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applications, developing a business case, and engaging wearables in risk assessment and post-injury compensability assessment.

Albers, J., et al. (2005). "Identification of ergonomics interventions used to reduce musculoskeletal loading for building installation tasks." *Appl Ergon* 36(4): 427-439.

Skilled workers in the mechanical and electrical installation (M/EI) building and construction trades experience high rates of disabling work-related musculoskeletal disorders (WMSDs). The M/EI trades involve installing piping; heating, ventilation and air conditioning (HVAC), and electrical systems in residential, commercial, and industrial buildings. In the absence of an ergonomics standard in

One of the main issues in occupational studies focusing on musculoskeletal disorders of the upper extremity is how to best quantify workers' exposures to risk factors during a workday. Direct measurement is preferred because it is objective and provides precise measurements. To measure elevation angle exposure of the upper extremity, accelerometers are commonly used. The main problem with the use of accelerometers is the fact that they are sensitive to linear acceleration and can only assess two axes of rotation. In the present study the Virtual Corset, a pager-sized, battery powered, tri-axial linear accelerometer with an integrated data logger, was validated in vitro for the reconstruction of elevation angles under static conditions and angle error prediction under dynamic conditions. For static conditions, the RMS angle error was less than 1°. Under dynamic conditions the elevation angle error was influenced by the radius and angular acceleration. However, the angle error was predicted well with an RMS difference of 3°. It was concluded that the Virtual Corset can be used to accurately predict arm elevation angles under static conditions. Under dynamic conditions, an understanding of the motion being studied and the placement of the Virtual Corset relative to the joint are necessary.

Anderson, A. M., et al. (2007). "A biomechanical analysis of anterior load carriage." *Ergonomics* 50(12): 2104-2117.

Front load carriage is a common occupational task in some industries (e.g. agriculture, construction), but, as compared to lifting tasks, relatively little research has been conducted on the biomechanical loading during these activities. The focus of this study was to explore the low back biomechanics during these activities and, specifically, to examine the effects of load height and walking speed on trunk muscle activity and trunk posture. Eleven male participants participated in two separate front load-carriage experiments. The first experiment called for carrying a barbell (with weight corresponding to 20% of elbow flexion strength) at three heights (knuckle height, elbow height and shoulder height) at a constant horizontal distance from the spine. The second experiment called for participants to carry a bucket of potatoes weighing 14 kg at the same three heights, but with no further restrictions in technique. In both experiments, the participants performed this task while either standing still or walking at a self-selected speed. As they performed these tasks, the activity levels of the right-side muscle of the rectus abdominis, external oblique, biceps brachii, anterior deltoid and three levels (T9, T12 and L3) of the erector spinae were sampled. Mid-sagittal plane trunk posture was also quantified using three magnetic field-based motion sensors at T9, T12 and L3. The results showed a significant effect of both walking speed and load height on trunk posture and trunk muscle activity levels in both the barbell and bucket experiments. In the barbell experiment, the walking trials generated 43% more trunk muscle activity than the standing trials. Trials at shoulder height produced 11% more muscle activity than trials at elbow height in the T9 erector spinae muscles and 71% more muscle activity in the anterior deltoid. In the bucket experiment, trunk muscle activity responded in a similar fashion, but the key result here was the quantification of the natural hyperextension posture of the spine used to balance the bucket of potatoes. These results provide insight into muscle activation patterns in dynamic settings,

a stepladder. Root mean square amplitude (AMP) of EMG activity from the dominant side anterior deltoid, biceps brachii and triceps brachii muscles was used to determine muscular load. Digital video was used to determine shoulder joint moment using 2-dimensional static link segment modelling in the sagittal plane. The results demonstrated that, compared to the far reach position, using the close reach position significantly decreased anterior deltoid AMP and biceps brachii AMP and moment, but increased triceps brachii AMP. Compared to the lower step, using the higher step significantly decreased anterior deltoid AMP and triceps AMP and moment, while increasing biceps AMP in the close position. There was no significant change noted in EMG median frequency indicating that fatigue was minimized. Moment increased monotonically with AMP. The findings indicated that workers performing overhead tasks should work close to their body in order to minimize shoulder forces. The implications of this recommendation are discussed.

Antonucci, A., et al. (2017). "Effect of Bit Wear on Hammer Drill Handle Vibration and Productivity." *J Occup Environ Hyg* 14(8): 642-651.

INTRODUCTION: The use of large electric hammer drills exposes construction workers to high levels of hand vibration that may lead to hand arm vibration syndrome and other musculoskeletal disorders. The aim of this laboratory study was to investigate the effect of bit wear on drill handle vibration and drilling productivity (e.g., drilling time per hole). **METHODS:** A laboratory test bench system was used with an 8.3 kg electric hammer drill and 1.9 cm concrete bit (a typical drill and bit used in commercial construction). The system automatically advanced the active drill into aged concrete block under feed force control to a depth of 7.6 cm while handle vibration was measured according to ISO standards (ISO 5349 and 28927). Bits were worn to 4 levels by consecutive hole drilling to 4 cumulative drilling depths: 0, 1900, 5700 and 7600 cm. **RESULTS:** Z-axis handle vibration increased significantly ($p < 0.05$) from 4.8 to 5.1 m/s^2 (ISO weighted) and from 42.7 to 47.6 m/s^2 (unweighted) when comparing a new bit to a bit worn to 1900 cm of cumulative drilling depth. Handle vibration did not increase further with bits worn more than 1900 cm of cumulative drilling depth. Neither x- nor y- axis handle vibration was effected by bit wear. The time to drill a hole increased by 58% for the bit with 5700 cm of cumulative drilling depth compared to a new bit.

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self-report and job title based ratings. CONCLUSIONS: Both work and personal factors mediated median nerve impairment. Construction workers are at an increased risk of CTS so awareness should be raised and interventions should specifically target this risk group.

Atkins, D. and A. S. B. Bohnert (2022). "The Work-Opioid Connection: What Do Construction Workers and Military Veterans Have in Common?" *Am J Public Health* 112(S1): S33-S35.

Baek, W. and G. Sheean (2007). "Occupational dystonia affecting truncal muscles in a bricklayer." *Mov Disord* 22(2): 284-285.

(Case of a neurological disorder caused by poor ergonomic work conditions)

Bangaru, S. S., et al. (2020). "Data Quality and Reliability Assessment of Wearable EMG and IMU Sensor for Construction Activity Recognition." *Sensors (Basel)* 20(18).

The workforce shortage is one of the significant problems in the construction industry. To overcome the challenges due to workforce shortage, various researchers have proposed wearable sensor-based systems in the area of construction safety and health. Although sensors provide rich and detailed information, not all sensors can be used for construction applications. This study evaluates the data quality and reliability of forearm electromyography (EMG) and inertial measurement unit (IMU) of armband sensors for construction activity classification. To achieve the proposed objective, the forearm EMG and IMU data collected from eight participants while performing construction activities such as screwing, wrenching, lifting, and carrying on two different days were used to analyze the data quality and reliability for activity recognition through seven different experiments. The results of these experiments show that the armband sensor data quality is comparable to the conventional EMG and IMU sensors with excellent relative and absolute reliability between trials for all the five activities. The activity classification results were highly reliable, with minimal change in classification accuracies for both the days. Moreover, the results conclude that the combined EMG and IMU models classify activities with higher accuracies compared to individual sensor models.

Berrios-Torres, S. I., et al. (2003). "World Trade Center rescue worker injury and illness surveillance, New York, 2001." *Am J Prev Med* 25(2): 79-87.

BACKGROUND: The September 11, 2001, terrorist attacks on the World Trade Center

injuries and/or illnesses reported times 200,000 (100 equivalent full-time 0 pics00 equivalent full

Worker Health intervention study. **METHODS:** Survey responses and health assessments were collected from a total of 349 employees in two municipal utility departments. **RESULTS:** Participants demonstrated poor weight control and body mass index and provided reports of frequent poor health habits, injury, and pain. Although safety climate was good, less desirable levels of psychosocial workplace stressors and supports were observed. These stressors and supports were found to relate with many of the health, injury, and pain indicators. **CONCLUSIONS:** These results demonstrate the need for workplace interventions to promote and protect construction worker health and the importance of the psychosocial work environment.

Borstad, J. D., et al. (2009). "A longitudinal analysis of the effects of a preventive exercise programme on the factors that predict shoulder pain in construction apprentices." *Ergonomics* 52(2): 232-244.

Construction apprentices are at risk for developing shoulder pain with increasing exposure to repetitive overhead work. Risk may decrease if shoulder biomechanics are optimised and if risk factors that contribute to shoulder pain onset are identified. This prospective cohort study examined demographic and work-related factors and shoulder pain onset over 2 years in a cohort of 240 construction apprentices. Approximately 50% of the sample (n = 117) performed a home exercise programme intended to have a protective effect, while the other 50% served as controls. The proportion of new-onset shoulder pain in the control group was higher than in the exercise group. Regression analysis identified four factors related to new-onset shoulder pain: previous neck pain; working in hot, cold or humid conditions; subject height; and bending and twisting the back. This information may assist employers and workers in preventing shoulder pain. By knowing factors predictive of shoulder pain development in construction workers, employers can take measures to protect workers and may secondarily decrease medical expenses and maintain productivity. Previous neck pain, working in extreme environmental conditions and being shorter all increased a worker's risk of developing shoulder pain. Exercises to optimise shoulder biomechanics have a small effect on preventing shoulder pain development. © 2009 Taylor & Francis.

Borstad, J. D. and P. M. Ludewig (2002). "Comparison of scapular kinematics between elevation and lowering of the arm in the scapular plane." *Clin Biomech (Bristol, Avon)* 17(9-10): 650-659.

OBJECTIVE: To compare scapular orientation during both the concentric (elevation) and eccentric (lowering) phases of scapular plane abduction in subjects with and without shoulder impingement. **DESIGN:** Mixed model analysis of variance with one between-subjects factor (group) and within-subjects factors of phase, humeral angle, and trial. **BACKGROUND:** Abnormal scapular kinematics have been identified in patients with shoulder impingement.

The researchers completed a secondary data analysis of 217 interviews conducted in 2009 with

OBJECTIVE: We characterize and compare the self-reported physical exposures, work tasks, and OSHA-10 training in a non-probabilistic sample of temporary and payroll construction workers. **METHODS:** In June 2016, a total of 250 payroll and temporary general laborers employed at Florida construction sites completed a survey at the job site as part of the falls reported among minority employees (FRAME) study. **RESULTS:** Workers employed through temp agencies (57.1%) were significantly more likely to report moving or lifting materials more than 100 pounds than payroll workers (38.5%; $P < 0.01$). Temporary construction workers with 10-hour OSHA training (22.2%) spent significantly less time with intense hand use/awkward hand posture than temporary workers without 10-hour OSHA training (46.9%; $P = 0.048$). **CONCLUSIONS:** Temp construction workers with OSHA 10-hour training reported less hazardous physical postures than workers without the same training.

Chávez, S. and C. E. Altman (2017). "Gambling with life: Masculinity, risk, and danger in the lives of unauthorized migrant roofers." *Am J Ind Med* 60(6): 537-547.

Background: This paper examines the occupational experiences of unauthorized immigrants employed in one of the most dangerous occupations in the United States: roofing. **Methods:** We draw on 40 in-depth interviews with return migrants in Guanajuato, Mexico, to examine how the adoption of masculinity, dangerous working conditions, the labor market structure, and absence of legal status exacerbates injuries for unauthorized roofers. **Findings:** Undocumented men return to Mexico injured with chronic pain, health complications, and trauma. We find that men "do gender" that is adopt masculine beliefs, when they skirt safety practices, police each other's behaviors, withhold their emotions, experience heightened stress, and engage in poor health behaviors. It is a combination of dangerous working conditions, economic insecurity, and men seeking to fulfill their masculine roles that all combine to create unsafe working conditions and lead to injuries. © 2017 Wiley Periodicals, Inc.

Cheng, T., et al. (2013). "Data Fusion of Real-Time Location Sensing and Physiological Status Monitoring for Ergonomics Analysis of Construction Workers." *Journal of Compu*

were used to test 20 construction workers for straight walking or turning, with or without carrying tools while wearing safety shoes or stilts at different heights. The results indicated that gait on stilts is characterised by increases in stride length, step width and the percentage of double support period, dec

materials. The findings from this study may assist safety and health professionals in the constr

This paper quantified the incidence of opioid use and OUD among construction workers with and without musculoskeletal disorders. METHODS: We conducted a retrospective study using union health claims from January 2015 to June 2018 from 19,909 construction workers. Claims for diagnoses of chronic musculoskeletal disorders, acute musculoskeletal injuries,

work, high job strain, heavy lifting, low coworker support, and low supervisor support were each independently associated with one or more work or health outcomes. These findings suggest that interventions should seek to improve coworker and supervisory supportive behaviors, decrease job strain, and reduce organizational stressors, such as mandatory overtime work. Our study shows disparities in health and safety between construction sectors and highlights the need for interventions tailored to the residential sector.

Dale, A. M., et al. (2011). "Evaluation of anti-vibration interventions for the hand during sheet metal assembly work." *Work* 39(2): 169-176.

OBJECTIVE: Occupational use of vibrating hand tools contributes to the development of upper extremity disorders. While several types of vibration damping materials are commercially available, reductions in vibration exposure are usually tested in the laboratory rather than in actual work environments. This study evaluated reductions in hand vibration with different vibration damping interventions under actual work conditions. **METHODS:** Three experienced sheet metal assemblers at a manufacturing facility installed sheet metal fasteners with a pneumatic tool using no vibration da

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determine if higher physical exposures in construction lead to higher rates of claims on personal medical

weight, the peak loads for the half-weight bags were only 25% less than the more available full-weight bags (a reduction of about 320 N of shear and 1000 N of compression). Lifts allowing movement of the feet reduced the loads by about 22% in shear and 27% in compression compared to constrained postures. Interestingly, cumulative spine loads were greater for the lighter bags than the heavy bags (approximately 40%). The subjective ratings of exertion and risk were significantly lower for the lighter bags. **RELEVANCE TO INDUSTRY:** The reduction in peak spine loading for the half-weight bags, particularly at the higher heights and when the feet were allowed to move could significantly reduce the injuries of masonry workers. However, there were trade-offs with cumulative loads that may minimize the reduced risk. Overall, given the limited amount of time lifting bags, the reduction of peak loads.

DeArmond, S., et al. (2011). "Individual safety performance in the construction industry: development and validation of two short scales." *Accid Anal Prev* 43(3): 948-954.

In the current research a short measure of safety performance is developed for use in the construction industry and the relationships between different components of safety performance and safety outcomes (e.g., occupational injuries and work-related pain) are explored within the construction context. This research consists of two field studies. In the first, comprehensive measures of safety compliance and safety participation were shortened and modified to be appropriate for use in construction. Evidence of reliability and validity is provided. Both safety compliance and safety participation were negatively related to occupational injuries, yet these two correlations were not statistically different. In the second study, we investigated the relationships between these two components of safety performance and work-related pain frequency, in addition to replicating Study 1. Safety compliance had a stronger negative relationship with pain than safety participation. Implications for research are discussed.

Diaz Fuentes, C. M., et al. (2016). "Latino immigrant day laborer perceptions of occupational safety and health information preferences." *Am J Ind Med* 59(6): 476-485.

BACKGROUND: We address immigrant day laborers' experiences with occupational safety in the construction industry in New Orleans, and opinions about content and method of communication for educational interventions to reduce occupational risks. **METHODS:** In 2011, we conducted seven focus groups with 48 Spanish-speaking day laborers (8 women, 40 men, 35 years on average). Focus group results are based on thematic analysis. **RESULTS:** Most employers did not provide safety equipment, threatened to dismiss workers who asked for it, and did not provide health insurance. Attitudes toward accepting unsafe work conditions varied. Women faced lower pay and hiring difficulties than men. Day laborers preferred audio format over written, and content about consequences from and equipment for different jobs/exposures. **CONCLUSIONS:** Day laborers have common occupational experiences, but differences existed by gender, literacy and sense of control over safety. Day laborer information preferences and use of media needs further studying. *Am. J. Ind. Med.* 59:476-485, 2016. (c) 2016 Wiley Periodicals, Inc.

Dong, R. G., et al. (2004). "An evaluation of the standardized chipping hammer test specified in ISO 8662-2." *Ann Occup Hyg* 48(1): 39-49.

OBJECTIVES: Prolonged exposure to severe chipping hammer vibration may cause hand-arm vibration syndrome. A reliable test method is required to select appropriate tools and assist in the development of better chipping hammers. In the present study, the ISO

injuries and musculoskeletal disorders significantly increased prescription opioid use among construction workers. To prevent opioid use disorders, multipronged strategies should be approached. (*Am J Public Health*. 2022;112(S1):S77-S87. <https://doi.org/10.2105/AJPH.2021.306510>).

Dong, X. S., et al. (2014). "Risks of a lifetime in construction Part I: Traumatic injuries." *Am J Ind Med* 57(9): 973-983.

Background: Estimates of occupational risk are typically computed on an annual basis. In contrast, this article provides estimates of lifetime risks for fatal and nonfatal injuries among construction workers. A companion paper presents lifetime risks for occupational illnesses. Methods: Using 2003-2007 data from three large data sources, lifetime risk was computed based on the number of fatal and nonfatal injuries per 100 FTEs for a working lifespan of 45 years. Results: For a working life in construction, the risk of fatal injuries were approximately one death per 200 FTE, and the leading causes were falls and transportation incidents. For nonfatal injuries resulting in days away from work, the adjusted lifetime risk was approximately 78 per 100 FTEs, and the leading causes were contact with objects/equipment, overexertion, and falls to a lower level. Conclusions: Lifetime risk estimates help inform both workers and policymakers. Despite improvements over the past decades, risks in construction remain high. *Am. J. Ind. Med.* 57:973-983, 2014. © 2014 Wiley Periodicals, Inc.

Dong, X. S., et al. (2011). "Chronic diseases and functional limitations among older construction workers in the United States: a 10-year follow-up study." *J Occup Environ Med* 53(4): 372-380.

OBJECTIVES: To examine the health status of older construction workers in the United States, and how occupation and the aging process affect health in workers' later years. **METHODS:** We analyzed six waves (1998 to 2008) of the Health and Retirement Study, a longitudinal survey of US residents age 50+. The study sample totaled 7200 male workers (510 in construction trades) in the baseline. Multiple logistic regression and paired t tests were conducted to compare health outcomes across occupations and within individuals over time. **RESULTS:** Compared with white-collar workers, construction workers had increased odds of arthritis, back problems, chronic lung disease, functional limitations, work disability, and work-related injuries after controlling for possible confounders. **CONCLUSIONS:** Safety and health interventions, as well as retirement and pension policy, should meet the needs of older construction workers, who face increasingly chronic health conditions over time.

Dong, X. S., et al. (2012). "Chronic back pain among older construction workers in the United States: a longitudinal study." *Int J Occup Environ Health* 18(2): 99-109.

This study assessed chronic back pain among older construction workers in the United States by analyzing data from the 1992-2008 Health and Retirement Study (HRS), a large-scale longitudinal survey. Fixed-effects methods were applied in the multiple logistic regression model to explore the association between back pain and time-varying factors (e.g., employment, job characteristics, general health status) while controlling for stable variables (e.g., gender, race, ethnicity). Results showed that about 40% of older construction workers over the age of

exposed to a greater risk of developing knee MSDs with the increase of roof slope during shingle installation due to increased muscle loading. Abbreviations: MSDs: musculoskeletal disorders; EMG: electromyography; ANOVA: analysis of variance; MNMA: maximum normalized muscle activation; RF: rectus femoris; VL: vastus lateralis; VM: vastus medialis; BF: biceps femoris; S: semitendinosus.

Eilertsen, M., et al. (2018). "Characterization of load reduction while lifting drywall using an unpowered drywall lifting device." *Work* 60(4): 661-671.

BACKGROUND: Drywall installation has an injury rate four times that of the construction industry average. Workers are exposed to hazards related to slips, falls, and falling objects, in addition to the large and awkward loads they must carry. Drywall sheets can weigh more than 100 lb. and contribute to disabling musculoskeletal injuries of the shoulders and

conducted a retrospective study of 234 active construction workers with medical claims for CTS and 249 workers without CTS claims; non-cases were matched on age, trade, and insurance eligibility. We conducted telephone interviews with cases and non-cases and collected administrative data on work hours. Results: Compared to non-cases, CTS cases were more likely to report recurrent hand

OBJECTIVES: This study examined the effect of sampling duration, in units of work cycles, on the precision of estimates of exposure to forceful exertion obtained with surface electromyography (EMG). **METHODS:** Recordings of the activity of the flexor digitorum superficialis, extensor digitorum, and upper trapezius muscles over 30 consecutive work cycles were obtained for a random sample of 25 manufacturing workers, each of whom was performing a unique production task representing a portion of the whole job. The mean root-mean-square amplitude and the 10th, 50th, and 90th percentiles of the distribution function of the amplitude probability were calculated for each cycle. Bootstrap analyses were used to examine the precision of the summary measures as the sampling duration increased incrementally from 1 to 30 work cycles. Precision was estimated by calculating the coefficient of variation (CV) of the bootstrap distributions at each sampling duration increment. **RESULTS:** The average minimum sampling duration for a bootstrap distribution CV of 15% ranged from 2.0 (SD 1.5) cycles to 7.5 (SD 9.6) cycles, depending on muscle and summary measure. For a 5% CV, the average minimum sampling duration ranged from 11.9 (SD 9.0) to 20.9 (SD 10.5) cycles. **CONCLUSIONS:** The results suggest that sampling as few as three work cycles was sufficient to obtain a bootstrap distribution CV of 15% for some of the muscles and summary measures examined in this study. While limited to machine-paced, cyclic manufacturing work, these results will assist the development of exposure assessment strategies in future epidemiologic studies of physical risk factors and musculoskeletal disorders.

Fethke, N. B., et al. (2011). "Comparison of biomechanical loading during use of conventional stud welding equipment and an alternate system." *Appl Ergon* 42(5): 725-734.

We investigated the effect of an alternative welding system designed to reduce exposure to extreme trunk flexion on measures of trunk inclination and muscle activity. Among 10 participants, data were collected while using conventional stud welding equipment and while using the alternate system. Paired t-tests were used to compare results between the two welding systems. Mean trunk inclination angle was reduced with the alternate system (34.4 degrees versus 9.7 degrees, $p < 0.01$). Percent time with trunk inclination angles greater than 60 degrees was also reduced (40.0% versus 4.7%, $p < 0.01$). In general, the alternate system resulted in less desirable upper trapezius muscle activity levels. The alternate system appears to be effective in reducing exposure to extreme trunk flexion among stud welders. Continued development of the system should explore features designed to reduce shoulder forces and improve productivity.

Forde, M. S., et al. (2005). "Prevalence of musculoskeletal disorders in union ironworkers." *J Occup Environ Hyg* 2(4): 203-212.

The prevalence of musculoskeletal disorder (MSD) symptoms and doctor-diagnosed musculoskeletal disorders (DDMDs) were estimated among union construction ironworkers by a telephone-administered questionnaire. Of 1996 ironworkers eligible, 1566 were contacted and 981 were interviewed. The prevalence of self-reported MSD symptoms was high for the lower back (56%), wrist/hands/fingers (40%), knees (39%), and shoulders (36%). The most common DDMDs were tendonitis (19%), ruptured disk in the back (18%), bursitis in the shoulder (15%), and carpal tunnel syndrome (12%). Generally, the prevalence of DDMDs and MSD symptoms increased with duration of employment. In age-adjusted logistic regression analyses, those who

(OR 5.1, 95% CI 1.025.1), and ruptured intervertebral back disk (OR 6.7, 95% CI 2.617.5). The effect of prior injury was also consistently high (upper extremities, OR 4.6; lower extremities OR 5.1; lower back, OR 6.0). Among workers without prior injuries, MSD symptoms were more frequent for the lower back in structural ironwork (OR 1.7, 95% CI 1.12.6), and for the upper extremity in concrete reinforcement ironwork (OR 1.9, 95% CI 1.22.9). These findings suggest that some musculoskeletal morbidity in construction ironworkers may be work related and thus preventable.

Free, H., et al. (2020). "Lifetime Prevalence of Self-Reported Work-Related Health Problems Among U.S. Workers - United States, 2018." *MMWR Morb Mortal Wkly Rep* 69(13): 361-365.

Approximately 2.8 million nonfatal workplace illnesses and injuries were reported in the United States in 2018 (1). Current surveillance methods might underestimate the prevalence of occupational injuries and illnesses (2,3). One way to obtain more information on occupational morbidity is to assess workers' perceptions about whether they have ever experienced health problems related to work (4). Occupational exposures might directly cause, contribute to, exacerbate, or predispose workers to various health problems (work-related health problems). CDC's National Institute for Occupational Safety and Health estimated the lifetime prevalence of self-reported, work-related health problems for the currently employed population overall and stratified by various demographic and job characteristics using data from the 2018 version of the SummerStyles survey. Overall, 35.1% of employed respondents had ever experienced a work-related health problem (95% confidence interval [CI] = 33.0%-37.3%). The most commonly reported work-related health problem was back pain (19.4%, 95% CI = 17.6%-21.2%). Among industries, construction (48.6%, 95% CI = 36.54%-60.58%) had the highest prevalence of any work-related health problems. Workplace injury and illness prevention programs are needed to reduce the prevalence of work-

grown to contain nearly 2,000 items, with more than 30,000 unique visitors each month, including safety and health professionals, researchers, workers, contractors and trainers. The site's content had also diversified. For example, a search on noise brings up presentations, videos, images of noisy situations, toolbox talks, handouts for use by trainers or employers, as well as recent research findings and studies on noise and hearing conservation....

Gilkey, D. P., et al. (2007). "Low back pain in Hispanic residential carpenters." *J Chiropr Med* 6(1): 2-14.

OBJECTIVE: Low back pain (LBP) is a leading cause of lost work time and has been recognized as America's number one workplace safety challenge. Low back pain is occurring at epidemic proportions among construction workers, and minority populations have been underinvestigated for risk of back injury. This project investigated the multiple potential risk factors for occupational LBP among Hispanic residential carpenters. **METHODS:** This investigation evaluated 241 Hispanic residential framing carpenters. Data for this study were collected using a 91-question survey. End points of interest included point, annual, and lifetime prevalence of LBP. **RESULTS:** Nineteen percent of respondents reported they had an episode of LBP in their lifetime. **CONCLUSIONS:** Hispanic residential carpenters reported less than expected prevalence of LBP compared with non-Hispanic counterparts in the same trade and location. Job tasks and personal and workplace risk factors, including psychological and morphological characteristics, affect the prevalence of LBP among Hispanic framing carpenters.

Gilkey, D. P., et al. (2007). "Low back pain among residential carpenters: ergonomic evaluation using OWAS and 2D compression estimation." *Int J Occup Saf Ergon* 13(3): 305-321.

Occupational low back pain (LBP) remains a leading safety and health challenge. This cross-sectional investigation measured the prevalence of LBP in residential carpenters and investigated ergonomic risk factors. Ninety-four carpenters were investigated for LBP presence and associated risk factors. Ten representative job-tasks were evaluated using the Ovako Working Posture Analysis System (OWAS) and ErgoMaster 2D software to measure elements of posture, stress, and risk. Job-tasks were found to differ significantly for total lumbar compression and shear at peak loading ($p < .001$), ranging from 2 956 to 8 606 N and 802 to 1 974 N respectively. OWAS indicated that slight risk for injury was found in 10 job-tasks while distinct risk was found in 7 of the 10 job-tasks. Seven of the 10 job-tasks exceeded the National Institute for Occupational Safety and Health (NIOSH) action limit of 3 400 N for low back loading. The point prevalence for LBP was 14% while the annual prevalence was 38%.

Golabchi, A., et al. (2015). "An Automated Biomechanical Simulation Approach to Ergonomic Job Analysis for Workplace Design." *Journal of Construction Engineering and Management* 141(8): 04015020.

Work-related musculoskeletal disorders (WMSDs) are reported to be the most common category of nonfatal occ

had higher rates of OROD. CONCLUSIONS: These findings underscore the need for policy and educational interventions to reduce OROD tailored to the needs of high rate worker populations. Interventions should address workplace hazards that cause injuries for which opioids are prescribed, as well as best practices in medical management and return to work following injury, safer prescribing, enhanced access to treatment for opioid use disorders, and overdose prevention education.

Hess, J., et al. (2010). "Ergonomic best practices in masonry: regional differences, benefits, barriers, and recommendations for dissemination." *J Occup Environ Hyg* 7(8): 446-455.

Within construction the masonry trade has particularly high rates of musculoskeletal disorders (MSDs). A NIOSH-sponsored meeting of masonry stakeholders explored current and potential "Best Practices" for reducing MSDs in masonry and identified potential regional differences in use of practices. To verify and better understand the regional effects and other factors associated with differences in practice use, a national telephone survey of masonry contractors was conducted. The United States was divided into four regions for evaluation: Northeast, Southeast, Midwest, and West Coast. Nine practices with the potential to reduce MSDs in masonry workers were evaluated. Masonry contractors, owners, and foremen completed 183 surveys. The results verify regional differences in use of best practices in masonry. Half-weight cement bags and autoclave aerated concrete were rarely used anywhere, while lightweight block and mortar silos appear to be diffusing across the country. The Northeast uses significantly fewer best practices than other regions. This article examines reasons for regional differences in masonry best practice, and findings provide insight into use and barriers to adoption that can be used by safety managers, researchers, and other safety advocates to more effectively disseminate ergonomic solutions across the masonry industry.

Hess, J. A., et al. (2004). "A participatory ergonomics intervention to reduce risk factors for low-back disorders in concrete laborers." *Appl Ergon* 35(5): 427-441.

Construction laborers rank high among occupational groups with work-related musculoskeletal injuries involving time away from work. The goals of this project were to: (1) introduce an ergonomic innovation to decrease the risk of low-back disorder (LBD) group membership, (2) quantitatively assess exposure, and (3) apply a participatory intervention approach in construction. Laborers manually moving a hose delivering concrete to a placement site were evaluated. The hypothesis tested was that skid plates would prevent hose joints from catching on rebar matting, and the hose would slide more easily. This would decrease the need for repetitive bending and use of excessive force. Four laborers were evaluated wearing the Lumbar Motion Monitor (LMM), a tri-

higher velocities and accelerations, yet neither tool placed workers at risk for wrist injury. The ESG resulted in significantly less low back flexion, left-sided bending and twisting, velocity and acceleration. The probability of low back disorder group membership risk was 53% with TSG use and 47% with ESG use. Carpenters liked using ESGs and reported less exertion when using them. The ESG's autofeed feature enhanced productivity. Training may be important to further reduce back flexion and improve tool maintenance, and design changes would improve ESGs overall.

Hess, J. A., et al. (2010). "The impact of drywall handling tools on the low back." *Appl Ergon* 41(2): 305-312.

Carpenters and other construction workers who install drywall have high rates of strains and sprains to the low back and shoulder. Drywall is heavy and awkward to handle resulting in increased risk of injury. The purpose of this study was to evaluate several low-cost coupling tools that have the potential to reduce awkward postures in drywall installers. Five coupling tools were evaluated using the Lumbar Motion Monitor that measures trunk kinematics and predicts probability of low back disorder group membership risk (LBD risk). Workers answered surveys about their comfort while using each tool. The results indicate that use of the 2-person manual lift and the J-handle provide the best reduction in awkward postures, motions, low back sagittal moment, and LBD risk. The two-person manual lift appears to be the safest method of lifting and moving drywall, though using the two-person J-handle also significantly reduces injury risk. Given that carpenters are skeptical about using equipment that can get in the way or get lost, a practical recommendation is promotion of two-person manual lifting. For single-person lifts, the Old Man tool is a viable option to decrease risk of MSDs.

Hess, J. A., et al. (2012). "Alternatives to lifting concrete masonry blocks onto rebar: biomechanical and perceptual evaluations." *Ergonomics* 55(10): 1229-1242.

This study examined the use of and barriers to H-block and high lift grouting, two alternatives to lifting concrete masonry blocks onto vertical rebar. Peak and cumulative shoulder motions were evaluated, as well as adoption barriers: H-block cost and stakeholder perceptions. Results indicated that using the alternatives significantly decreased peak shoulder flexion ($p < 0.001$). A case study indicated that building cost was higher with H-block, but the difference was less than 2% of the total cost. Contractors and specifiers reported important differences in perceptions, work norms, and material use and practices. For example, 48% of specifiers reported that use of high lift grouting was the contractor's choice, while 28% of contractors thought it must be specified. Use of H-block or high-lift grouting should be considered as methods to reduce awkward upper extremity postures. Cost and stakeholders' other perceptions present barriers that are important considerations when developing diffusion strategies for these alternatives. **PRACTITIONER SUMMARY:** This study provides information from several perspectives about ergonomic controls for a high risk bricklaying task, which will benefit occupational safety experts, health professionals and ergonomists. It adds to the understanding of shoulder stresses, material cost and stakeholder perceptions that will contribute to developing effective diffusion strategies. iD2.-2

occurred during the third hour of work. Training interventions should be extensively utilized for inexperienced workers, and prework exercises could potentially reduce injury frequency and severity.

Hsiao, H., et al. (2008). "Effect of scaffold end frame carrying strategies on worker stepping response, postural stability, and perceived task difficulty." *Hum Factors* 50(1): 27-36.

cab design checklist. However, results of the cab design checklist were not significantly correlated with shoulder abduction or awkward postures of the neck and trunk. Results suggest that the cab design checklist may be useful for identifying cab design characteristics that need further improvement and for identifying design characteristics that increase shoulder flexion. The strength of the repeatability assessment suggests that outcomes of the cab design checklist administered by different individuals may be consistent, independent of the type of equipment being assessed.

Kao, D. S., et al. (2008). "Serological tests for diagnosis and staging of hand-arm vibration syndrome (HAVS)." *Hand (N Y)* 3(2): 129-134.

The current gold standard for the diagnosis and staging of hand-arm vibration syndrome (HAVS) is the Stockholm workshop scale, which is subjective and relies on the patient's recalling ability and honesty. Therefore, great potentials exist for diagnostic and staging errors. The purpose of this study is to determine if objective serum tests, such as levels of soluble thrombomodulin (sTM) and soluble intercellular adhesion molecule-1 (sICAM-1), may be used in the diagnosis and staging of HAVS. Twenty two nonsmokers were divided into a control group (n = 11) and a vibration group (n = 11). The control group included subjects without history of frequent vibrating tool use. The vibration group included construction workers with average vibrating tool use of 12.2 years. All were classified according to the Stockholm workshop scale (SN, sensorineural symptoms; V, vascular symptoms. SN0, no numbness; SN1, intermittent numbness; SN2, reduced sensory perception; SN3, reduced tactile discrimination; V0, no vasospastic attacks; V1, intermittent vasospasm involving distal phalanges; V2, intermittent vasospasm extending to middle phalanges; V3, intermittent vasospasm extending to proximal phalanges; V4, skin atrophy/necrosis). All control subjects were SN0 V0. Seven out of 11 vibration subjects were SN1 V1, and 4 out of 11 were SN1 V2. A 10-cm³ sample of venous blood was collected from each subject. The sTM and sICAM-1 levels were determined by enzyme-linked immunosorbent assay. The mean plasma sTM levels were as follows: control group = 2.93 +/- 0.47 ng/ml, and vibration group = 3.61 +/- 0.24 ng/ml. The mean plasma sICAM-1 levels were as follows: control group = 218.8 +/- 54.1 ng/ml, and vibration group = 300.3 +/- 53.2 ng/ml. The sTM and sICAM-1 differences between control and vibration groups were statistically significant (p < 0.0002 and p < 0.001, respectively). When reference ranges provided by Hemostasis Reference Lab were used as cut-off values, all sTM and sICAM-1 levels were within range, except three vibration individuals (27%) who had sICAM-1 levels greater than the reference range. This was not statistically significant (p = 0.08). When subjects were compared based on the Stockholm workshop scale, mean plasma sTM levels were SN0 V0 group = 2.93 +/- 0.47 ng/ml, SN1 V1 group = 3.59 +/- 0.25 ng/ml, and SN1 V2 group = 3.65 +/- 0.27 ng/ml, and mean plasma sICAM-1 levels were SN0 V0 = 219 +/- 54.1 ng/ml, SN1 V1 = 275 +/- 33.5 ng/ml, and SN1 V2 = 345 +/- 54.6 ng/ml. The difference in sTM level among the three groups was statistically significant (p < 0.001). The difference in sICAM-1 level among the three groups was also statistically significant (p < 0.002). The sTM and sICAM-1 levels are statistically higher in subjects with HAVS, with levels proportional to the disease

Kaur, H., et al. (2021). "Workers' Compensation Claim Rates and

New technology designed to increase productivity in residential construction may exacerbate the risk of work-related musculoskeletal disorders (WMSDs) among residential construction workers. Of interest here are panelised (prefabricated) wall systems (or panels) and facilitating an ongoing effort to provide proactive control of ergonomic exposures and risks among workers using panels. This study, which included 24 participants, estimated WMSD risks using five methods during common panel erection tasks and the influences of panel mass (sheathed vs. unsheathed) and size (wall length). WMSD risks were fairly high overall; e.g. 34% and 77% of trials exceeded the 'action limits' for spinal compressive and shear forces, respectively.

ergonomics, both identifying and correcting work hazards is often difficult because of these changing work environments. In the past decade, the incidence rates of nonfatal occupational injuries and illnesses for construction have been consistently higher than those of private industry despite a trend of reduction for both categories. The Bureau of Labor Statistics (BLS) data for 2002 shows an incidence rate of nonfatal occupational illnesses and injuries of 7.1 recordable cases per 100 workers for construction compared with 5.3 recordable cases per 100 workers for private industry. The goals of this study were to (1) develop an ergonomic intervention (a footer pad drop device) designed to reduce lowback disc compression force for a manual material handling task in which a construction crew member lifts and releases concrete footer pads into predrilled holes, (2) determine the estimated effect of the intervention on lowback compression force, (3) determine the effect of the intervention on other work intensity measures such as heart rate and self-reported ratings of perceived exertion, and (4) characterize the pre- and post-intervention mean cycle time associated with the task of interest.

Kucera, K. L., et al. (2011). "Medical care surrounding work-related back injury claims among Washington State Union Carpenters, 1989-2003." *Work* 39(3): 321-330.

OBJECTIVE: We describe medical care received through workers' compensation (WC) and union-provided insurance surrounding work-related back injuries and examine relationships between care provided and time off work among a large cohort of carpenters. **METHODS AND PARTICIPANTS:** Union records identified a cohort of 20,642 carpenters working in Washington State from 1989-2003 and their private health insurance claims. These data were linked to workers' compensation files from this state-run program including records of medical care. **RESULTS:** Over 74,000 WC medical encounters resulted from 2959 work-related back injuries. Eleven percent received private care for musculoskeletal back pain within 90 days of work-related injury; this proportion increased with increasing lost days. Delay to physical therapy was more prevalent among those out of work longest. The proportion of claimants with care from both systems and from private utilization only increased after the first 90 days and, for the subset with at least one paid lost work day, after return to work. **CONCLUSIONS:** Examination of medical care through both systems versus solely in workers' compensation provides a more complete understanding of back injury care while also demonstrating complexity. Differences in outcomes based upon treatment shortly after injury are worthy of further exploration.

Kucera, K. L., et al. (2009). "Predictors of delayed return to work after back injury: A case-control analysis of union carpenters in Washington State." *Am J Ind Med* 52(11): 821-830.

METHODS: Union administrative records identified 20,642 union carpenters who worked in Washington State from 1989 to 2003. The Department of Labor and Industries provided records of workers' compensation claims and associated medical care. Work-related back claims (n = 4,241) were identified by ANSI codes (back, trunk, or neck/back) or ICD-9 codes relevant to medical care consistent with a back injury. Cases (n = 738) were defined as back injury claims with >90 days of paid lost time; controls (n = 699) resulted in return to work within 30 days. Logistic regression models estimated odds ratios and 95% confidence intervals (OR, 95% CI) of delayed return to work (DRTW). **RESULTS:** Thirty percent of case claims and 8% of control claims were identified by an ICD-9 code. DRTW after back injury was associated with being female (2.7, 95% CI: 1.3-5.5), age 30-44 (1.2, 95% CI: 0.9-1.7) and age over 45 (1.6, 95% CI: 1.1-2.3), four or more years union experience (1.4, 95% CI: 1.1-1.8), previous

paid time loss back claim (1.8, 95% CI: 1.3-2.5), and ≥ 30 -day delay to medical care (3.6, 95% CI: 2.1, 6.1). Evidence of more acute trauma was also associated with DRTW.

CONCLUSIONS: Use of ICD-9 codes identified claims with multiple injuries that would otherwise not be captured by ANSI codes alone. Though carpenters of younger age and inexperience were at increased risk for a paid lost time back injury claim, older carpenters and more experienced workers, once injured, were more likely to have DRTW as were those who experienced acute events.

Lee, W., et al. (2020). "Workforce development: understanding task-level job demands-resources, burnout, and performance in unskilled construction workers." *Safety science* 123: 104577.

This study examines how task demands and personal resources affect unskilled construction worker productivity and safety performance. It extends the job demands-resources (JD-R) burnout model to show how job characteristics interact with burnout to influence performance. A modified model was designed to measure burnout, with exhaustion and disengagement among unskilled construction workers taken into consideration. An observational study was conducted in a laboratory environment to test the research hypotheses and assess the prediction accuracies of outcome constructs. Twenty-two subjects participated in multiple experiments designed to expose them to varying levels of task-demands and to record their personal resources as they performed common construction material-handling tasks.

Specifically, both surveys and physiological measurements using wearable sensors were used to operationalize the model constructs. Moreover, partial least squares structural equation modeling was applied to analyze data collected at the task and individual levels. Exhaustion and disengagement exhibited different relationships with productivity and safety performance outcomes as measured by unit rate productivity and ergonomic behavi-2 n01 (w)2 (e)4 (r)- (n)-10 (c)rei rtrtedon

injury. **METHODS:** This study identified a dynamic cohort of 18 768 carpenters who worked in the State of Washington 1989-2003, their hours worked each month, and their work-related back injuries and medical claims for treatment including ICD-9 codes. Using Poisson regression we calculated rates and rate ratios (RRs) of incident and recurrent injury adjusting for age, gender, union tenure and type of carpentry work. Predictors of subsequent musculoskeletal back injury were explored based on different definitions of the incident injury, as were time periods of greatest risk following return to work. **RESULTS:** Recurrent back injuries occurred at a rate 80% higher than initial injuries. Survival curves were significantly different for incident and recurrent injuries, but patterns of relative risk were similar. Individuals with greatest union tenure were at lowest risk, likely reflecting a healthy worker effect or lower physical exposures with seniority. Individuals with long periods of work disability with their first injury were at particularly high risk of subsequent musculoskeletal injury compared with those with no prior history (RR 2.3; 95% CI 2.0 to 2.7), as were individuals with degenerative diagnoses (RR 2.0; 95% CI 1.5 to 2.6). Risk for second injury peaked between 1000 and 1500 h after return to work and then gradually declined. **CONCLUSIONS:** Carpenters with long periods of work disability following back injury warrant accommodation and perhaps better rehabilitation efforts to avoid re-injury. Challenges to workplace accommodation and limited ability to clearly define readiness to return to work following injury demonstrate the need for primary prevention of back injuries through attention to engineering solutions among carpenters involved in strenuous work.

Lipscomb, H. J., et al. (2009). "Compensation costs of work-related back disorders among union carpenters, Washington State 1989-2003." *Am J Ind Med* 52(8): 587-595.

OBJECTIVE: Factors associated with private health insurance payment rates for musculoskeletal back disorders were examined among a 15-year cohort of union carpenters. Payment patterns were contrasted with work-related back injury rates over time. **METHODS:** Negative binomial regression was used to assess payment rates; generalized estimated equations accounted for multiple observations per person and cost correlation within subjects. **RESULTS:** Payment rates increased after work-related injury and with the number of injuries. Increasing private payments and deductibles (inflation-adjusted and discounted) were observed in contrast with a marked decline in reported work-related injuries. **CONCLUSIONS:** Private insurance payments do not appear to be independent of work-related back injury. Findings suggest cost-shifting from workers' compensation to the union-provided health insurance and to the worker; they also provide a warning regarding reliance on workers' compensation statistics for surveillance of work-related disorders or disease.

Lipscomb, H. J., et al. (2009). "Health care utilization for musculoskeletal back disorders, Washington State union carpenters, 1989-2003." *J Occup Environ Med* 51(5): 604-611.

OBJECTIVE: Private health care utilization rates for musculoskeletal back disorders were contrasted to rates of work-related injuries or disorders for a large cohort of union carpenters over a 15-year period. **METHODS:** Yearly utilization rates were compared with rates of work-related back injuries or disorders. Negative binomial regression with generalized estimating equations was used to assess utilization rates based on age, gender, union tenure, type of work, and previous work-related back injuries. **RESULTS:** Private utilization rates were over twice as high in 2003 as in 1989 whereas compensation rates declined substantially. Utilization was higher among carpenters with less union tenure and increased with the number of work-related injuries. **CONCLUSIONS:** Patterns of utilization across private and workers' compensation delivery systems are not independent; we need to look broadly at sources of health care coverage to better understand the health of working populations.

Lipscomb, H. J., et al. (2006). "Injuries from slips and trips in construction." *Appl Ergon* 37(3): 267-274.

Construction injuries preceded by a slip or trip were documented using data from the building of the Denver International Airport (Denver, Colorado, USA), the largest construction project in the world at the time. Slips and trips occurred at a rate of 5/200,000 h worked accounting for 18% of all injuries and 25% of workers' compensation payments, or more than \$10 million. Slips contributed to the vast majority (85%) of same-level falls and over 30% of falls from height, as well as a significant number of musculoskeletal injuries sustained after slipping or tripping but without falling. The injury burden would have been under-recognized in analyses of most coded compensation records. In contrast to other types of injuries, the most common contributing factors were environmental in nature including conditions of walking and working surfaces, terrain and weather. Due to the very dynamic nature of construction work, reducing slips and trips will require a focus on environmental and organizational solutions that evolve as the site changes and the construction project evolves.

Lipscomb, H. J., et al. (2015). "Musculoskeletal concerns do not justify failure to use safer sequential trigger to prevent acute nail gun injuries." *Am J Ind Med* 58(4): 422-427.

Background: Acute nail gun injuries can be controlled significantly by using tools with sequential triggers and training. Concern has been raised that sequential triggers, which require

that the nose piece of the gun be depressed prior to pulling the trigger, could increase risk of musculoskeletal problems. Methods: We conducted active injury surveillance among union carpenter apprentices to monitor acute injuries and musculoskeletal disorders between 2010 and 2013. Results: Acute injury risk was 70% higher with contact trip rather than sequential triggers. Musculoskeletal risk was comparable (contact trip 0.09/10,000hr (95% CI, 0.02-0.26); sequential 0.08/ 10,000hr (95% CI 0.02-0.23)). Conclusions: Concern about excess risk of musculoskeletal problems from nail guns with sequential triggers is unwarranted. Both actuation systems carry comparable musculoskeletal risk which is far less than the risk of acute injury; there is clearly no justification for failure to prevent acute injuries through use of the safer sequential trigger. Am. J. Ind. Med. 58:422-427, 2015. © 2015 Taylor & Francis (1)-2 (ur)3 (e3 (ndubtype /Footer

Lipscomb, H. J., et al. (2015). "Workers' compensation claims for musculoskeletal disorders and injuries of the upper extremity and knee among union carpenters in Washington State, 1989-2008." *Am J Ind Med* 58(4): 428-436.

BACKGROUND: Numerous aspects of construction place workers at risk of musculoskeletal disorders and injuries (MSDIs). Work organization and the nature of MSDIs create surveillance challenges. **METHODS:** By linking union records with workers' compensation claims, we examined 20-year patterns of MSDIs involving the upper extremity (UE) and the knee among a large carpenter cohort. **RESULTS:** MSDIs were common and accounted for a disproportionate share of paid lost work time (PLT) claims; UE MSDIs were three times more common than those of the knee. Rates declined markedly over time and were most pronounced for MSDIs of the knee with PLT. Patterns of risk varied by extremity, as well as by age, gender, union tenure, and predominant work. Carpenters in drywall installation accounted for the greatest public health burden. **CONCLUSIONS:** A combination of factors likely account for the patterns observed over time and across worker characteristics. Drywall installers are an intervention priority.

Lowe, B., et al. (2013). "Finger Tendon Travel Associated with Sequential Trigger Nail Gun Use." *IIE Trans Occup* 1(2): 109-118.

BACKGROUND: Pneumatic nail guns used in wood framing are equipped with one of two triggering mechanisms. Sequential actuation triggers have been shown to be a safer alternative to contact actuation triggers because they reduce traumatic injury risk. However, the sequential actuation trigger must be depressed for each individual nail fired as opposed to the contact actuation trigger, which allows the trigger to be held depressed as nails are fired repeatedly by bumping the safety tip against the workpiece. As such, concerns have been raised about risks for cumulative trauma injury, and reduced productivity, due to repetitive finger motion with the sequential actuation trigger. **PURPOSE:** This study developed a method to predict cumulative finger flexor tendon travel associated with the sequential actuation trigger nail gun from finger joint kinematics measured in the trigger actuation and productivity standards for wood-frame construction tasks. **METHODS:** Finger motions were measured from six users wearing an instrumented electrogoniometer glove in a simulation of two common framing tasks-wall building and flat nailing of material. Flexor tendon travel was calculated from the ensemble average kinematics for an individual nail fired. **RESULTS:** Finger flexor tendon travel was attributable mostly to proximal interphalangeal and distal interphalangeal joint motion. Tendon travel per nail fired appeared to be slightly greater for a wall-building task than a flat nailing task. The present study data, in combination with construction industry productivity standards, suggest that a high-production workday would be associated with less than 60 m/day cumulative tendon travel per worker (based on 1700 trigger presses/day). **CONCLUSION AND APPLICATIONS:** These results suggest that exposure to finger tendon travel from sequential actuation trigger nail gun use may be below levels that have been previously associated with high musculoskeletal disorder risk.

Lowe, B. D., et al. (2020). "Review of Construction Employer Case Studies of Safety and Health Equipment Interventions." *Journal of Construction Engineering and Management* 146(4): 04020012.

This paper presents a review of 153 case studies of equipment interventions to improve safety and health of construction businesses in Ohio in 2003–2016. These represent

\$6.46 million (2016 USD) in purchases incentivized through the Ohio Bureau of Workers' Compensation (OHBWC) Safety Intervention Grant (SIG) program. The source data in the review were extracted from employer grant applications and final reports of the case studies. Results were aggregated by type of construction equipment and included the reduction in safety and ergonomic hazards (risk factors for work-related musculoskeletal disorders), and an assessment of the quality of the case studies as determined through criteria established by the authors. Equipment associated with greatest reduction in risk factors and with case studies of higher quality were electrical cable feeding/pulling systems, concrete sawing equipment, skid steer attachments for concrete breaking, and manlifts (boom lifts). This review illustrates challenges in demonstrating efficacy of equipment interventions to improve construction safety/health—even from case studies within a structured health/safety program. The authors are aware of no other systematic review of case studies reporting on experiences with health/safety intervention equipment specific to the construction industry.

Lucas, D. L., et al. (2020). "Using Workers' Compensation Claims Data to Describe Nonfatal Injuries among Workers in Alaska." *Saf Health Work* 11(2): 165-172.

BACKGROUND: To gain a better understanding of nonfatal injuries in Alaska, underutilized data sources such as workers' compensation claims must be analyzed. The purpose of the current study was to utilize workers' compensation claims data to estimate the risk of nonfatal, work-related injuries among occupations in Alaska, characterize injury patterns, and prioritize future research. **METHODS:** A dataset with information on all submitted claims during 2014-2015 was provided for analysis. Claims were manually reviewed and coded. For inclusion in this study, claims had to represent incidents that resulted in a nonfatal acute traumatic injury, occurred in Alaska during 2014-2015, and were approved for compensation. **RESULTS:** Construction workers had the highest number of injuries (2,220), but a rate lower than the overall rate (34 per 1,000 construction workers, compared to 40 per 1,000 workers overall). Fire fighters had the highest rate of injuries on the job, with 162 injuries per 1,000 workers, followed by law enforcement officers with 121 injuries per 1,000 workers. The most common types of injuries across all occupations were sprains/strains/tears, contusions, and lacerations. **CONCLUSION:** The successful use of Alaska workers' compensation data demonstrates that the information provided in the claims dataset is meaningful for epidemiologic research. The predominance of sprains, strains, and tears among all occupations in Alaska indicates that ergonomic interventions to prevent overexertion are needed. These findings will be used to promote and guide future injury prevention research and interventions.

Ludewig, P. M. and J. D. Borstad (2000) "Effects of a home exercise programme on shoulder pain and functional status in construction workers." *Occup Environ Med* 60(11): 841- 849.

Background: Repetitive or sustained elevated shoulder postures have been identified as a significant risk factor for occupationally related shoulder musculoskeletal disorders.

33); asymptomatic subjects (n = 25) participated as an additional control group. Subjects in the intervention group were instructed in a standardised eight week home exercise programme of five shoulder stretching and strengthening exercises. Subjects in the control groups received no intervention. Subjects returned after 8-12 weeks for follow up testing. Results: The intervention group showed significantly greater improvements in the Shoulder Rating Questionnaire (SRQ) score and shoulder satisfaction score than the control groups. Average post-test SRQ scores for the exercise group remained below levels for asymptomatic workers. Intervention subjects also reported significantly greater reductions in pain and disability than controls. Conclusions: Results suggest a home exercise programme can be effective in reducing symptoms and improving function in construction workers with shoulder pain.

Ludewig, P. M. and T. M. Cook (2002). "Translations of the humerus in persons with shoulder impingement symptoms." 2stse-2 (s)-1 (.)10(t)-2 (s)-1 (s)-5g1(pt)-2 ()-1 ()-1 (-2 (s)-1 (.)10 (")-2 (2s)-8 (de)6.)-

SAS-callable SUDAAN software. RESULTS: About 11.2 million workers reported WUEMSDs based on three surveys (2006, 2009, and 2014). The 30-day prevalence of WUEMSDs was 8.23% the prevalence of WUEMSDs affecting work was 1.24%. The Construction occupation and industry had the highest age- and sex-adjusted 30-day prevalence of WUEMSDs (10.98% for Construction occupation; 9.94% for Construction industry) and WUEMSDs affecting work (3.32% for Construction occupation; 2.31% Construction industry). CONCLUSIONS: Our results show that construction workers had the highest prevalence of both WUEMSDs and WUEMSDs affecting work. They may be a priority group for interventions to reduce upper extremity musculoskeletal disorders.

Mahmud, D., et al. (2022). "Identifying Facilitators, Barriers, and Potential Solutions of Adopting Exoskeletons and Exosuits in Construction Workplaces." *Sensors (Basel)* 22(24).

Exoskeletons and exosuits (collectively termed EXOs) have the potential to reduce the risk of work-related musculoskeletal disorders (WMSDs) by protecting workers from exertion and muscle fatigue due to physically demanding, repetitive, and prolonged work in construction workplaces. However, the use of EXOs in construction is in its infancy, and much of the knowledge required to drive the acceptance, adoption, and application of this technology is still lacking. The objective of this research is to identify the facilitators, barriers, and corresponding solutions to foster the adoption of EXOs in construction workplaces through a sequential, multistage Delphi approach. Eighteen experts from academia, industry, and government gathered in a workshop to provide in (t)-2 (ons).prt[(r)-7 (e7i)-2 (ght)-2(O)02pidlutithehr, Bshrg the facilitatoen

McCoy, A. J., et al. (2013). "Twenty years of work-related injury and illness among union carpenters in Washington State." *Am J Ind Med* 56(4): 381-388.

BACKGROUND: Individuals who work in the construction industry are at high risk of occupational injury. Robust surveillance systems are needed to monitor the experiences of these workers over time. **METHODS:** We updated important surveillance data for a unique occupational cohort of union construction workers to provide information on long-term trends in their reported work-related injuries and conditions. Combining administrative data sources, we identified a dynamic cohort of union carpenters who worked in Washington State from 1989 through 2008, their hours worked by month, and their workers' compensation claims. Incidence rates of reported work-related injuries and illnesses were examined. Poisson regression was used to assess risk by categories of age, gender, time in the union, and calendar time contrasting medical only and paid lost time claims. **RESULTS:** Over the 20-year study period, 24,830 carpenters worked 192.4 million work hours. Work-related injuries resulting in medical care or paid lost time (PLT) from work occurred at a rate of 24.3 per 200,000 hr worked (95% CI: 23.5-25.0). Medical only claims declined 62% and PLT claims declined 77%; more substantive declines were seen for injuries resulting from being struck and falls to a lower level than from overexertion with lifting. Differences in risk based on union tenure and age diminished over time as well. **CONCLUSIONS:** Significant declines in rates of reported work-related injuries and illnesses were observed over the 20-year period among these union carpenters. Greater declines were observed among workers with less union tenure and for claims resulting in PLT.

McGaha, J., et al. (2014). "Exploring physical exposures and identifying high-risk work tasks within the floor layer trade." *Appl Ergon* 45(4): 857-864.

Introduction: Floor layers have high rates of musculoskeletal disorders yet few studies have examined their work exposures. This study used observational methods to describe physical exposures within floor laying tasks. **Methods:** We analyzed 45 videos from 32 floor layers using Multimedia-Video Task Analysis software to determine the time in task, forces, postures, and repetitive hand movements for installation of four common flooring materials. We used the WISHA checklists to define exposure thresholds. **Results:** Most workers (91%) met the caution threshold for one or more exposures. Workers showed high exposures in multiple body

the percent of positive responses to musculoskeletal symptom questions. Odds ratios and 95 percent confidence intervals were the measures of association between prevalent musculoskeletal symptoms and demographic, leisure, and job factors and were determined by logistic regression. The low back was the site most commonly reported for job-related musculoskeletal symptoms (54.4%), which was also the most common reason for seeking care from a physician (16.8%) and missing work (7.3%). Number of years worked in the construction trade was significantly associated with knee (p-trend = 0.0009) and wrist/hand (p-trend < 0.04) MSD symptoms and was suggestive of an association with low back pain (p-trend = 0.05). "Working in the same position for long periods" was the job factor identified as most problematic, with 49.7 percent of all construction apprentices rating it as a moderate/major problem contributing to musculoskeletal symptoms. Musculoskeletal symptoms are a significant problem among young construction workers at the beginning of their careers. Prevention strategies are needed early in the apprentice training program to reduce the potential disability associated with work-related musculoskeletal symptom disorders.

Mitropoulos, P. and M. Namboodiri (2011). "New Method for Measuring the Safety Risk of Construction Activities: Taseodir:ic, wndt (i)-2 (vi)-2 (a)4 (t)-0 (T)71 (a)71 (a)it an.1 (t)-J (t)-2u2 (onn)-2 (pt)-2

subdivides construction work into the categories of stage, operation, task, and activity. It is based on a bidding specification system already in use within the industry and thus provides a terminology common among workers, supervisors, and managers. The identification of tasks and activities that are present in multiple stages and/or trades contributes to the efficiency of

claims in the construction and services sectors, as well as for claims arising from falls and motor vehicle crashes. Conclusions: The results suggest that the construction and service sectors confront unique challenges to prevention and management of LBP disability, LBP related to discrete antecedents such as falls and motor vehicle crashes merits consideration on the basis of exceptionally severe disability. (C) 2000 Wiley-Liss, Inc.

Nahmens, I. and L. H. Ikuma (2012). "Effects of lean construction on sustainability of modular homebuilding." *Journal of Architectural Engineering* 18(2): 155-163.

Construction activities and the built environment have an enormous effect on the environment, human health, and the overall economy. Sustainable homebuilding in all three dimensions of economic, environmental, and social effects is attainable through practical innovations and technologies. However, the greatest barrier to the widespread application of sustainable homebuilding is the higher initial costs largely attributable to the learning curve of workers building with these practical innovations and technologies, and the added cost resulting from ill-defined construction processes. To address these challenges and reach the ideal of sustainable construction, this paper proposes the use of lean construction as a viable and effective strategy, in particular the lean tool kaizen. This paper uses several case studies to showcase the effect of lean on the triple bottom line of sustainability in modular homebuilding. Each case study highlights one dimension of sustainability. Lean construction resulted in a significant environmental effect by reducing material waste by 64%, a significant social effect by reducing or eliminating key safety hazards of excessive force, poor posture, and struck-by, and a significant economic effect by reducing production hours by 31%. Findings from this research will contribute to a better understanding of the effect of lean on homebuilding sustainability and will promote lean and safe building techniques in modular homebuilding. © 2012 American Society of Civil Engineers.

Nath, N. D., et al. (2017). "Ergonomic analysis of construction worker's body postures using wearable mobile sensors." *Appl Ergon* 62: 107-117.

Construction jobs are more labor-intensive compared to other industries. As such, construction workers are often required to exceed their natural physical capability to cope with the increasing complexity and challenges in this industry. Over long periods of time, this sustained physical and mental stress leads to the workers which in turn, (p. 10) (p. 11) (p. 12) (p. 13) (p. 14) (p. 15) (p. 16) (p. 17) (p. 18) (p. 19) (p. 20) (p. 21) (p. 22) (p. 23) (p. 24) (p. 25) (p. 26) (p. 27) (p. 28) (p. 29) (p. 30) (p. 31) (p. 32) (p. 33) (p. 34) (p. 35) (p. 36) (p. 37) (p. 38) (p. 39) (p. 40) (p. 41) (p. 42) (p. 43) (p. 44) (p. 45) (p. 46) (p. 47) (p. 48) (p. 49) (p. 50) (p. 51) (p. 52) (p. 53) (p. 54) (p. 55) (p. 56) (p. 57) (p. 58) (p. 59) (p. 60) (p. 61) (p. 62) (p. 63) (p. 64) (p. 65) (p. 66) (p. 67) (p. 68) (p. 69) (p. 70) (p. 71) (p. 72) (p. 73) (p. 74) (p. 75) (p. 76) (p. 77) (p. 78) (p. 79) (p. 80) (p. 81) (p. 82) (p. 83) (p. 84) (p. 85) (p. 86) (p. 87) (p. 88) (p. 89) (p. 90) (p. 91) (p. 92) (p. 93) (p. 94) (p. 95) (p. 96) (p. 97) (p. 98) (p. 99) (p. 100)

Nimbarte, A. D., et al. (2010). "Neck disorders among construction workers: understanding the physical loads on the cervical spine during static lifting tasks." *Ind Health* 48(2): 145-153.

In this study a common yet very strenuous construction work activity, was evaluated biomechanically by studying electromyography (EMG) of the major neck muscles. The muscles studied were the sternocleidomastoid and the upper trapezius. Fifteen healthy participants (10 males and 5 females) with no history of musculoskeletal abnormalities participated in this study. The participants lifted 25%, 50%, and 75% of their maximum shoulder height static strength at neutral, maximally flexed, and maximally extended neck postures. The weight lifted as well as the neck posture significantly affected the activities of the neck muscles. Increase in the weight increased the activation of the neck muscles. The sternocleidomastoid muscle was most active at the extended neck posture, while the upper trapezius muscle was most active at

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implementation of the DSS. Successful development of such tools, which allow for proactive control of exposures, is argued as having substantial potential benefit.

Paquet, V., et al. (2005). "Reliable exposure assessment strategies for physical ergonomics stressors in construction and other non-routinized work." *Ergonomics* 48(9): 1200-1219.

The objective of this research was to provide guidelines for the reliable assessment of ergonomics exposures in non-routinized work. Using a discrete-interval observational sampling approach, two or three observers collected a total of 5852 observations on tasks performed by three construction trades (iron workers, carpenters and labourers) for periods of several weeks. For each observation, nine exposure variables associated with awkward body postures, tool use and load handling were recorded. The frequency of exposure to each variable was calculated for each worker during each of the tasks on each of the days. ANOVA was used to assess the importance of task in explaining between-worker and within-worker variability in exposures across days. A statistical re-sampling method (bootstrap) was used to evaluate the reliability of exposure estimates for groups of workers performing the same task for different sampling periods. Most exposures were found to vary significantly across construction tasks within trade, and between-worker exposure variability was generally smaller than within-worker exposure variability within task. Bootstrapping showed that the reliability of the group estimates exposure for the most variable exposures within task tended to improve as the assessment periods approached 5-6 d, with marginal improvements for longer assessment periods. Reliable group estimates of exposure for the least variable exposures within task were obtained with 1 or 2 d of observation. The results of this study demonstrate that an initial estimate of the important environmental or task sources of exposure variability can be used to develop an efficient sampling strategy that provides reliable estimates of ergonomics exposures during non-routinized work.

Peters, S. E., et al. (2018). "A Cluster Randomized Controlled Trial of a Total Worker Health((R)) Intervention on Commercial Construction Sites." *Int J Environ Res Public Health* 15(11): 11916.

This study evaluated the efficacy of an in

tervention on construction sites.

Int J Environ Res Public Health 2018, 15(11):11916. doi:10.3390/ijerph151111916

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pneumatic rock drills drilling into concrete block on a test bench system. METHOD: Three experk o gpvu" y gtg"eqpfwevgf"qp"c"vguv"dgpej"u{uvgo"vq"eqo rctg"cp"nggevtke":05 mi+"cpf" rpgwo cvke"ftkm":08 mi+"qp"*3+"pqkug"cpf"jcpfng"xkdtcvkqp."*4+"tgurktcdng"ukkec"fwuv."cpf"*5+"ftkknkpi"rtqfwevxxkv{0"Vjg"vguv"dgpej"u{uvgo"tgrgcvgfn{"ftkmgf"3; oo"fkocgvgt"z"322 oo"fgrvj" holes into cured concrete block while the respective exposure levels were measured following eS, he ra(t)-2 ur ls(4 (sLO)2 (4 (sP(e)-10)3 (a(t)-2)4 (s1 (T)1 ((ur)1)4ur)17.7 (den)-4 (t)-6 (8>4 <dFbl)-2 (oc)40

Handle vibration levels with different drills and bit sizes were similar to those collected

either two or four weeks later. Of the 216 employees participating in the initial round, 99 (45.8%) agreed to participate in the retest portion of the study. The kappa coefficient was used to determine repeatability for categorical outcomes. The majority of the kappa coefficients for the 58 questionnaire items were above 0.50 but ranged between 0.13 and 1.00. The section of the questionnaire having the highest kappa coefficients was the section related to hand symptoms. Interval lengths of two and four weeks between the initial test and retest were found to be equally sufficient in terms of reliability. The results indicated that the symptom and job factors questionnaire is reliable for use in epidemiologic studies. Like all measurement instruments, the reliability of musculoskeletal questionnaires must be established before drawing conclusions from studies that employ the instrument.

Schneider, S., et al. (1995). "Noise, vibration, and heat and cold." *Occup Med* 10(2): 363-383.

Using information from the U.S. government and the scientific literature, the authors identify preventive strategies for specific types of injuries and categorize features of employers and workers that are associated with low injury rates. They conclude that safe working conditions are possible and are related to the attitudes of workers and management.

Schoenfisch, A. L., et al. (2013). "Work-related injuries among union drywall carpenters in Washington State, 1989-2008." *Am J Ind Med* 56(10): 1137-1148.

BACKGROUND: Drywall installers are at high-risk of work-related injury. Comprehensive descriptive epidemiology of injuries among drywall installers, particularly over time, is lacking. **METHODS:** We identified worker-hours and reported and accepted workers' compensation (WC) claims for a 20-year (1989-2008) cohort of 24,830 Washington State union carpenters. Stratified by predominant type of work (drywall installation, other carpentry), work-related injury rates were examined over calendar time and by worker characteristics. Expert interviews provided contextual detail.

RESULTS: The overall injury rate was 1.84% (dr)3 (yw)2 (a)4 (l)-2 (l)-2 (i)-2 (ns)-1 (t)-2 (a)4 (l)-2 (l)-2 (e)4 (r)3 (s)-1 d i,a20 (We8)4 (a)4 osio Stat (or)3 ((e)4 (r)3 (s)-1 (-)10 ae)4 (r)3 (e)4 , thiw(r)3 is wore-

known about the back injury experience and care seeking behavior among drywall installers, a high-risk workgroup regularly exposed to repetitive activities, awkward postures, and handling heavy building materials. **METHODS:** Among a cohort of 24,830 Washington State union carpenters (1989-2008), including 5,073 drywall installers, we identified WC claims, visits for health care covered through union-provided health insurance and time at risk. Rates of work-related overexertion back injuries (defined using WC claims data) and health care utilization for musculoskeletal back disorders covered by private health insurance were examined and contrasted over time and by worker characteristics, stratified by type of work (drywall installation, other carpentry). **RESULTS:** Drywall installers' work-related overexertion back injury rates exceeded those of other carpenters (adjusted IRR 1.63, 95% CI 1.48-1.78). For both carpentry groups, rates declined significantly over time. In contrast, rates of private healthcare utilization for musculoskeletal back disorders were similar for drywall installers compared to other carpenters; they increased over time (after the mid-1990s), with increasing years in the union, and with increasing numbers of work-related overexertion back injuries. **CONCLUSIONS:** Observed declines over time in the rate of work-related overexertion back injury, as based on WC claims data, is encouraging. However, results add to the growing literature suggesting care for work-related con

Seo, J., et al. (2016). "Simulation-Based Assessment of Workers' Muscle Fatigue and Its Impact on Construction Operations." *Journal of Construction Engineering and Management* 142(11).

Construction workers are frequently exposed to excessive physical demands due to repetitive lifting and material handling while performing tasks. Consequently, many construction workers suffer from a significant level of muscle fatigue that may negatively impact a project's performance. Thus, evaluating the level of muscle fatigue prior to work and implementing appropriate interventions to reduce physical demands will help to prevent adverse effects of workers' fatigue on construction operations. Even though several research efforts have suggested methodologies to evaluate muscle fatigue, the extent to which workers' muscle fatigue would affect construction performance has not yet been fully studied. To address this issue, a simulation-based framework is proposed to estimate physical demands and corresponding muscle fatigue, and thus to quantitatively evaluate the impact of muscle fatigue during construction operations. Specifically, physical demands from a planned operation modeled using discrete event simulation (DES) are estimated through

provide a sufficient level of detail on human kinematics to conduct biomechanical analysis, thus allowing for the identification of particular body parts where excessive forces are placed during tasks. The issues and directions of future research are also discussed to perform on-site biomechanical analysis during construction tasks. © 2014 American Society of Civil Engineers.

Shewchuk, J. P. and C. Guo (2012). "Panel stacking, panel sequencing, and stack locating in residential construction: Lean approach." *Journal of Construction Engineering and Management* 138(9): 1006-1016.

A current trend in residential construction is the use of prefabricated wall panels. Panels are manufactured at a factory, then arranged into stacks for transporting to the construction site, where they are assembled. Current approaches to planning panelized construction are focused on stacking and transport efficiency, with little consideration given to assembly. This results in excessive panel material handling during construction, increased construction lead time, and increased risk of worker overload and/or injury. This paper proposes a lean approach to panel stacking, panel sequencing, and stack locating, where panels within each stack form a continuous structure and are erected via continuous flow. The objectives are to minimize the quantity of stacks, panel material handling distance, and the work required to position and brace panels-panel interference is ignored. Few researchers have addressed this problem: a single algorithm has been reported, and this only works for certain building shapes and may provide infeasible solutions. The proposed approach and algorithm result in improved performance, have no shape restrictions, and always provide feasible solutions. Additionally, computational experiments show that the algorithm outperforms methods being employed in the construction industry today. © 2012 American Society of Civil Engineers.

Shin, G. and G. Mirka (2004). "The effects of a sloped ground surface on trunk kinematics and L5/S1 moment during lifting." *Ergonomics* 47(6): 646-659.

There are many work environments that require workers to perform manual materials handling tasks on ground surfaces that are not perfectly flat (e.g. in agriculture, construction, and maritime workplaces). These sloped ground surfaces may have an impact on the lifting strategy/technique employed by the lifter, which may, in turn, alter the biomechanical loading of the spine. Describing the changes in kinematics and kinetics of the torso is the first step in assessing the impact of these changes and is the focus of the current research. Subjects' whole-body motions were recorded as they lifted a 10 kg box while standing on two inclined surfaces (facing an upward slope: 10 degrees and 20 degrees), two declined surfaces (facing a downward slope: -10 degrees and -20 degrees), and a flat surface (0 degrees) using three lifting techniques (leg lift, back lift and freestyle lift). These data were then used in a two-dimensional, five-

and therefore needs to be considered when evaluating risk of low back injury in these working conditions.

Shockey, T. M., et al. (2018). "Frequent Exertion and Frequent Standing at Work, by Industry and Occupation Group - United States, 2015." MMWR Morb Mortal Wkly Rep 67(1): 1-6.

Repeated exposure to occupational ergonomic hazards, such as frequent exertion (repetitive bending or twisting) and frequent standing, can lead to injuries, most commonly musculoskeletal disorders (1). Work-related musculoskeletal disorders have been estimated to cost the United States approximately \$2.6 billion in annual direct and indirect costs (2). A recent literature review provided evidence that prolonged standing at work also leads to adverse health outcomes, such as back pain, physical fatigue, and muscle pain (3). To determine which industry and occupation groups currently have the highest prevalence rates of frequent exertion at work and frequent standing at work, CDC analyzed data from the 2015 National Health Interview Survey (NHIS) Occupational Health Supplement (OHS) regarding currently employed adults in the United States. By industry, the highest prevalence of both frequent exertion and frequent standing at work was among those in the agriculture, forestry, fishing, and hunting industry group (70.9%); by occupation, the highest prevalence was among those in the construction and extraction occupation group (76.9%). Large differences among industry and occupation groups were found with regard to these ergonomic hazards, suggesting a need for targeted interventions designed to reduce workplace exposure.

Shrestha, P. P., et al. (2018). "Types and factors affecting injury rates of mechanical contractors." Work 61c)135

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focus of the current research was to evaluate a knee support device designed to reduce the biomechanical loading of these postures. Ten participants performed a series of sudden loading tasks while in a semisquat posture under two conditions of knee support (no support and fully supported) and two conditions of torso flexion (45 and 60 degrees). A weight was released into the hands of the participants who then came to steady state while maintaining the designated posture. As they performed this task, the EMG responses of the trunk extensors (multifidus and erector spinae) were collected, both during the "sudden loading" phase of the trial as well as the steady weight-holding phase of the trial. As expected, the effects of torso flexion angle showed significant decreases in the activation of the multifidus muscles with greater torso angle (indicating the initiation of the flexion-relaxation response). Interestingly, the results showed that the knee support device had no effect on the activation levels of the sampled muscles, indicating that the loss of the degree of freedom from the ankle joint during the knee support condition had no impact on trunk extensor muscle response. The a priori concern with regard to these supports was that they would tend to focus loading on the low back and therefore would not serve as a potential ergonomic solution for these stooping/semisquatting tasks. Because the results of this study did not support this concern, further development of such an intervention is underway.

Sneller, T. N., et al. (2018). "Awareness and perceptions of ergonomic programs between workers and managers surveyed in the construction industry." *Work* 61(1): 41-54.

BACKGROUND: Work-related musculoskeletal injuries and disorders (WMSDs) are among the most frequently reported causes of lost or restricted work time in the construction industry. Ergonomics is still a relatively new theme for the construction industry. Understanding of the workers' and managers' knowledge and perception of ergonomic issues in construction can play a critical role to develop and implement effective ergonomic programs and policies. **OBJECTIVE:** To study the similarities and differences of the workers' and managers' knowledge and perceptions of ergonomics matters in the construction industry. **METHODS:** A survey questionnaire was developed and distributed to both workers and management personnel employed by sixteen different construction contractors performing various types of construction work. The final questionnaire comprised of a total of forty questions and consisted of four major sections: background, safety and ergonomic programs, injuries and illnesses, and work conditions. **RESULTS:** Eighty-eight workers and managers completed the survey questionnaire. Nearly all of their employer had a written safety program, while only one third had an ergonomics program. Ergonomics was perceived as relatively less important compared to the safety issues. Managers were more likely to think that management encourages feedback from site employees than were workers. Managers appeared to be more likely to know that their companies have an ergonomic training program or policy than were workers. Workers were more likely to consider to purchase or select the ergonomic hand tools than were managers. Workers and managers alike reported having slight regard for the potential occurrence of a work-related musculoskeletal disorder. **CONCLUSIONS:** While the construction industry has done an admirable job developing safety programs, it has done far less to develop comprehensive ergonomic programs and policies that would help provide education and guidance to its workers and managers in the industry.

Sobeih, T., et al. (2009). "Psychosocial Factors and Musculoskeletal Disorders in the Construction Industry." *Journal of Construction Engineering and Management* 135(4): 267-277.

Musculoskeletal disorders (MSDs) constitute more than half of the total injuries and illnesses within the construction industry. The aim of this study was to assess the prevalence of MSD among construction workers and identify the psychosocial and physical risk factors associated with their occurrence using an on-site survey instrument. One hundred forty seven construction workers (representing three trades) participated in the study. The 1-year prevalence of MSD was high with 61.2% reporting severe symptoms and 39.7% having some functional impairment due to MSD. Physical task requirement was the most important factor associated with MSD reflecting the physical nature of construction work. Economic and performance factors were the most stressful psychosocial factors reported and significantly increased the risk of reporting MSD. The findings of this research underscore the independent role that psychosocial factors play in the health and safety of construction workers. Understanding this role is imperative for practitioners and academics alike in the quest to make construction a safer work environment for all workers.

Sparer, E. H., et al. (2015). "Length of time spent working on a commercial construction site and the associations with worker characteristics." *Am J Ind Med* 58(9): 964-973.

Background: Construction workers move frequently from jobsite to jobsite, yet little is documented about length of stay on-site and associations with worker characteristics. **Method:**

Tak, S., et al. (2009). "Variability in risk factors for knee injury in construction." *J Occup Environ Hyg* 6(2): 113-120.

This study investigated sources of variance in exposure to risk factors for knee pain in a variety of highway construction trades, operations, and tasks. Over 15,000 discrete observations of leg postures and weights handled were made on 120 construction workers in five construction trades, in nine operations over 79 days. The contributions of trade, operation, task, and worker to the variability in work time spent kneeling, squatting, and carrying loads were evaluated with multilevel random effects models. Construction operation and task explained about 20% to 30% of total variation in kneeling, squatting, and carrying loads. There was a large unexplained component of variance thought to represent day-to-day variability of exposure within task. Reliable assessments of knee exposures require multiple days to accommodate the high variability of exposures among operations and tasks and over time. These sources of variability should be carefully considered in efforts to estimate exposures to knee loading for epidemiologic or intervention studies. Homogenous exposure groups are not

intervention study with multiple observations in which body part discomfort surveys were collected from an intervention and a control group during normal working days. The intervention group also completed a CPLMS preference survey after completing use of the CPLMS for 646 h. Results from the body part discomfort survey showed no significant difference in low back discomfort between mornings and evenings for the first seven days, but a significant difference on the eighth and final day for the intervention group. In the control group, there was a significant difference between mornings and evenings on three out of five days for the low back discomfort score, where, the evening score was always higher than the morning score for all days. In addition, comparisons between the control and intervention groups indicated that the difference between morning and evening low back discomfort rating approached significance ($p = 0.06$). The CPLMS preference survey showed that 54% of the operators felt very comfortable using the CPLMS, 36% wanted one for their equipment, and 54% showed interest in experimenting with the CPLMS for a longer time period. Results from this study suggest that the use of this intervention may effectively reduce the development rate of low back discomfort experienced by operators of heavy earth-moving equipment throughout the work day. Relevance to industry: This study indicates that providing an intervention that promotes dynamic changes and improving lumbar curvature during prolonged static sitting in a whole body vibration environment may have a positive effect by reducing the development rate of low back discomfort.

Waehrer, G. M., et al. (2007). "Costs of occupational injuries in construction in the United States." *Accid Anal Prev* 39(6): 1258-1266.

This paper presents costs of fatal and nonfatal injuries for the construction industry using 2002 national incidence data from the Bureau of Labor Statistics and a comprehensive cost model that includes direct medical costs, indirect losses in wage and household productivity, as well as an estimate of the quality of life costs due to injury. Costs are presented at the three-digit industry level, by worker characteristics, and by detailed source and event of injury. The total costs of fatal and nonfatal injuries in the construction industry were estimated at \$11.5 billion in 2002, 15% of the costs for all private industry. The average cost per case of fatal or nonfatal injury is \$27,000 in construction, almost double the per-case cost of \$15,000 for all industry in 2002. Five industries accounted for over half the industry's total fatal and nonfatal injury costs. They were miscellaneous special trade contractors (SIC 179), followed by plumbing, heating and air-conditioning (SIC 171), electrical work (SIC 173), heavy construction except highway (SIC 162), and residential building construction (SIC 152), each with over \$1 billion in costs.

Wang, D., et al. (2017). "Assessing Work-Related Risk Factors on Low Back Disorders among Roofing Workers." *Journal of Construction Engineering and Management* 143(7): 04017026.

The construction industry has one of the worst occupational health and safety records of all industries. In recognition of this, several innovative safety techniques have been introduced to mitigate undesired events before they occur, including safety risk assessment. However, evaluation of safety risk is challenging due to the dynamic nature of the construction work environment and lack of reliable references. This study (1) compares safety risk of different construction trades in terms of common hazard types and sources of injuries, and (2) proposes safety risk quantification models by occupations, which can play a role as a safety reference for reliable safety risk assessment. Using occupational injury data, two relative injury indexes,

Welch, L. and R. Baker (2015). "Introduction to the collection on research to practice in the construction industry." *Am J Ind Med* 58(8): 807-808.

Introduction to special AJIM issue

Welch, L., et al. (2009). "Musculoskeletal disorders among construction roofers--physical function and disability." *Scand J Work Environ Health* 35(1): 56-63.

OBJECTIVES: This study investigated the relationships between work demands, chronic medical and musculoskeletal conditions, aging, and the ability to remain on the job in a longitudinal study of 979 construction roofers between the ages of 40 and 59 years.

METHODS: In a phone interview at baseline and 1 year later, the participants were asked about the presence of medical conditions and musculoskeletal disorders, work limitations and work accommodations, and social and economic functioning. **RESULTS:** Among the workers for whom a musculoskeletal disorder was their most serious condition at baseline, 8% left roofing due to a health condition during the first year of follow-up. A comparison between those who left and those who stayed identified older age and lower physical functioning as statistically significant predictors of leaving the trade. Workers with a musculoskeletal disorder and who, in the baseline interview, reported receiving some type of job accommodation for their musculoskeletal disorder had an odds ratio of 0.24 ($P=0.07$) for leaving work by the time of the 1-year follow-up when compared with workers with a musculoskeletal disorder and no job accommodation. The workers with three or more work limitations were also more likely to leave roofing, but this association disappeared after adjustment for other factors.

CONCLUSIONS: Musculoskeletal conditions among roofers are strongly associated with work limitation, missed work, and reduced physical functioning, factors that are predictive of premature departure from the workforce. Job accommodation was provided for 31% of the roofers with a musculoskeletal disorder, and it was associated with a reduced likelihood of subsequently leaving roofing for health-related reasons.

Welch, L. S. (2009). "Improving work ability in construction workers--let's get to work." *Scand J Work Environ Health* 35(5): 321-324.

(Intro to special journal issue on aging, health and work limitations/ability/accommodations in construction.)

Welch, L.

higher risk of disability retirement compared to younger workers with similar medical conditions and work limitations.

Welch, L. S., et al. (2010). "Impact of musculoskeletal and medical conditions on disability retirement-a longitudinal study among construction roofers." *Am J Ind Med* 53(6): 552-560.

BACKGROUND: To assess the intersection of work demands, chronic medical and musculoskeletal conditions, aging, and disability, we initiated a longitudinal study of construction roofers who were current union members between the ages of 40 and 59.

METHODS: Participants were asked about the presence of medical conditions and musculoskeletal disorders; the Work Limitations Questionnaire, the SF-12, and other validated assessments of social and economic impact of injury were included. **RESULTS:** Factors at baseline that predicted leaving for a health-related reason were older age, lower physical functioning, work limitations, and having missed work. Those who left roofing for a health-related reason were much more likely to have a lower economic score at the 1 year interview. **CONCLUSIONS:** Medical and musculoskeletal conditions are strongly associated with work limitation, missed work, and reduced physical functioning; these factors are also associated with premature departure from the workforce.

Welch, L. S. and K. Hunting (2003). "Injury surveillance in construction: what is an "injury", anyway?" *Am J Ind Med* 44(2): 191-196.

BACKGROUND: Over the last decade, there has been a decline in injuries with days away from work in construction, associated with an increase in injuries with restricted work activity only. **METHODS:** We abstracted demographics, diagnosis, cause-of-injury, and hospital discharge information for 481 workers from one large construction project treated in an urban Emergency Department (ED). The project safety team provided data on all injuries from this site, including first aid cases. **RESULTS:** This site had fewer injuries with days away from work than expected from national rates. Two hundred and fifty-six injuries were reported on the OSHA log, and of those 93 entailed days away from work; 1,515 injuries were considered first aid/medical only. We used a sample of the data to estimate that the site classified as "recordable" 128 of the 481 ED-treated injuries from this site (27%). **CONCLUSIONS:** The pattern of injury varies depending on the subset of injuries examined. Lost time injuries, as reported in BLS data, record fewer lacerations and eye injuries, and more strains and sprains.

a business case model, and in-depth case studies including development, testing, manufacturing, marketing, and diffusion. Conclusions: A more comprehensive understanding of the health and safety technology transfer landscape, the various actors, and their motivators and goals will help to foster the successful commercialization and diffusion of health and safety innovations. *Am. J. Ind. Med.* 58:849-857, 2015. © 2015 Wiley Periodicals, Inc.

Wellman, H., et al. (2004). "Work-Related Carpal Tunnel Syndrome (WR-CTS) in Massachusetts, 1992-1997: Source of WR-CTS, Outcomes, and Employer Intervention Practices." *Am J Ind Med* 45(2): 139-152.

Background: The Massachusetts Sentinel Event Notification System for Occupational Risks (MASS SENSOR) receives reports of work-related carpal tunnel syndrome (WR-CTS) cases from (1) workers' compensation (WC) disability claims for 5 or more lost work days; and (2) physician reports (PR). **Methods:** From 1992 through 1997, 1,330 WC cases and 571 PR cases completed follow-back surveys to provide information on industry, occupation, attributed source of WR-CTS, outcomes, and employer intervention practices. **Results:** Sixty-four percent of the respondents had bilateral CTS and 61% had surgery, both of which were proportionally more frequent among WC cases. Office and business machinery was the leading source of WR-CTS (42% of classifiable sources) in every economic sector except construction, followed by hand tools (20%). Managers and professional specialty workers were the most likely to report employers' interventions and were up to four times more likely to report equipment or work environment changes than higher risk groups. **Conclusions:** State-based surveillance data on the source of WR-CTS provided valuable information on how and where to implement interventions. New occurrences of WR-CTS are likely, especially in the highest risk industries where very few cases reported primary prevention measures (e.g., changes to equipment or work environment) implemented by their employers. © 2004 Wiley-Liss, Inc.

West, G. H., et al. (2016). "An analysis of permanent work disability among construction sheet metal workers." *AIHA J (Fairfax, Va)* 59(3): 186-195.

BACKGROUND: Causes of permanent work disability in the sheet metal industry are not well characterized. **METHODS:** Pension records were used to compare causes of disability among sheet metal workers and the U.S. working population. Subgroup analysis examined the major causes of sheet metal worker disability. **RESULTS:** Musculoskeletal disorders (MSDs), circulatory disease, and injuries were leading causes of sheet metal worker disability (47.2%, 13.7%, 10.9% of awards, respectively). Award distribution differed from the U.S. working population ($P < 0.0001$); MSDs and injuries accounted for higher proportions of sheet metal worker awards, particularly at spine, shoulder, and knee. **CONCLUSIONS:** Higher proportions of awards caused by MSD or injury among sheet metal workers may reflect higher rates of work-related injuries and MSDs, a high likelihood of disability with construction work given the same impairment, or higher prevalence of other conditions in the general population. Prevention requires task-specific ergonomic innovations and proven participatory interventions.

Winnemuller, L. L., et al. (2004). "Comparison of ergonomist, supervisor, and worker assessments of work-related musculoskeletal risk factors." *J Occup Environ Hyg* 1(6): 414-422.

In primary prevention efforts to reduce the incidence of work-related musculoskeletal disease (MSD), many employers will use supervisor or worker assessments for initial evaluation of MSD risk factors. This cross-sectional study examined the ability of supervisors

and workers to accurately assess the presence of MSD risk factors at four work sites in four different industries, examining five jobs that represented six primary categories of risk factors: posture, force, repetition, impact, lifting, and vibration. Thirty

2018, rates among JLP with no apprenticeship training were 46% higher for total workers' compensation claims (1.60, 95% CI: 1.22-2.11), compared to rates among JLP who completed a plumbing apprenticeship. Apprentice graduates experienced a greater decline in the rate of total claims between the 5 years preceding JLP certification and the years after certification (55.3% vs. 41.4% among JLP with no apprenticeship training).

The present study utilized an integrated biomechanical modeling approach that was previously developed by the researcher to investigate the effects of position and size of drywall on the physical demands for drywall installers.

Yuan, L. and B. Buchholz (2014). "The effects of position and size of drywall on the physical

Yuan, L. and M. Buvens (2015). "Ergonomic Evaluation of Scaffold Building." *Procedia Manufacturing* 3: 4338-4341.

The present study evaluated the ergonomic hazards that are associated with scaffold building/erecting for one of the local construction companies and proposed recommsgths -1.15 4 (s)-5 4 (s)-5 (c

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