

MUSCULOSKELETAL DISORDERS/ ERGONOMICS

ERGONOMIC ENGINEERING INTERVENTIONS FOR THE CONSTRUCTION INDUSTRY

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PURPOSE: Determine engineering controls that can reduce the incidence of musculoskeletal disorders among construction workers, particularly what engineering interventions can reduce workers' exposure to the physical risks that lead to back injuries.

RESEARCH SUMMARY: Back injuries are prevalent in the construction industry. The incidence rate of days away from work because of back injuries is 58% higher in construction than in general industry. Of these back injuries, 72% are due to overexertion, and 96% are classified as back pain or sprains/strains. There remains a paucity of information in the scientific literature on the effectiveness of engineering controls in reducing or preventing back injuries. More research is needed to determine what engineering interventions are effective for each sector of the construction industry.

The project will be modeled after a highly successful shipyard ergonomics study. It will involve meeting with leaders of companies, unions, and associations and developing a plan for engineering controls to reduce back injuries. Ten or more sites representing many of these construction sectors will be visited to document engineering controls already in use that are found to be effective and to identify jobs with the highest physical risk factors. Controls will be developed, applied, and tested for those occupations and tasks identified as having the highest level of physical risk factors. Production information corresponding to use of the engineering control will also be collected. A compendium of successful engineering controls and good ergonomic practices for the construction industry will be compiled, and during the final year, a series of best-practices workshops will be held to disseminate study findings.



KEYWORDS: Control technology, intervention, musculoskeletal disorders

RECENT CITATIONS:

Albers, J.T., C.F. Estill, and L.A. MacDonald. (In press.) In *Proceedings: Exploring Ergonomic Interventions in the Mechanical and Electrical Trades* (San Jose, CA, Feb. 25-26, 2002). NIOSH.

Estill, C.F., and J.T. Albers. 2002. Ergonomic interventions in the construction industry. In *Power Through Partnerships: 12th Annual Construction Safety and Health Conference, Proceedings* (May 21-23, 2002, Rosemont, IL).

TECHNOLOGY INVESTMENT AGREEMENT WITH ADVANCED TECHNOLOGY INSTITUTE

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PURPOSE: Devise and implement cost-effective ergonomic controls for a variety of construction, repair, and recycling processes in the shipyard industries.

RESEARCH SUMMARY: The domestic shipbuilding, repair, and recycling industries have historically had much higher injury and illness incidence rates than has general industry, manufacturing, or construction. In 1998, the Bureau of Labor Statistics reported that shipbuilding and repair had an injury/illness incidence rate of 22.4 per 100 full-time employees, whereas the manufacturing, construction, and “all industries” sector reported rates of 9.7 per 100, 8.8 per 100, and 6.7 per 100, respectively. Approximately half of all shipyard injuries can be classed as musculoskeletal disorders.

Because of the number of multifaceted job tasks performed by workers in the various trades in ship construction, repair, and recycling, the perception is that fitting the job to the shipyard worker may not be practical. In addition, ergonomic engineering controls employed in general industry, construction, or manufacturing are not necessarily transferrable because tasks in a shipyard are quite diverse.

Nonetheless, it is imperative that the high rates of musculoskeletal disorders and associated job risk factors be better understood. Once an association is clear, effective ergonomic intervention strategies can be developed to prevent such injuries. This study will be conducted in three phases. Phase 1 includes examining trade- or department-specific injury and illness rates for the past 5 years, assessing qualitative job risk factors in various trades or job processes, and determining if individual shipyards are willing to cooperate in data collection and implementation of pilot ergonomic interventions. Phase 2 includes quantifying job risk factors for selected jobs in selected shipyards, recommending unique ergonomic engineering and administrative controls to reduce exposure to the identified risk factors, and implementing pilot ergonomic interventions. Phase 3 includes evaluating the effectiveness of the pilot interventions and disseminating results to the public.

Broader application of the ergonomic interventions will be to transfer the lessons learned in specific shipyards to other shipyards, boatyards, and other industries such as manufacturing and construction.



KEYWORDS: Ergonomics, intervention, musculoskeletal disorders

RECENT CITATIONS:

Wasserman, D.E., S.D. Hudock, J.F. Wasserman, L. Mullinix, S.J. Wurzelbacher, and K.V. Siegfried. 2002. Hand-arm vibration in a group of hand-operated grinding tools. *Human Factors and Ergonomics in Manufacturing*, v. 12, no. 2, pp. 211-226.

Hudock, S.D., S.J. Wurzelbacher, L.D. Reed, T.R. Hales, and K.V. Siegfried. 2001. A precursor of ergonomics best practices for the shipyard industries. *Journal of Ship Production*, v. 17, no. 13, pp. 145-150.

Lowe, B.D., S.J. Wurzelbacher, S.A. Shulman, and S.D. Hudock. 2001. Electromyographic and discomfort analysis of confined-space shipyard welding processes. *Applied Ergonomics*, v. 32, no. 3, pp. 255-269.

WORK-RELATED MUSCULOSKELETAL DISORDERS RESEARCH IN CONSTRUCTION

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PURPOSE: Help develop and implement a work-related musculoskeletal disorder program in construction.

RESEARCH SUMMARY: Strains and sprains are commonly used as a stand-in for work-related musculoskeletal disorders. According to the Bureau of Labor Statistics (BLS), work-related musculoskeletal disorders include cases where the nature of injury or illness involves sprains, strains, tears, back pain, carpal tunnel syndrome, hernia, or musculoskeletal system symptoms, and connective tissue diseases and disorders. These problems occur when the event or exposure leading to the injury or illness involves bending, climbing, crawling, reaching, twisting, overexertion, or repetition.

Analysis of BLS data for all industries for 1999 showed that only 61% of strains and sprains are actually work-related musculoskeletal disorders as defined by the BLS. The rest included acute injuries resulting from falls, slips and trips, contact with objects, etc. Thus, the event or exposure categories of "overexertion" (96%), "bending and twisting" (a subcategory of bodily reaction) (93%), and "repetitive motion" (95%) are better indicators of work-related musculoskeletal disorders.

The Center to Protect Workers' Rights is coordinating the investigation of whether use of lightweight (17 lb) cement blocks instead of regular (34-40 lb) cement blocks can reduce lower back injuries among cement masons. This intervention project involves masons from the International Union of Bricklayers and Allied Craftworkers and consists of three separate studies: (1) an on-site evaluation and symptom questionnaire survey of masons using both types of cement block (Medstar Research Institute and George Washington University), (2) a laboratory investigation by the University of Iowa, and (3) a productivity study in collaboration with NIOSH's Division of Safety Research.

The laboratory investigations have been completed. Preliminary analyses suggest a reduction in upper back muscle load while using the lightweight block, but indicate no difference in lumbar or shoulder posture.



KEYWORDS: Musculoskeletal disorders and injuries, ergonomics, cement masons, lightweight blocks, intervention

DIRECT PHYSICAL EXPOSURE ASSESSMENT METHODS FOR EVALUATING NONCYCLIC CONSTRUCTION WORK

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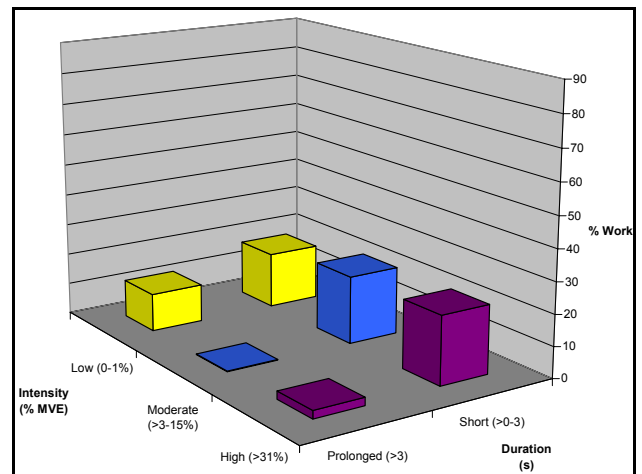
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CONSORTIUM: Center to Protect Workers' Rights

PURPOSE: Develop an exposure assessment tool for evaluating forceful exertions in highly variable, noncyclic work settings such as construction.

RESEARCH SUMMARY: There is a need for improved methods for quantifying physical risk factors. Surface electromyography has been used in several ergonomic studies to assess exposure to forceful exertions, and electrogoniometry has been used to evaluate awkward postures. However, exposure assessment and quantification of work such as construction and agriculture have proven to be especially challenging, since the tasks are typically highly variable and noncyclic.

Exposure variation analysis (EVA) is a data-reduction method applicable to electromyography or electrogoniometry. When used with electromyography, EVA describes a certain work period in terms of load or intensity of muscular contraction and period length or duration of muscular contraction. A graph is created that illustrates the percentage of sampled work time at the combined levels of intensity and duration. Although EVA is a beneficial method of quantifying work, examination of the results is a statistically complex process, and the graphs may be difficult to interpret. A simplification of EVA has been developed called "clustered exposure variation analysis," or CEVA. CEVA has been used with dataloggers in studies evaluating exposure to forceful exertions of the flexor forearm (via electromyography) in construction workers. CEVA can quantify highly variable work and simultaneously evaluate multiple dimensions of physical exposure. It appears to be promising as an exposure assessment tool, since nonresearchers would be able to use the technique.



Clustered exposure variation analysis (CEVA) graph of mechanic's work.

KEYWORDS: Electromyography, ergonomics, exposure assessment, forceful exertion, musculoskeletal disorders, upper extremity

RECENT CITATIONS:

Anton, D. 2002. A comparison of risk factors in construction trades with contrasting prevalence of carpal tunnel syndrome. Doctoral dissertation, University of Iowa.

Jansen, J.P, A. Burdorf, and E. Steyerberg. 2001. A novel approach for evaluating level, frequency and duration of lumbar posture simultaneously during work. *Scandinavian Journal of Work, Environment, and Health*, v. 27, pp. 373-380.

Anton, D., J.L. Clark, P. Krawczyk-Adamus, T. Cook, J. Rosecrance, and L. Merlino. 2002. Reliability of clustered exposure variation analysis. In *Proceedings of the 16th Annual International Occupational Ergonomics and Safety Conference*.

EVALUATION OF TOOL DESIGN CHARACTERISTICS FOR USE IN CONSTRUCTION WORK

RESEARCHER: Brian Lowe

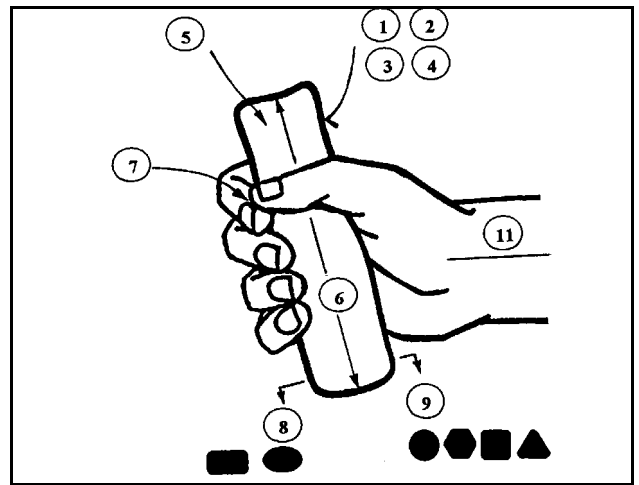
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PURPOSE: Identify and specify ergonomic design criteria for hand tools used in construction work.

RESEARCH SUMMARY: Construction workers have high exposure to physical stressors, such as awkward postures, repetitive motion, heavy force exertions, and long work hours. Each year musculoskeletal disorders account for more than 60% of the disabling injuries experienced by approximately 200,000 construction workers. Many of the injuries and physical stresses associated with construction work are recognized to be the direct result of poorly designed hand tools in construction tasks. Ergonomically designed tools can reduce the risk of injury resulting from poor tool design.

Workers, employers, and manufacturers need to know what criteria or features make a tool “ergonomic” and what are the benefits of ergonomic tool design. This project is designed to answer these two questions. This need is increasingly apparent with the proliferation of new hand tools that have recently become available for common construction tasks.

A checklist has been developed by NIOSH for use by construction workers and supervisors to enable them to select the most appropriate nonpowered hand tools. The next step in the development process is to conduct two laboratory studies and a field study to validate the checklist. The laboratory studies will quantitatively examine how tool characteristics, such as slipperiness, handle compliability, handle contour, tool weight, handle cross-sectional shape, etc., affect the biomechanical demands of hand tool use. For some hand tool characteristics, the effects of the specific design features on biomechanical demands are well established from published research. For others, the effects are not well grounded in research data. The field component will be an intervention study comparing hand tools that rank at the low and high ends of the checklist in terms of the required posture grip force and subjective discomfort. The validated checklist should differentiate tools that require high levels of musculoskeletal loading and those that require low levels. Results of the laboratory and field validation studies will be used to revise the checklist as needed.



KEYWORDS: Exposure assessment, musculoskeletal disorders, repetitive stress injury, hand tools

RECENT CITATIONS:

Dababneh, A., and T. Waters. 1999. The ergonomic use of hand tools: Guidelines for the practitioner. *Applied Occupational and Environmental Hygiene*, v. 14, pp. 208-215.

TEMPORAL AND IMPULSIVE CHARACTERISTICS OF HAND TOOLS

KEYWORDS: Vibration, musculoskeletal disorders

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PURPOSE: Explore the effects of tool impulse, temporal pattern, and high- and low-frequency acceleration on acute physiological responses among users of hand tools.

RESEARCH SUMMARY: Repetitive shock and vibration are routinely encountered when using both powered and nonpowered hand tools. The use of these tools has been associated with injuries to the arm, shoulder, and neck and with neurologic and neurovascular disorders of the hand. Standards for the control of disease from vibration (in particular ISO 5349) have been shown to be inapplicable to tools having a large impact component (for example, hammers).

Acute physiological responses to repetitive shock and vibration are transient threshold shifts (TTS) in the three major classes of mechano-receptors of the fingertip—slow-acting I (SAI), fast-acting I (FAI), and fast-acting II (FAII)—and changes in surface electromyogram. No prior TTS experiment has attempted to detect response thresholds in the SAI and FAI receptors, which are the two most important mechano-receptor nerves controlling muscle activity.

Understanding the cause of TTS deficits should provide useful insights on the nature of shorter-term functional sensory problems, which may be pertinent to hand-arm dysfunction and acute traumatic injury. Accordingly, construction workers who use powered and nonpowered impact hand tools and who have high rates of hand injury are the target population of this study. Tool characteristics will be simulated in the laboratory, after which laboratory results will be applied to actual tools. Goals include addressing unresolved scientific questions on the risks from extrinsic forces associated with hand tools and the development of reliable, effective field assessment methods.

COMPARISON OF AVIATION SNIP DESIGN FOR SHEET METAL WORKERS

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CONSORTIUM: Center to Protect Workers' Rights

PURPOSE: Compare musculoskeletal load on sheet metal workers during the use of aviation snips of different designs while the workers are in different positions and different work postures.

RESEARCH SUMMARY: Awkward postures and forceful exertions of the forearm and upper extremity may contribute to work-related musculoskeletal disorders, such as carpal tunnel syndrome, wrist tendinitis, and rotator cuff syndrome. Modification of typical snip designs has been proposed as an intervention that could reduce these work-related physical actions. However, limited research has been conducted on many tools before they are marketed as "ergonomic tools."

Using three different designs of aviation snips, 20 third- and fourth-year apprentice sheet metal workers from Sheet Metal Local 91 cut circular holes repetitively in 24-gauge sheet metal panels positioned waist and shoulder high. One tool was commonly used to make a curved cut (standard snip, also called a right or a left snip). The second tool was a straight-cut design with a modified handle, and the third was an aviation snip with the blade modified to a 90° angle from the handle (angled blade) to allow easier overhead cuts. Muscular loads on the worker's dominant forearm (finger flexors, wrist extensors) and upper back (upper trapezius) were evaluated with electromyography while the worker made the cuts. Likewise, the posture of the dominant wrist was evaluated with electrogoniometry during the cuts. After making three waist-high and three shoulder-high cuts at random, workers subjectively evaluated the different designs on a 0-to-10 scale for such factors as maneuverability, grip feel, and force required to cut.

Preliminary results indicated that the modified-handle snip required over 40% more exertion of the finger and wrist flexors than the other two snips while used at waist level. The standard snip at waist level required approximately 30% more exertion of the wrist extensors than the other two snips, while use of the angled-blade snip resulted in more than a 100% reduction in load on the upper back muscles compared to the other designs. Despite being originally developed for easier overhead cutting and the workers' favorite snip at shoulder level, the angled-blade snip required an increase in load of more than 300% on the upper back muscles if used at shoulder level. Both the curved and upright snips reduced forearm muscle load if used at shoulder level.

The results indicate that tool modifications may have both beneficial and deleterious effects on different muscles, and that all muscles are not positively affected by interventions. Similarly, an "ergonomic tool" may not reduce load in the way the designer planned. Sheet metal workers may benefit from using a variety of aviation snips, depending on the task, and should be educated in their proper use.

KEYWORDS: Electrogoniometry, electromyography, ergonomics, hand tools, interventions, musculoskeletal disorders, overhead work, posture, upper extremities

RECENT CITATIONS:

Welch, L.S., K.L. Hunting, and J. Kellogg. 1995. Work-related musculoskeletal symptoms among sheet metal workers. *American Journal of Industrial Medicine*, v. 27, pp. 783-791.

HEALTH EFFECT OF CONSTRUCTION POWER TOOLS ON THE HAND AND WRIST

KEYWORDS: Musculoskeletal disorders, carpal tunnel syndrome, vibration white finger

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CONSORTIUM: Center to Protect Workers' Rights

PURPOSE: Determine if the use of power grinders (such as those used in a tuck-pointing task) during a 6-hour period alters median and/or ulnar nerve function across the wrist.

RESEARCH SUMMARY: Tasks involving the intensive use of the hands and wrists have been associated with upper limb disorders such as carpal tunnel syndrome and vibration white finger. A slowing of nerve conduction velocity, similar to that found in the electrodiagnosis of carpal tunnel syndrome, may occur as a result of short-term exposure to stressful work activities.

This study investigated changes in nerve conduction velocity of the median and ulnar nerves across the wrist during 6 hours of highly intensive power grinding tasks similar to the task of tuck-pointing. Sensory nerve conduction velocities were measured in hands of workers before work and then at 2-hour intervals during the workday. The conduction velocities slowed across the wrist in the median and ulnar nerves for workers performing the grinding task, but not for control workers performing low-intensity hand tasks.

This investigation demonstrated that short-term exposure to highly intensive hand tasks involving vibration, forceful exertions, and awkward hand positions causes significant slowing of nerve conduction velocity across the wrist. Prolonged exposure to highly intensive occupational hand tasks, for example, during the use of power grinders, may lead to disorders such as vibration white finger or carpal tunnel syndrome.

ERGONOMIC STUDY OF DRYWALL FINISHING TOOLS AND TASKS

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CONSORTIUM: Center to Protect Workers' Rights

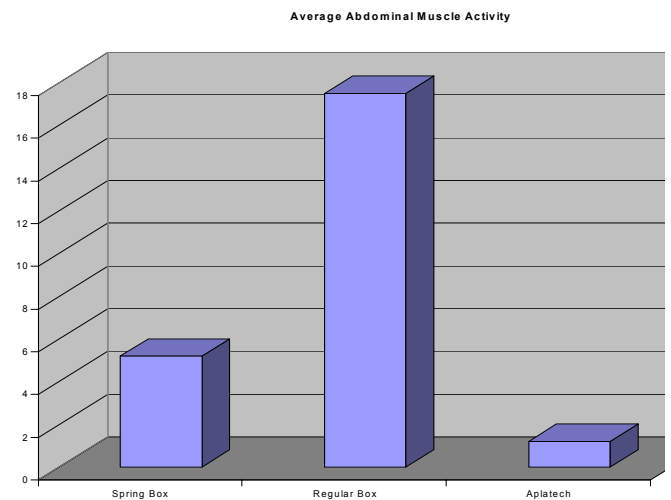
PURPOSE: Identify the ergonomic risks of drywall finishing and identify and test ways to reduce those risks.

RESEARCH SUMMARY: The drywall finishing trade is physically demanding. The tasks are highly repetitive, require significant force, and involve many awkward postures. Most finishers develop musculoskeletal injuries during their careers. In a recent survey of a small group of drywall finishers, the following symptoms were reported by the workers during the past 12 months: elbow and forearm pain, 88%; back pain, 75%; hand/wrist pain, 63%; neck pain, 38%; and shoulder pain, 38%. Almost all of these workers reported that the pain and discomfort were moderate or severe.

In this study, finishers from Painters Local 178 were surveyed, interviewed, and videotaped to identify the tasks, techniques, and tools most responsible for this high injury rate. We found that all tasks have risks associated with them, but finishing with automatic tools and hand finishing represented the most serious or common problems.

- *Automatic tools.* Automatic tools include flat boxes, tape guns, tape banjos, and pumps used to fill the tools with drywall compound. A high degree of force is required to use these tools, as well as a combination of pulling, pushing, bending at the waist, and other repetitive physical movements. Several new types of tools were tested and evaluated to study whether they could reduce the amount of force required in finishing yet be accepted by finishers. Results show that they can be both efficient and used more safely than traditional tools.
- *Hand finishing.* Risk factors in hand finishing include the high frequency of repetitions of the arm and hand movements and awkward leg, torso, shoulder, arm, and wrist postures. Hand finishing requires constant reaching overhead and bending to the floor, often within seconds of one another. Finishers are also required to adopt extreme wrist postures to smooth the wall joint.

From our analysis of hand finishing, we believe the design of hand knives can significantly alter wrist posture and the forces required to grip the handle and to smooth the joint. We are analyzing the design factors (handle shape, size, composition, and orientation to the blade; blade flexibility, depth, and composition) and finisher techniques, all of which affect the way knives are used. The results will be used to develop recommendations for best practices in the trade.



Average abdominal muscle activity (surface EMG) measured during use of three flat-finishing methods by one user.

KEYWORDS: Ergonomics, drywall finishing, best practices

BIOMECHANICS OF OCCUPATIONAL SHOULDER INJURIES

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PURPOSE: Determine if repetitive arm motion will lead to altered shoulder kinematics. Develop a simple index of muscle fatigue that is associated with repetitive arm motion and altered scapular kinematics.

RESEARCH SUMMARY: Although NIOSH has identified a clear epidemiological link between repetitive arm motion and shoulder disorders in the workplace, there are few scientific data available regarding the biomechanics of this connection. This is surprising considering that occupational shoulder disorders have a direct medical cost of \$4 billion annually in the United States.

There is evidence that repetitive motion is associated with muscle fatigue and abnormal shoulder motion, which in turn may lead to damage of the rotator cuff musculature. It is hypothesized that fatigue of the scapular muscles during a repetitive arm motion will result in a decrease in scapular motion. A fatigue index based on a muscle's electromyographic frequency components has been shown to be a good predictor of muscle impairment for low-back muscles. It is hypothesized that a similar index for scapular muscles could be associated with alterations in scapular kinematics after repetitive motion.

These hypotheses will be tested by having healthy volunteers with no shoulder pathologies perform a simulated work activity until they are fatigued. Based on NIOSH findings, this will be a high-repetition, low-load activity. Kinematics will be measured with a magnetic tracking device that has been found to be both reliable and accurate for measuring scapular motion. Fatigue susceptibility will be identified with a previously established muscle fatigue index. This proposal represents the first step toward developing a screening tool for assessing an individual's ability to resist the potentially harmful consequences of repetitive motion. Ultimately, this information will be used to develop both strategies for modifying work tasks, as well as conditioning programs for workers performing high-risk activities.

KEYWORDS: Ergonomics, repetitive strain injury, musculoskeletal disorders

RECENT CITATIONS:

Karduna, A., et al. 2002. Effects of low-load, high-repetition motion on scapular kinematics. Presentation at the World Congress of Biomechanics, Calgary, AB, Aug. 2002.

EFFECTS OF A HOME EXERCISE PROGRAM ON SHOULDER PAIN, MOTION, AND MUSCLE ACTIVITY IN CONSTRUCTION WORKERS

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CONSORTIUM: Center to Protect Workers' Rights

PURPOSE: Implement and evaluate a therapeutic exercise program to reduce pain and modify previously identified motion and muscle activity alterations in construction workers with shoulder pain related to working overhead.

RESEARCH SUMMARY: Repetitive or sustained elevated shoulder postures have been identified as a significant risk factor for occupationally related musculoskeletal disorders of the shoulder. Construction workers exposed to routine overhead work have high rates of shoulder pain that frequently progresses to functional loss and disability. Exercises may be able to reduce this progression.

One-hundred-eight volunteer workers from the construction trades (Sheet Metal Local 10, Electric Locals 29 and 110, Pipefitters Local 539, Plumbers Local 34, and Heat and Frost Insulators Local 34) were screened by their histories and clinical examinations for criteria consistent with shoulder pain and impingement syndrome. Sixty-seven symptomatic workers were randomized into a treatment intervention group (34 people) and a control group (33 people); 25 asymptomatic people participated as an additional control group. All subjects were male; mean age was 48. Subjects completed the Shoulder Rating Questionnaire (SRQ), a shoulder satisfaction rating, and answered additional work-related questions about shoulder pain and disability. They were then measured for electromyographic activity of shoulder muscles and shoulder joint kinematics during arm elevation motions. Subjects in the treatment group were given instructions for a standardized 8-week home program consisting of five shoulder stretching and strengthening exercises. Subjects in the control groups received no instruction. After 8 to 12 weeks, the subjects returned for follow-up tests. Four intervention and three control subjects were lost from follow-up.

Two-factor (group by time) analysis of variance was used to compare dependent variables (questionnaire scores, shoulder kinematics, and shoulder muscle activity between groups) over time with a significance level of $p < 0.05$. The home exercise group demonstrated significantly greater improvements in the SRQ and shoulder satisfaction scores than did the control groups, as well as significantly greater reductions in pain and disability than the control subjects. Average post-test SRQ scores for the exercise group remained below levels for asymptomatic workers. Preliminary results indicate positive improvements in motion and muscle activity variables as well.

These results suggest a home exercise program can be effective in reducing symptoms and improving function in construction workers with shoulder pain.

KEYWORDS: Ergonomic interventions, motion analysis, shoulder musculoskeletal disorders, overhead work, electromyography

RECENT CITATIONS:

Ludewig, P.M., and T.M. Cook. 2000. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. *Physical Therapy*, v. 80, pp. 276-291.

Ludewig, P.M., and J.D. Borstad. 2002. Effects of a home exercise program on shoulder symptoms and functional status in construction workers. *Journal of Orthopedic Sports Physical Therapy*, v. 32, p. A-9.

Ludewig, P.M. and T.M. Cook. 2002. Translations of the humerus in persons with shoulder impingement symptoms. *Journal of Orthopedic Sports and Physical Therapy*, v. 32, pp. 248-259.

EFFECTS OF A HOME EXERCISE PROGRAM ON PREVENTING SHOULDER PAIN IN CONSTRUCTION APPRENTICES

KEYWORDS: Ergonomic interventions, overhead work, shoulder musculoskeletal disorders, prevention

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CONSORTIUM: Center to Protect Workers' Rights

PURPOSE: Develop and evaluate an exercise and stretching program for preventing shoulder pain among construction workers involved in overhead work.

RESEARCH SUMMARY: Repetitive or sustained elevated shoulder postures have been identified as a significant risk factor for occupationally related shoulder musculoskeletal disorders. Construction workers exposed to routine overhead work have high rates of shoulder pain that frequently progresses to functional loss and disability. Exercise interventions have the potential for reducing this progression and have been shown to reduce shoulder pain and disability in journeymen construction workers.

Three-hundred apprentice construction workers are being recruited from the electrical, sheet metal, and plumbing and pipefitting trades (Sheet Metal Local 10, Electric Local 110, Pipefitters Local 539, and Plumbers Local 34). The apprentices (matched by trade) will be randomized into an exercise intervention group or a control group. Subjects will complete questionnaires on an annual basis to provide demographic, occupational exposure, and musculoskeletal symptom and injury information. Subjects randomized to the intervention group will be instructed about a standardized home program of shoulder stretching and strengthening exercises, while subjects in the control group will either receive information on stretching and strengthening exercises for the knee joint or no instruction. Subjects will be reevaluated annually for 3 years. Newly reported cases of shoulder pain confirmed by clinical screening will be incorporated annually. Three-year incidence rates will be compared across the intervention and control groups using chi-square analysis to determine if a home exercise program can effectively reduce the development of occupationally related symptoms of shoulder disorders.

EFFECT OF OVERHEAD DRILLING POSITION ON SHOULDER MOMENT AND ELECTROMYOGRAPHY

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CONSORTIUM: Center to Protect Workers' Rights

PURPOSE: Determine the effects of moving closer to work overhead while standing on a stepladder and performing simulated drilling tasks.

RESEARCH SUMMARY: Forceful exertion during tasks in which the arms are positioned overhead, such as drilling into a ceiling, may be associated with various upper-extremity musculoskeletal disorders. Extended reaches while working overhead may substantially increase upper extremity load. However, little is known whether altering upper body posture changes the load on the shoulder and upper extremity.

Twenty subjects simulated an overhead drilling task using a close-, middle-, and far-reach position while standing on either the lower or higher step of a stepladder. Muscular loads of the dominant side anterior deltoid, biceps brachii, and triceps brachii were recorded with surface electromyography. Shoulder joint moment was determined by two-dimensional static link segment modeling in the sagittal plane with a digital video. The results demonstrated that using the close-reach position significantly decreased the muscular load on the anterior deltoid and biceps brachii, but increased load on the triceps brachii when compared to the far-reach position. Using the higher step significantly decreased anterior deltoid and triceps load as well as shoulder joint moment compared to using the lower step. However, load on the biceps increased when using a close reach while on the higher step. Shoulder joint moment increased monotonically with muscular load.

These findings indicate that construction workers should generally work close to their bodies to minimize shoulder forces when performing overhead tasks.

KEYWORDS: Biomechanics, electromyography, ergonomics, musculoskeletal disorders, overhead work, posture, upper extremities

RECENT CITATIONS:

Anton, D., L.D. Shibley, N.B. Fethke, J. Hess, T.M. Cook, and J. Rosecrance. 2001. The effect of overhead drilling position on shoulder moment and electromyography. *Ergonomics*, v. 44, pp. 489-501.

Anton, D., L.D. Shibley, N.B. Fethke, J. Hess, T.M. Cook, and J. Rosecrance. 2002. Effect of step height on overhead drilling in construction. Presentation at 14th Triennial Congress of the International Ergonomics Association and 44th annual meeting of the Human Factors and Ergonomics Society.

COMPARISON OF RISK FACTORS IN CONSTRUCTION TRADES WITH CONTRASTING PREVALENCE OF CARPAL TUNNEL SYNDROME

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CONSORTIUM: Center to Protect Workers' Rights

PURPOSE: Investigate muscle load on the forearms of workers in two construction trades and associate these loads with the prevalence of carpal tunnel syndrome.

RESEARCH SUMMARY: Recent evidence suggests that carpal tunnel syndrome is prevalent among construction workers, particularly among heavy equipment operators (approximately 7%) and heavy equipment mechanics (27%). Little is known about exposure to the physical risk factors for carpal tunnel syndrome in these trades and their effects, partly because the work is noncyclic and highly variable. However, it is known that forceful exertion of the forearm may be associated with carpal tunnel syndrome or tendinitis.

Muscular load on the dominant finger flexors of 24 heavy equipment operators and 24 heavy equipment mechanics were recorded using surface electromyography for approximately 1 hour of normal work. Exposure variation analysis and clustered exposure variation analysis (CEVA), a new method of describing work exposure, were used to evaluate the forces produced by the forearm in these two trades.

The results of CEVA indicated that the mechanics spent 9% of their work time performing high-intensity, short-duration contractions of the forearm, while operators spent only 2% of their time. Mechanics spent 19% of their time performing moderate-intensity, short-duration contractions, contrasted to operator time at 7%. Operators spent a disproportionate amount of work time with either low levels of forceful exertion or resting the flexor forearm. The operators and mechanics did not differ significantly in typical nonwork-related variables (e.g., body weight) often associated with carpal tunnel syndrome.

Since mechanics may spend approximately 70% of their workday using tools, greater efforts to develop ergonomic interventions for this group may be indicated. Other types of intervention, such as increasing the amount of power tool use, may be needed.

KEYWORDS: Carpal tunnel syndrome, electromyography, ergonomics, exposure assessment, operating engineers, mechanics, musculoskeletal disorders, upper extremity.

RECENT CITATIONS:

Anton, D. 2002. A comparison of risk factors in construction trades with contrasting prevalence of carpal tunnel syndrome. Doctoral dissertation, University of Iowa.

CARPAL TUNNEL SYNDROME AMONG APPRENTICE CONSTRUCTION WORKERS

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CONSORTIUM: Center to Protect Workers' Rights

PURPOSE: Characterize the prevalence of carpal tunnel syndrome among construction apprentices.

RESEARCH SUMMARY: Symptom surveys and nerve conduction studies used to identify carpal tunnel syndrome were administered to 1,142 construction apprentices from four trades (sheet metal, electrical, plumbing and pipefitting, and operating engineers). The prevalence of carpal tunnel syndrome among all apprentices was 8.2%. Within the operating engineer trade, the prevalence of carpal tunnel syndrome was seven times greater among the mechanics working on heavy equipment than among drivers of that equipment. Body mass index, age, and self-reports of working overhead were associated with prevalent carpal tunnel syndrome. Less than 15% of the apprentices with carpal tunnel syndrome sought medical attention for their disorder. Many construction workers begin developing carpal tunnel syndrome before or during their apprenticeship training. Few apprentices seek medical attention for the hand symptoms characteristic of carpal tunnel syndrome. The results of this study indicate a public health need for the implementation of prevention strategies for carpal tunnel syndrome in the construction industry.

This study provides a better understanding of the specific work factors associated with carpal tunnel syndrome, supplies data for planning future projects to study the natural history of this disease, and assists in the development of strategies for its prevention in construction and nonconstruction workplaces.

KEYWORDS: Carpal tunnel syndrome, musculoskeletal disorders

RECENT CITATIONS:

Rosecrance, J., T.M. Cook, D. Anton, and L. Merlino. (In press.) Prevalence of carpal tunnel syndrome among apprentice construction workers. *American Journal of Industrial Medicine*.

INFLUENCE OF PHYSICAL WORKPLACE FACTORS ON THE DEVELOPMENT OF CARPAL TUNNEL SYNDROME AMONG CONSTRUCTION WORKERS

Sheet Metal Local 91, and the Plumbers and Steamfitters Local 290 Training Center.

RESEARCHER: John Rosecrance

KEYWORDS: Carpal tunnel syndrome, apprentices, prevalence

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PURPOSE: Gain insight into the etiology of carpal tunnel syndrome and determine the physical factors at construction workplaces that contribute to carpal tunnel syndrome.

RESEARCH SUMMARY: Construction is consistently ranked among the most dangerous industries and accounts for a disproportionately large percentage of occupational illnesses and injuries. Of all work-related disabling conditions in the United States, carpal tunnel syndrome accounts for the largest number of missed workdays on a per-case basis. Previous research into the prevalence of carpal tunnel syndrome among construction workers indicates it is nearly three times that of the general population. However, the causes and consequences of carpal tunnel syndrome among the 8 million people employed in the U.S. construction industry have not been investigated.

The central hypothesis of this study is that carpal tunnel syndrome will increase as exposure to stressful physical factors in the workplace increases. This hypothesis will be tested by (1) estimating the incidence rate of carpal tunnel syndrome among 1,100 construction trade workers and stratifying the incidence estimates by specific construction trades, (2) characterizing exposures to physical workplace factors among construction workers quantitatively using methods developed specifically for the highly variable noncyclic tasks common among the construction trades, and (3) estimating the risk of carpal tunnel syndrome associated with exposure to physical workplace factors while controlling for confounding variables (such as age, body mass index, gender).

The research will build on an established cohort of more than 1,100 construction workers and will be the first cohort study of incident carpal tunnel syndrome among construction workers. It will also be one of the few studies of musculoskeletal disorders that will incorporate a stringent epidemiologic classification of carpal tunnel syndrome and a direct quantitative exposure assessment. One outcome of the research will be a useful quantitative exposure assessment tool for measuring physical risk factors in a variety of work environments. The knowledge gained from this research will provide a better understanding of the etiology of carpal tunnel syndrome and lead to the development of interventions that have a positive impact on the prevention of carpal tunnel syndrome and other musculoskeletal disorders.

Collaborators on this project include Quad Cities Electrical Joint Apprenticeship and Training Committee, Operating Engineers Local 150,

MUSCULOSKELETAL DISORDERS AMONG APPRENTICE CONSTRUCTION WORKERS

RESEARCHER: John Rosecrance

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CONSORTIUM: Center to Protect Workers' Rights

PURPOSE: Examine the frequency of self-reported musculoskeletal disorder symptoms, the frequency of work missed due to these symptoms, and factors that may be associated with these conditions in four construction trades.

RESEARCH SUMMARY: Musculoskeletal disorders are a major cause of work-related disabilities and lost-time illnesses. Workers in the construction trades have the second highest incident rate for reported illnesses and injuries. With about 8 million people employed in the construction industry, this represents a substantial problem. Data are limited on the prevalence of musculoskeletal disorders among construction workers and the factors that may be associated with these disorders. In addition, determination of what factors contribute to lost time by workers who do report musculoskeletal symptoms is lacking. Information on these factors may contribute to finding solutions to reduce absenteeism.

Self-administered surveys among a cohort of apprentice construction workers in four trades (plumbing, electrical, sheet metal, and operating engineer) from four states were obtained. The results indicate that the low back was the body area most commonly reported for job-related musculoskeletal injuries among all workers in all trades. Pain in the low back was also the most common reason for missing work among construction workers. The wrist/hand and knee also appear to be sites of problems for apprentice construction workers. Continuing to work with an injury is the factor most commonly identified with missing work.

Musculoskeletal disorders are a significant problem among young construction workers at the beginning of their careers. Primary and secondary prevention strategies are needed early in the apprentice training program to reduce disabilities associated with work-related musculoskeletal disorders.

Construction trade collaborators include the Quad Cities Electrical Joint Apprenticeship and Training Committee, Operating Engineers Local 150, Sheet Metal Local 91, and the Plumbers and Steamfitters Local 290 Training Center.

KEYWORDS: Musculoskeletal disorders, job risk factors, injury

RECENT CITATIONS:

Merlino, L., J.C. Rosecrance, D. Anton, and T.M. Cook. (Jan. 2003. In press.) Musculoskeletal disorders and job factors among apprentice construction workers. *Applied Occupational and Environmental Hygiene*.

MUSCULOSKELETAL DISORDERS AMONG APPRENTICE AND EXPERIENCED HUNGARIAN CONSTRUCTION WORKERS

RESEARCHER: John Rosecrance

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PURPOSE: Determine the prevalence of occupationally related musculoskeletal disorders and carpal tunnel syndrome among construction workers in Hungary.

RESEARCH SUMMARY: Symptoms of occupational musculoskeletal disorders and the job factors contributing to these symptoms were determined through an administered symptom and job factors survey. The prevalence of carpal tunnel syndrome was assessed among apprentices on the basis of a case definition that included hand symptoms and nerve conduction studies of the median nerve across the carpal tunnel. The participation rate was 96% among the 201 eligible construction apprentices and 65 experienced construction workers. The average ages of the apprentices and experienced construction workers were 17 and 48 years, respectively.

More than 50% of the apprentices reported occupationally related musculoskeletal symptoms in the previous 12 months. Job tasks that required awkward postures and working in a static position were the two factors that contributed most to musculoskeletal disorders. No cases of carpal tunnel syndrome were found in this sample of apprentices. In a pilot project of 65 Hungarian journeyman construction workers, the prevalence of musculoskeletal disorders in all parts of the body, number of missed work days, and visits to physicians were nearly twice as high for experienced workers as compared to apprentices. For example, 58% of the 65 experienced construction workers reported work-related musculoskeletal disorders in the low back as compared to 30% of the apprentices. (It was surprising, however, that apprentices in their late teens reported work-related musculoskeletal disorders at such an early age.) Whereas 42% of experienced Hungarian construction workers missed work due to low back symptoms, only 12% of the apprentices missed work for this reason. This difference suggests that the musculoskeletal disorders among apprentices may be less severe than those among experienced construction workers.

The higher prevalence of symptoms among experienced construction workers is likely to be related to a combination of factors, including general health, age, and the cumulative physical stresses involved with construction tasks. Although disorders of the musculoskeletal system are more prevalent among experienced construction workers, this study indicates that symptoms of musculoskeletal disorders are present among young workers. Assessing the magnitude and nature of occupation-related musculoskeletal disorders is the first step in promoting a healthier, safer, and more efficient workforce.

KEYWORDS: Carpal tunnel syndrome, musculoskeletal disorders, Hungary

RECENT CITATIONS:

Rosecrance, J.C., J. Proszasz, T. Cook, D. Anton, E. Fekecs, and T.T. Karacsony. 2000. Musculoskeletal disorders among young apprentices and journey-level construction workers in Hungary. *Ergonomics*, v. 43, no. 7, pp. 640-643.

Rosecrance, J., J. Proszasz, E. Fekecs, T. Karacsony, L. Merlino, D. Anton, and T. Cook. 2001. Musculoskeletal disorders among Hungarian construction apprentices. *Central European Journal of Public Health*, v. 9, no. 4, pp. 183-187.

OCCUPATIONAL LOW BACK PAIN IN RESIDENTIAL CARPENTRY: ELEMENTS OF POSTURE AND STRAIN

KEYWORDS: Low back disorders, carpenters, residential construction

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PURPOSE: Identify and measure potential ergonomic job-task-related causes of occupational back pain among carpenters engaged in residential construction framing.

RESEARCH SUMMARY: Occupational back pain is America's No. 1 workplace safety challenge. Back pain is second only to the common cold as a cause of lost gainful employment. Estimates of primary and secondary costs to the nation's economy because of back pain range from \$50 to \$100 billion annually.

Ergonomic elements have been implicated in the onset of back pain in many industries, and construction has been identified as an industry with excessive numbers of sufferers of back pain because it requires heavy physical demands to complete many tasks.

The relationship of personal and worksite characteristics to work practices, environmental exposures, job tasks, and back pain will be evaluated among 350 carpenters engaged in residential framing. The study will involve focus groups, job site ergonomic analyses, and surveys to identify job tasks being performed and perceived exertion rating, and establish quantitative measures of spinal loading. The immediate, 12-month, and lifetime prevalence of low back pain among workers will be determined. The software programs ErgoMaster and Ovako Working Posture Analysis will be used to assess posture and loading. The forces perceived by workers as they complete tasks will be compared to measured demands. An integrated model for the prediction of back pain in residential carpentry will be developed using subjective and objective variables.

The ultimate goal of this study is to lay the groundwork for preventing back injuries among residential construction workers by a better understanding of the actual causes.

EFFECT OF LIGHTWEIGHT BLOCK ON MUSCULAR LOAD AND CARDIOVASCULAR STRESS IN BRICKLAYERS

KEYWORDS: Bricklaying, electromyography, ergonomic interventions, low back and upper-extremity musculoskeletal disorders

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CONSORTIUM: Center to Protect Workers' Rights

PURPOSE: Determine the effects of using lightweight concrete blocks on muscle activity, physiological variables, and fatigue compared to using standard-weight concrete blocks.

RESEARCH SUMMARY: Work-related musculoskeletal disorders of the low back, shoulder, and upper extremity are common in the masonry trade. Repetitive heavy lifting of concrete blocks and awkward postures may contribute to these disorders. However, few interventions have been proposed that could reduce these risk factors. An 8- by 8- by 16-in (20.3- by 20.3- by 40.6-cm) standard concrete block weighs approximately 38 lb (17.2 kg). A similar-sized lightweight concrete block weighs approximately 10 lb (4.5 kg) less. Little is known about the physiological effects of laying lightweight block compared to laying standard block.

Twenty-one third- and fourth-year apprentices or journeyman bricklayers from the International Union of Bricklayers and Allied Craftworkers Local No. 3 of Iowa participated in the study. Each subject constructed two walls 80 in wide by 55.5 in high (203.2 by 141.0 cm), seven courses high, in a running bond pattern in the laboratory. One wall was constructed with standard concrete block and one with lightweight concrete block. The bricklayers were instructed to lay the block at their usual work pace and to lay mortar in the typical fashion. The musculoskeletal load of the bricklayers' bilateral low back (erector spinae), upper back (upper trapezius), and finger flexors, as well as the dominant side wrist extensors, were recorded telemetrically with surface electromyography while the wall was constructed. Heart rate was also telemetrically recorded.

Preliminary results suggest a substantial reduction in muscle load on the upper back while laying lightweight block, especially at the higher courses. No difference was noted in posture using either type of block. The bricklayers in the study constructed the wall slightly faster using the lightweight block.

EVALUATION AND INTERVENTION IN CONSTRUCTION OR DEMOLITION OF CONCRETE STRUCTURES

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PURPOSE: Evaluate the methods, tools, and work reorganizations designed to reduce exposure to risks for musculoskeletal disorders in concrete work and other stages of construction.

RESEARCH SUMMARY: Construction workers have the highest rates of musculoskeletal disorders of any industrial population. Evaluation of the risk factors for developing musculoskeletal disorders is difficult because of the dynamic nature of the industry. Previous work within the Construction Occupational Health Program at the University of Massachusetts led to the development of an ergonomic assessment tool that enabled the quantification of risk in the nonroutine work environments characteristic of construction. The present 5-year study continues to develop the PATH (posture, activities, tools, handling) method for studying the postural risk associated with various tasks in the construction or demolition of concrete structures and examines the impact of ergonomic improvements on defined construction tasks by comparing tasks with and without interventions.

Tasks identified as having high risks for musculoskeletal injury were considered for possible ergonomic interventions. These tasks were selected on the basis of outcomes of construction ergonomics training in the trades, informal interviews and data collection, observations by trained ergonomics professionals, and health and safety committees. For example, two alternative methods for manually moving slickline (concrete hose) were compared using 530 pre- and post-PATH observations. An articulated arm attached to the end of the slickline showed a decrease in trunk flexion and a decrease in force. A slide skid showed an increase in trunk deviation, and forces are still being calculated. Other on-going investigations include studies of abrasive blasting, rebar tying, concrete reinforcement construction, and concrete form construction. Information from this study is being disseminated in local newsletters and project-related networks in the area for practical use by industry.



KEYWORDS: Musculoskeletal disorder, highway construction, constructing or deconstructing concrete structures

RECENT CITATIONS:

Buchholz, B., V. Paquet, H. Wellman, and M. Forde. (In press.) Quantification of ergonomic hazards for ironworkers performing concrete reinforcement tasks during heavy highway construction. *American Industrial Hygiene Association Journal*.