Musculoskeletal Disorders Research at NIOSH

December 3, 2021 by Jack Lu, PhD, CPE, and Julie Tisdale-Pardi, MA

Throughout its 50 years, NIOSH has been at the forefront of efforts to protect workers from musculoskeletal disorders (MSDs). MSDs were recognized as having occupational causes as early as the beginning of the 18th century. However, it was not until the 1970's that occupational factors were examined using epidemiologic methods, and the work-relatedness of these conditions began appearing regularly in the international scientific literature. By the 1990s, the literature has increased dramatically with more than six thousand published scientific articles addressing ergonomics in the workplace. Yet, the relationship between MSDs and work-related factors remained the subject of considerable debate. From the 1970s, when NIOSH researchers were pioneering the study of musculoskeletal health, to present, NIOSH has produced a strong body of research bringing quality science to many of the topics involving ergonomics and MSDs. Several examples are include below.

Vibration

Since the early 1970s NIOSH research has contributed significantly to understanding work-related whole-body and hand-transmitted vibration exposures and health effects. In the 1980s, the results of this research confirmed that hand–arm vibration syndrome remained one of the major occupational diseases among workers exposed to hand-transmitted vibration in the U.S. and led to publication of the NIOSH. Criteria for a Recommended Standard: Occupational Exposure to Hand-Arm Vibration and Current Intelligence Bulletin 38—Vibration Syndrome. The results also confirmed that the major work-related musculoskeletal disorders associated with the whole-body vibration exposure were low back pain, early degeneration of the lumbar spinal system, and herniated lumbar discs. This research contributed to the establishment of national and international standards and guidelines on the measurement and assessment of whole-body and hand-transmitted vibration exposures. In the last 20 years, the research has primarily involved studies characterizing the vibration exposures and how they influenced the development and severity of vibration spinal disorders and hand–arm vibration syndrome. This research emphasized fundamental biodynamic and biological research along with engineering intervention studies.[1,2] Some examples include: Tool-specific performance of vibration-reducing gloves [3]; Effective engineering methods for controlling handheld workpiece vibration in grinding processes [4]; and using a process management approach to reducing noise and hand-arm vibration while improving productivity and quality [5]. More detailed information on NIOSH's work-related human vibration research can be found in the following review papers: A Unique Historical Perspective of Occupational Hand-arm Vibration in the U.S. from 1918-2004; A Review of Hand–Arm Vibration Studies Conducted by US NIOSH since 2000.

NIOSH Lifting Equation

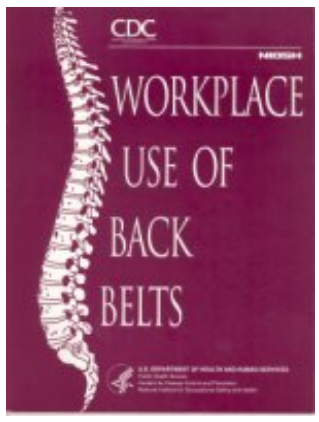
In 1981 the NIOSH Lifting Equation (NLE) was first published and went on to be an important tool for preventing manual handling injury in the workplace. The equation helps users measure the position and capabilities of their body in relation to the object(s) they intend to lift and tells users how to lift the object(s) to minimize risks of MSDs. The Revised NIOSH Lifting Equation (RNLE) was published in 1991 which includes the lifting index, a risk estimate of the RNLE. Certified professional ergonomists in the U.S. and many other English-speaking countries recognized the RNLE as the most popular ergonomic risk assessment tool.

The original RNLE applications manual was officially published in 1994 and archived in 2021. The new digital version of the manual was published in September 2021 to improve its usability (See related blog). The manual provides methods for accurately applying the RNLE for assessing the risk of low back pain associated with a variety of manual lifting tasks. Because many measurements and calculations are required for using the RNLE, NIOSH published a mobile app to help users calculate the lifting index.

Back Belts

In 1994 NIOSH published two documents (Pub. Nos. 94-122 and 94-127) concluding that there was insufficient evidence to recommend the use of back belts as a back injury prevention measure. Since then, NIOSH conducted a large epidemiologic study and two laboratory evaluations to determine more conclusively that the use of back belts did not prevent back injury.

In one of the largest studies of its kind, a prospective cohort study was conducted among material handlers in a retail setting to examine the effects of back belt use on back injuries in the workplace. The 2000 study, published in the *Journal of the American Medical Association,* controlled for multiple individual risk factors and found that elastic support back belt use was not associated with reduced incidence of back injury claims or low back pain.



Elements of an Ergonomics Program

In March 1997, NIOSH released Elements of an Ergonomics Program: A Primer Based on Workplace Evaluations of Musculoskeletal Disorders. This document includes the basic elements of a workplace program aimed at preventing work-related musculoskeletal disorders (WMSDs). The document was updated in 2017 as a web-based version (Elements of Ergonomic Programs) that includes seven simple steps to evaluate and address musculoskeletal concerns in the workplace.

The Yellow Book

In July 1997 NIOSH published "The Yellow Book" or the *Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back*. The document provided answers to many of the questions that had arisen on this topic in the 1990's. This document was the most comprehensive compilation to date of the epidemiologic research on the relation between selected MSDs and exposure to physical factors at work. Based on a review of the literature, NIOSH concluded that a large body of credible epidemiologic research existed that showed a consistent relationship between MSDs and certain physical factors, especially at higher exposure levels.

Meanwhile, OSHA had begun an ergonomics rule-making process in 1992 and started drafting an ergonomics standard in 1995, which eventually culminated in the issuance of an Ergonomics Program Standard on Nov. 4, 2000. The standard became effective on Jan. 16, 2001. On March 20, 2001, a new administration repealed the new standard shortly after taking office. [6] To date, there is still no national ergonomics standard in the United States. Some states adopted voluntary guidelines for manual materials handling, such as Washington and Ohio. The Yellow Book provided the research foundation for the Ergonomics Program Standard and for the states that produced guidance.

Upper Limb Musculoskeletal Disorder Consortium

In 2000, NIOSH started a collaborative research program, the Upper Limb Musculoskeletal Disorder Consortium, to prevent work-related upper limb musculoskeletal disorders (MSD's, conditions involving the nerves, tendons, muscles, and supporting structures of the upper limb). The program has research partners at six universities and one state agency. Many of the impacts of the Consortium, including contributing research findings to the American Conference of Governmental Industrial Hygienists (ACGIH) to revise the Threshold Limit Value (TLV) for the Hand Activity Level (HAL) standard, can be found in a recent blog post.

Lower Back Disorder Consortium

In 2015, NIOSH started another consortium with five university research groups to determine the longitudinal relationships between risk factors and different low back pain outcomes (self-reported pain, seeking medical attention and sickness absence due to low back pain), in particular the relationship between the lifting index and the low back pain outcomes. The background of the consortium is described in a research article. Collectively, the consortium members contributed to research aimed at validating the effects of lifting index on work related low back pain. NIOSH published findings of the collective efforts in a systematic review paper which was adopted by the ISO for their 2021 updated ergonomic standard 11228-1 (manual lifting, lowering and carrying). This ISO lifting standard has been used extensively in many countries as their national standard.

Interventions for Airport Baggage Handling

NIOSH partnered with TSA to assess ergonomic risk factors associated with manual baggage screening and handling at airports. In 2015, NIOSH published a workplace solutions document (Reducing Musculoskeletal Disorders among Airport

airports. In 2015, NIOSH published a workplace solutions document (Reducing Musculoskeletal Disorders among Airport Baggage Screeners & Handlers) that demonstrated the effectiveness of lifting assist devices in reducing lifting risks. In 2018, NIOSH partnered with the Ohio State University (OSU) to publish research in Applied Ergonomics showing that a vacuum lift assist system resulted in reduced spinal loads during airline baggage handling. Results showed that the vacuum lifting assist device reduced compression and shear forces on the lower back by 39% and 25%, respectively. These forces were reduced below the damage threshold for musculoskeletal injury (See related blog). In 2020, this partnership resulted in another publication that shows the spinal loads for performing baggage handling tasks in three commonly used postures (kneeling, sitting and stooping) in the compartments of narrow-bodied airplanes. Findings of this publication indicated that kneeling offers the greatest benefit when lifting in the confined spaces because of the ability to keep the torso upright, subsequently reducing spinal loads.

Exoskeletons in the Workplace

When robots began appearing in the workplace in the 1980s NIOSH began researching robotics safety. This research was limited to robots designed to work in isolation from workers, such as robots in cages or cells. With the increase in robots and advances in their capabilities, the NIOSH Center for Occupational Robotics Research was established in September 2017 to address the safety of today's workers who use, wear, or work near robots. NIOSH Science Blog posts on exoskeletons and robots in the workplace discuss the pros and cons of the new technologies. NIOSH and other professionals are continuing to evaluate new technologies to help ensure that workers are protected. In 2020 NIOSH published a paper to guide the nation on exoskeleton research efforts for the prevention of WMSDs (see related blog).

In 2018, NIOSH and its partners in industry, academia, and government held the first national exoskeleton symposium, "ErgoX Symposium: Exoskeletons in the Workplace – Assessing Safety, Usability, & Productivity". The symposium provided a forum for designers, users and researchers to share insights and findings in a public setting on human factors issues related to exoskeleton and exosuit technology.

Industry Specific Efforts

In 2001, NIOSH released Simple Solutions: Ergonomics for Farm Workers, a collection of interventions to reduce MSDs from NIOSH and many NIOSH grant and co-operative agreement recipients. The publication gives short, two-page synopses describing the problem, solution, cost or productivity effects, and how to build the intervention. Approximately 36,000 copies of the English version were distributed in its first year. In 2002, the document was released in Spanish to reach the 1.5 million Hispanic workers in agriculture. Other examples of engineering controls to prevent MSDs include Simple Solutions: Ergonomics for Construction Workers, Hazard Controls: Controlling Ergonomic Hazards of Wiring Tasks for Household Appliances, Simple Solutions for Home Building Workers, and Ergonomic Solutions for Retailers. In 2017, NIOSH posted a Blog Series to Highlight Musculoskeletal Health Research at NIOSH featuring efforts to prevent MSDs in construction workers, temporary workers, couriers and baggage handlers, and surface miners. Research on ergonomic interventions by industry is available on the NIOSH website.

Moving Forward

Future efforts to prevent MSDs will be guided by the NIOSH Musculoskeletal Health Cross-Sector Program. The Program's mission is to reduce the burden of work-related MSDs through a focused program of research and prevention that protects workers from MSDs, helps management mitigate related risks and liabilities, and helps practitioners improve the efficacy of workplace interventions. MSDs have been represented in the National Occupational Research Agenda since its inception in 1996. The current NORA Musculoskeletal Health Council includes members from industry, academia, labor, and government. In 2018 the Council updated the Musculoskeletal section of NORA.

As a leader in the field of MSD research, NIOSH will continue efforts to protect the millions of workers at risk. MSDs are in all industries. The risk of MSDs continues to evolve as future of work changes the way traditional work has been done. Future workers may wear exoskeletons as a common practice. Workers may work with robots or cobots to enhance their productivity. To date, BLS data still show that MSDs or overexertion injuries comprise over one third of all lost-time workplace injuries. Clearly, much work remains to be done.

This blog is part of a series for the NIOSH 50th Anniversary. Stay up to date on how we're celebrating NIOSH's 50th Anniversary on our website.

celebrating NIOSH's 50th Anniversary on our website.

Jack Lu, PhD, CPE, is a Research Ergonomist in the Division of Field Studies and Engineering; and the Manager of the NIOSH Musculoskeletal Health Cross-Sector Program.

Julie Tisdale-Pardi, MA, is the NIOSH Science Blog Coordinator.

References

1.Dong R.G., Welcome D.E., McDowell T.W., Xu X.S., Krajnak K., and Wu J.Z., A proposed theory on biodynamic frequency weighting for hand-transmitted vibration exposure. Industrial Health, 2012. **50**(5): p. 412-424.

2.Krajnak, K. and Waugh, S., Systemic effects of segmental vibration in an animal model of hand-arm vibration syndrome. J Occup Environ Med, 2018. **60**: p. 886-895.

3.Dong R.G., Welcome D.E., Peterson D.R., Xu X.S., McDowell T.W., Warren C., Asaki T., Kudernatsch S., Brammer A., Tool-specific performance of vibration-reducing gloves for attenuating palm-transmitted vibrations in three orthogonal directions. International Journal of Industrial Ergonomics, 2014. **44**(6): p. 827-839.

4. Dong, R.G., Welcome D.E., Xu, S.X., McDowell, T.W., Identification of effective engineering methods for controlling handheld workpiece vibration in grinding processes. International Journal of Industry Ergonomics, 2020. **77**: p. 102946.

5. Zechmann, E., Geiger, M. and Beamer, B., How to buy safer, quieter tools: a process management approach to reducing noise and hand-arm vibration while improving productivity and quality. Synergist, 2018. **29**(1): p. 26-30.

6. OSHA and Ergonomics: The Past, Present and Future | EHS Today

December 3, 2021 by Jack Lu, PhD, CPE, and Julie Tisdale-Pardi, MA
50th Anniversary Blog Series, Musculoskeletal Disorders

Post a Comment

Email

Post Comment

Page last reviewed: December 3, 2021
Page last updated: December 3, 2021