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Observed use of voluntary controls to reduce physical exposures among sheet metal workers of the mechanical trade

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ABSTRACT

Introduction: Little is known about the transfer into the workplace of interventions designed to reduce the physical demands of sheet metal workers.
Methods: We reviewed videos from a case series of 15 sheet metal worksite assessments performed in 2007–2009 to score postures and physical loads, and to observe the use of recommended interventions to reduce physical exposures in sheet metal activities made by a NIOSH stakeholder meeting in 2002.
Results: Workers showed consistent use of material handling devices, but we observed few uses of recommended interventions to reduce exposures during overhead work. Workers spent large proportions of time in awkward shoulder elevation and low back rotation postures.
Conclusions: In addition to the development of new technologies and system designs, increased adoption of existing tools and practices could reduce time spent in awkward postures and other risks for musculoskeletal disorders in sheet metal work.

1. Introduction

Construction workers across all trades are at high risk for work-related musculoskeletal disorders (MSD), with incidence rates higher than the national average for all industries as reported by the U.S. Bureau of Labor Statisitics (2013). Sheet metal workers are at particularly high risk for developing MSD, with one of the highest rates of overexertion injuries among all construction trades (Albers et al., 2005; Fredericks et al., 2002; U.S. Bureau of Labor Statisitics, 2013; Welch et al., 1995). The rate of non-fatal lost time injuries and illnesses among sheet metal workers was 401.9 per 10,000 full time equivalents versus 160.6 among all construction trades from 2008 to 2010 (CPWR, 2013).

Specific MSD symptoms have been linked to exposures found in construction work. Engholm and Holmstrom showed strong body location-specific dose–response relationships with time spent working in awkward postures among construction workers (2005). Frequent working with hands above shoulders was associated with shoulder symptoms, while stooping and twisted postures showed stronger association to lower back and upper back symptoms. Among sheet metal workers, working overhead to hang ducts has been associated with neck and shoulder symptoms (neck odds ratio (OR) 7.9, $p = 0.08$; shoulder OR 2.7, $p = 0.16$) (Welch et al., 1995). In a more recent observational study, Mitropoulous et al. found that aligning ducts was the most time-consuming task, and creates prolonged periods of awkward postures (Mitropoulos et al., 2013). Despite these known associations between work tasks and injury risks, rates of MSD among sheet metal workers remain high.

To address this problem, the National Institute for Occupational Safety and Health (NIOSH) held stakeholder meetings in 2002 to gather information about perceived risk of work tasks, availability of ergonomic controls, and perceived barriers to controlling hazards (Albers et al., 2005; NIOSH, 2006). Stakeholders included researchers, contractors, and national union representatives from the mechanical and electrical trades. During trade-specific breakout sessions, stakeholders listed problematic work tasks in order of priority, and recommended interventions for each task. Most of the interventions could be implemented by the contractor although some interventions required support from the general contractor, or required long-term planning in the project design. These

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identified tasks and recommendations were made available to the public in a publication by Albers and colleagues (Albers et al., 2005) and a 2006 NIOSH document (NIOSH, 2006).

Tracking the diffusion and adoption of control measures is a recognized problem. There are no national mechanisms nor data available in the United States to track the transfer of recommendations, the implementation of voluntary control measures, the evaluation of the high-risk tasks for which control measures are needed, or the description of barriers to implementing hazard controls (Albers et al., 2005; Andersson, 1990; Wos et al., 1992). A workshop held by the Center for Construction Research and Training (CPWR) in 2012 brought together researchers, tool manufacturers, contractor associations, trade union representatives, and insurance industry representatives to explore the challenges of transferring technology to workers engaged in appropriate work tasks (Welch et al., 2015). The participants agreed that strong cultural norms within the construction industry can create barriers to change, and the constantly changing workplace makes implementation and evaluation of interventions very difficult. Different agents are responsible for the purchase and implementation of technologies at the worksite including the owner, contractor, project manager, and worker. Despite these challenges, some new safety technologies have been introduced successfully (CPWR, 2012).

Given the need for more controls in sheet metal tasks described in the NIOSH stakeholder meeting and the lack of monitoring transfer of technologies in the construction industry, this study was undertaken 1) to determine whether previously recommended voluntary control measures to reduce physical exposures in sheet metal tasks were being utilized in a sample of commercial heating, ventilating, and air conditioning (HVAC) installation projects between 2007 and 2009, and 2) to describe postures and loads associated with residual MSD risk that were observed for these jobs.

2. Materials and methods

2.1. Case selection

We analyzed data collected between 2007 and 2009 from sheet metal workers who participated in a study to monitor the natural history of carpal tunnel syndrome, the Predictors of Carpal Tunnel Syndrome study (PrediCTS) (Armstrong et al., 2008; Dale et al., 2010). An experienced ergonomist conducted worksite visits to examine tools, equipment, and materials used. Videos of workers were taken to characterize work postures and physical loads during normal work activities, and workers were interviewed to obtain an estimate of the time spent in each of the most common work activities. Fifty-eight videos were taken of sheet metal workers employed in residential and commercial duct installation, sheet metal assembly at the shop, architectural sheet metal installations, and HVAC service, of which 19 sampled commercial duct installation, the focus of the NIOSH recommendations. Four of the 19 videos on commercial duct installation projects were excluded from this study since at least 30% of the frames could not be coded due to blurring or obstructed views. The remaining 15 videos represented 10 sheet metal workers from 6 companies, with some workers observed on two separate construction projects. The workers, the union training center and the local union belonged to the Sheet Metal Workers' International Association (SMWIA), and the contractors belonged to the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA). All participants provided written informed consent to participate. The Institutional Review Board of Washington University School of Medicine provided the approval for this study.

2.2. Data collection framework

We structured the data extraction from our videos based on the published findings from the 2002 NIOSH stakeholder meeting (NIOSH, 2006). Stakeholder groups for the sheet metal trade identified the most common work activities and for each activity, determined the associated tasks, type of work-related physical exposures, risk level (High, Moderate, Low) and body region potentially affected by each risk, and suggested interventions to address the risk in each task (Albers et al., 2005; Everett, 1997; NIOSH, 2006); see Table 1. As described in the NIOSH proceedings, "activities were defined as 'all the field work which results in a recognizable, completed unit of work with spatial limits and/or dimensions.' Tasks were defined as the 'fundamental building blocks of construction field work, each representing one in a series of steps that comprise an activity'" (NIOSH, 2006). We restricted our analysis to the four activities identified with a moderate to high risk level: pack, support system, prep, and install. The *pack activity* involved moving material or equipment to or within the worksite. The *support system activity* involved installing hangars into the concrete or metal roof sheeting to hold the duct or equipment. The *prep activity* involved assembling duct sections, installing duct pieces, or cutting/trimming duct joists in preparation to install. The *install activity* involved raising the duct sections or equipment into the air close to the ceiling and attaching them to the hanging support system.

2.3. Identification of interventions

We reviewed each video to determine the activity, task, and whether an intervention was in use by the worker. If a physical exposure or recommended intervention was observed on video but did not fit into any of the NIOSH categories, it was noted to be a researcher addition. In our analysis, we identified the problems and associated solutions that could be observed related to awkward postures and forceful loads. We excluded problems or potential solutions related to work organization that could not be observed by video (such as work pace, work schedules, rest breaks, task coordination with other trades, planning and communication, job rotation, worker training, preventive maintenance on tools, shop work, and stretching programs). We summarized the interventions observed in each activity and then the residual exposures for the same activities in the series of cases for this review.

2.4. Video posture and load analysis

The physical exposures for awkward posture and load were evaluated using Multimedia-Video Task Analysis (MVTA) software (Ergonomics Analysis and Design Research Consortium, 2003; Yen et al., 1995). The program allows coding of continuous video for time studies and single frames for worker postures. Each video was coded for the following data: 1) duration of time in each activity, location of work relative to the worker (ground, overhead), and primary material used, 2) postures for six body parts (low back flexion/extension and/or rotation, right and left knee position, and right and left shoulder elevation/extension), and 3) type of load: no load, light load (lifting or holding items weighing <20 pounds, such as hand tools, pieces and light material, small equipment), or heavy load (20 pounds or more, such as large rectangular duct, small insulated pre-assembled duct, large equipment).

We conducted time studies using continuous coding of the activity observed at each frame of the video and described the average proportion of time spent in each activity from all videos. Task samples coded as null or not working were excluded from exposures for posture and load. Postures and load were coded