katz, et al; Krause, et al; Moore; Rempel, et al; Szabo; Viikari-Juntura and Silverstein; NRC]. Based on the findings from these publications, a simple conceptual framework of factors that contribute to MSDs can be formulated (Figure 1). In this model, loads are applied to the musculoskeletal system either by external or internal forces due to the mass of the body segments. These applied loads create internal tissue responses in the muscles and ligaments and at the joint surfaces.

Depending on the magnitude of the load and other individual, organizational or social factors, one or more outcomes may result, which may produce adaptation effects or potentially harmful effects. Adaptation effects include increases in strength, fitness or conditioning. Potentially harmful effects may include structural damage to tendons, nerves, muscles, joints or supporting tissues that may result in symptoms, impairment or disability. Whether the exposure leads to an MSD depends on a job's physical demands as well as organizational, individual, physical and psychological factors. In turn, these

may modulate the effects of the external load. Interventions designed to reduce risk of MSDs can be implemented anywhere along this pathway. Engineering interventions that reduce intensity, frequency and duration of exposure are often effective in reducing MSD incidence and severity.

NIOSH recognizes that a problem of this magnitude requires coordination and cooperation among its external partners. This philosophy underpins NIOSH's NORA, which is a collaborative effort between NIOSH and its partners to guide occupational safety and health research over the next decade. As part of the NORA process, NIOSH assembled a team of experts representing industry, labor, academics and government to evaluate the status of and define future research needs in the area of work-related MSDs. This agenda should serve as a blueprint for building a national research program by identifying high-priority research problems.

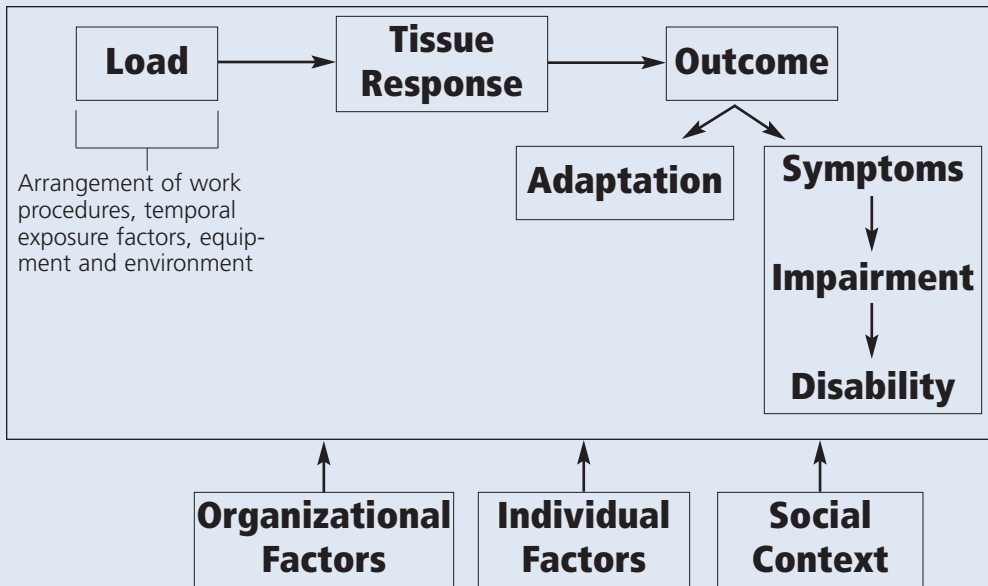
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**Figure 1**

## Conceptual Model of Factors that May Contribute to MSDs



Industry, labor and government partners are needed to help put this agenda into practice and to leverage the allocation of resources for preventing and treating MSDs.

In a related initiative, the U.S. Congress asked the NRC to report on the scientific base supporting the concepts of work-related MSDs (NRC). As part of its in-depth review of the literature, NRC also developed a research agenda, which will be compared with the NORA research agenda.

### Data Collection

To obtain maximum input from practitioners, academic and corporate researchers, and research-sponsoring organizations, the NIOSH team adopted a multi-phase approach. The first phase involved three regional focus group meetings, which were held in Chicago, Seattle and Washington, DC. During the second phase, academicians and researchers participated in a workgroup meeting (held in Houston); this group used the findings from the focus groups as the basis for further discussions.

Overall, more than 150 people participated in the three focus group meetings (16 workgroups) and some 50 researchers (five workgroups) at the Houston meeting. The Chicago focus group included representatives from agriculture, food processing, light manufacturing, office work environment, warehousing and transportation, healthcare and heavy manufacturing. The Seattle focus group was attended by representatives from forest products, agriculture, construction, maritime, healthcare, heavy manufacturing, office work environment, transportation, warehousing and light manufactur-

ing, and the Washington, DC, group included representatives from two major areas of the healthcare industry organized into three general healthcare groups and one long-term healthcare group.

Focus group attendees were asked to respond to three basic questions:

- What methods need to be developed to improve your ability to identify hazardous jobs (or working conditions) in your company or industry?

- What are the ergonomic problems in your workplace for which there is insufficient research to address the problems?

- What methods have you used that appear to be most effective or promising in reducing the frequency and/or severity of MSDs in your workplace and deserve

further research and development?

NORA team members reviewed the transcripts and flipcharts from the practitioner meetings and summarized them using a criteria-based extraction process. These assessments resulted in listings of research issues by industry sector and short summaries of the main discussion topics. These summaries were further analyzed using a manual search-and-extraction process by combining the results into a single file.

The Public Health model was then used to extract and organize material into four research topic areas: surveillance, etiology, interventions and improving the research process. Then each section was edited to consolidate similar ideas. In addition, participants at the Houston workgroup were asked to identify research topics where progress seemed most likely to occur in the next five years.

### Results

Based on responses from the four focus groups, the NORA MSD team developed an agenda of the most important research gaps in the four primary topic areas. The goal was to synthesize the responses, eliminate duplication and highlight the key gaps identified in each area. In some cases, the NORA team also added its viewpoints on research priorities. Furthermore, some issues are discussed in more than one topic area. Tables 1 and 2 list the main points of the NORA and NRC agendas.

### Discussion & Comparison

Although organized differently, the content of the agendas is similar. Comparison reveals that the NORA reflects the viewpoint of practitioners, while

**Table 1**

## **NORA Musculoskeletal Research Agenda**

the NRC agenda emphasizes the viewpoint of researchers. This is to be expected, as the NRC panel was comprised of leading researchers in the fields of medicine, information science and ergonomics. In addition, NORA is more specific in the areas of surveillance and interventions. Surveillance is defined as how to systematically collect, analyze and interpret data regarding workplace MSDs, while intervention is defined as how to modify the job or work setting. These two areas are key concerns for SH&E practitioners. Conversely, the NRC agenda emphasizes etiology as a key research interest. Etiology is defined as the relationship between risk factors and the disease process. These strategies, although different, are both needed for greater understanding and for effectively reducing MSDs.

Both agendas are also fairly similar in their recommendations for the development of standardized case definitions; human studies to help further quantify the relationship between exposures and outcomes; and efforts to determine how psychosocial stressors impact work-related MSDs. Regarding exposure assessment tools, both agendas recommend more research. NRC calls for practical, consistent methods to be developed for quantifying physical and psychosocial exposures. NORA recommends the same, but concentrates on needed exposure assessment methods for surveillance and for determining risk factors to assess etiology.

NRC's agenda concentrates on tissue mechanobiology, including characterizing ultrastructural and cellular responses to physical loading and the sources and mechanisms of discogenic, muscular and tendon-related pain. NORA covers this area only generally, suggesting the need for laboratory research models that would link exposures, tissue changes,

### **Surveillance**

Surveillance is the ongoing systematic collection, analysis, interpretation and dissemination of MSD health and hazard information to identify trends, develop prevention strategies and evaluate the effectiveness of those strategies. The most significant priorities for surveillance research activities identified by the NORA team are:

- Develop user-friendly, standardized workplace surveillance tools for use by both the nonexpert and the expert.
- Increase collaboration with federal, state and nongovernmental organizations to encourage comparability of data collection methods.
- Conduct an ongoing national hazard survey targeting physical workplace factors.

### **Etiologic & Medical Research**

Many risk factors associated with development of MSDs have been identified or suggested. Biomechanical risk factors include exposures to excessive force, awkward posture, movement and vibration. These can be characterized in terms of their magnitude and temporal factors, such as frequency, repetition, duty cycle and duration of exposure (Figure 1). Psychological and social factors include work organization arrangements (extended workhours, shiftwork, piecework, machine pacing), lack of training, inadequate conditioning, and cognitive or emotional stress. Personal factors include variables associated with size, strength, age, gender, cultural factors and history of injury. Research is needed to better describe the relationship between exposures to these risk factors, both singly and in combination, and the development of disease and disability. The most significant priorities in this area are:

- Refine instruments to detect and quantify the contribution of these factors to the disease process.
- More-clearly define stages of MSD process, develop precise diagnostic tools, and provide guidelines for effective treatment and return to work.
- Clarify the interplay of the factors of different stages of causation, development and treatment of MSDs and measurement of risk factors.

### **Intervention Research**

Research is needed to develop and evaluate new and existing intervention strategies for preventing or reducing the incidence, severity and disability associated with work-related MSDs. A large amount of research has been conducted, but because of the wide variability between individuals and the complexity of causal and contextual factors and their interactions, more research is needed on which interventions are the most effective. Intervention research is difficult to conduct because adequate comparison controls are often not available and because very large sample sizes are needed to show that an intervention is effective in reducing health outcomes. Often, it is not possible to conduct studies aimed at reducing health effects, so studies must rely on demonstrating reduced exposure. Interventions can be tested in the laboratory where confounding factors can be controlled or tested in the field. Effective control technology should work well in both environments. The most significant priorities are to evaluate the effects of the following on MSD development and prevention:

- alternative (product and/or tool) design criteria (force, spatial requirements of work);
- optimization of mechanical (force, movement and posture) work demands and temporal patterns of exposure;
- manual handling alternatives in posture, movement, force, productivity and quality;
- ergonomic training and education;
- costs and benefits of ergonomics intervention;
- job assignment, selection and choice.

*NORA reflects the viewpoint of practitioners and is more specific in the areas of surveillance and interventions.*



*Despite differences in their content and emphasis, much cross-over occurs between the NORA and NRC MSD research agendas.*

**Table 2**

## **NRC Research Agenda**

### **Methodological Research**

1) Develop improved tools for exposure (dose) assessment. This includes developing methods for objectively measuring physical stress in the workplace and developing valid measures of psychosocial exposures.

2) Develop improved measures of outcomes and case definitions for use in epidemiologic and intervention studies. This includes developing tools to identify clinical cases and tools and measures to quantify an MSD; further refining standardized survey instruments for epidemiological use; refining physical examination criteria to identify MSDs; refining epidemiologic case definitions; developing classification for nonspecific pain syndromes; refining physiological measures for epidemiological studies; and evaluating definitions of MSDs.

3) In studies of humans, further quantify the relationships between exposures and outcomes. This includes dose-response relationships of exposures; evaluating host factors; and interaction of physical and psychosocial factors.

### **Topic Area Research**

1) **Conduct tissue mechanobiology studies.** Perform animal tissue studies of structural and cellular responses to physical loading; determine whether response to repeated loading is determined by rate, peak or duration; and identify sources of pain as related to injury and physical loading.

2) **Biomechanics studies.** Investigate the role of repetition, work-shift and rotation on loading patterns and pain; quantify the relationship between loading and pain; and explore psychological stress on musculoskeletal response.

3) **Psychosocial studies.** Investigate psychosocial stressors' impact on MSDs.

4) **Epidemiologic studies.** Undertake longitudinal studies of MSDs related to: how MSDs form; physical and psychosocial influences; return to work; rest, recovery and repair; interventions; and individual factors.

5) **Workplace interventions studies.** Conduct workplace interventions using: randomized control models; multifactorial interventions; cost-effectiveness; working with industry; and disseminating to targeted industries.

physiologic responses, adaptation and disease. In addition, NRC suggests the need for biomechanics studies, including evaluation of tolerance limits for joints and soft tissue, the relationship between the loading of a joint and pain, and the influence of psychosocial stress on MSD response. To a lesser extent, NORA recommends assessing biomechanical risk factors by conducting field research.

The NRC agenda specifically recommends that epidemiologic studies be conducted for various purposes: to examine how MSDs form; to separate physical and psychosocial stressors; to assess return-to-work issues, rest periods, interventions and individual and psychosocial factors. Although not specifically stated, NORA implies that epidemiological studies should be conducted in order to determine the relationship between physical, personal and psychological factors to MSDs.

Workplace interventions are discussed in both agendas, but NORA places greater emphasis on researching interventions, which clearly reflects the interests of practitioners. It proposes research on engineering controls, work organization, protective equipment and other intervention issues (e.g., training, regulations, compensation, cost benefit).

The NRC research agenda recommends that intervention studies be conducted in the following areas: multifactorial interventions, economics, working in the community and information dissemination; it does not cover optimization of mechanical work demands, manual handling alternatives, ergonomic training and education, or job assignment evaluation.

In the area of surveillance, NORA recommends increased collaboration between federal, state and nongovernmental organizations in order to encourage comparability of data collection and analysis methods; it also recommends an ongoing national hazard survey be conducted to target physical workplace factors. Neither idea is captured in the NRC research agenda, which does not specifically mention surveillance, but implies that surveillance should be performed in the epidemiologic studies section.

With publication of its report, NRC completed its assignment to describe the state of knowledge on work-related MSDs. By contrast, the NIOSH agenda represents an early milestone in an ongoing effort to facilitate additional research.

The intention of the NORA initiative is to raise awareness of research needs, identify funding sources, promote partnership opportunities between employers and researchers, and publicize advances in knowledge. To those ends, for example, NIOSH, in partnership with the National Institute of Arthritis and Musculoskeletal and Skin Disorders, published a request for extramural grant applications specifically directed at areas contained in NORA. NIOSH is also attempting to identify additional funding agencies with the goal of bringing these groups and researchers together to address the most critical research gaps.

## Conclusion

Despite differences in their content and emphasis, much cross-over occurs between the NORA and NRC musculoskeletal disorder research agendas. Although 4,000 articles have been published in this area, additional research is needed to improve the SH&E community's understanding in the areas of surveillance, etiology and interventions. By increasing communication among researchers and practitioners, and coordinating plans for dissemination of research results, the limited available resources can be targeted for the greatest impact. Working together toward these common research goals can produce significant gains in reducing the number of workers afflicted with MSDs. ■

## References

- Andersson, G.B.J. "Epidemiology of Occupational Neck and Shoulder Disorders." In *Repetitive Motion Disorders of the Upper Extremity: Proceedings of American Academy of Orthopaedic Surgeons Symposium*, S.L. Gordon, et al, eds. Rosemont, IL: Academy of Orthopaedic Surgeons, 1995. 31-42.
- Bernard, B., ed. *Musculoskeletal Disorders and Workplace Factors. A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity and Low Back*. DHHS (NIOSH) Publication No. 97-141. Washington, DC: Dept. of Health and Human Services, NIOSH, 1997.
- Buckle, P. and J. Devereux. *Work-Related Neck and Upper Limb Musculoskeletal Disorders*. Luxembourg: European Agency for Safety and Health at Work, 1999.
- Ferguson, S. and W. Marras. "A Literature Review of Low Back Disorder Surveillance Measures and Risk Factors." *Clinical Biomechanics*. 12(1997): 211-226.
- Frank, J.W., et al(a). "Disability Resulting from Occupational Low Back Pain, Part II: What Do We Know About Secondary Prevention? A Review of the Scientific Evidence on Prevention After Disability Begins." *Spine*. 21(1996): 2918-2929.
- Frank, J.W., et al(b). "Disability Resulting from Occupational Low Back Pain, Part I: What Do We Know About Primary Prevention? A Review of the Scientific Evidence on Prevention Before Disability Begins." *Spine*. 21(1996): 2908-2917.
- Frank, J.W., et al(c). "Occupational Back Pain: An Unhelpful Polemic." *Scandinavian Journal of Work and Environmental Health*. 21(1995): 3-14.
- Katz, J.N., et al. "Prevalence and Predictors of Long-Term Work Disability Due to Carpal Tunnel Syndrome." *American Journal of Industrial Medicine*. 33(1998): 543-550.
- Krause, N., et al. "Modified Work and Return to Work: A Review of the Literature." *Journal of Occupational Rehabilitation*. 8(1998): 113-139.
- Moore, J.S. "Carpal Tunnel Syndrome." *Occupational Medicine*. 7(1992): 741-763.
- National Library of Medicine. PubMed literature search. Retrieved March, 25, 2002, from <<http://www.ncbi.nlm.nih.gov/PubMed/>>.
- National Research Council (NRC). "National Research Council Work Related to Musculoskeletal Disorders: Report, Workshop Summary and Workshop Papers." Washington, DC: National Academy Press, 1999.
- NRC and Institute of Medicine. "Musculoskeletal Disorders and the Workplace, Low Back and Upper Extremities." Panel on Musculoskeletal Disorders and the Workplace, Commission on Behavioural and Social Sciences and Education. Washington, DC: National Academy Press, 2001.
- NIOSH. "National Occupational Research Agenda for Musculoskeletal Disorders: Research Topics for the Next Decade—A Report by the NORA Musculoskeletal Disorders Team." DHHS (NIOSH) Publication No. 2001-117. Cincinnati: Dept. of Health and Human Services, NIOSH, 2001.
- Rempel, D., et al. "Consensus Criteria for the Classification of Carpal Tunnel Syndrome in Epidemiologic Studies." *American Journal of Public Health*. 88(1998): 1447-1451.
- Szabo, R.M. "Carpal Tunnel Syndrome as a Repetitive Motion Disorder." *Clinical Orthopaedics & Related Research*. 351(1998): 78-89.

## Improving the Research Process

Participants indicated that the research process could be improved by strengthening communication between those who conduct research and those who apply research. Researchers expressed frustration at the difficulties associated with gaining access to industrial sites to conduct research, and management and labor felt the need for more input into the research process. Some participants suggested that research might be more applicable to industry if management and labor reviewed research proposals and had a say in funding and prioritization. For example, workforce representatives expressed disappointment that researchers often did not have a thorough knowledge of the workplace process being studied, or performed their research under "best case" scenarios.

There seemed to be general agreement that improvements in dissemination of research results were needed. Most of these problems were attributed to inadequate communication between the parties involved in the research process. Better methods of dissemination are needed to improve the application of research findings in the workplace. Furthermore, when valuable research data were obtained, the method of dissemination made it difficult to apply in the workplace. The NORA Musculoskeletal Team considers coordination of research activities and information dissemination to be of prime importance in this area. As suggested by several focus group participants, coordination of studies through partnerships involving government agencies, university researchers, private industry and labor unions could help to bridge communication gaps, develop efficient research strategies and improve information dissemination.

U.S. Dept. of Labor, Bureau of Labor Statistics (BLS). "Lost Work Time Injuries and Illnesses: Characteristics and Resulting Time Away from Work." Washington, DC: BLS, 2000.

Viikari-Juntura, E. and B. Silverstein. "Role of Physical Load Factors in Carpal Tunnel Syndrome." *Scandinavian Journal of Work and Environmental Health*. 25(1999): 163-185.

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