Interventions for Overhead & Concrete Drilling

David Rempel, M.D.
Director, Ergonomics Graduate Training Program
University of California
Berkeley, CA

Introduction

One of the most physically demanding tasks that commercial construction workers perform is overhead drilling of holes into concrete or metal ceilings (Rosecrance 1996; NIOSH 2002; Miranda 2008; CPWR 2008). The job involves standing on a ladder or in a scissor lift, holding a 2-4 kg drill overhead with one hand, and pushing it upward a high force of typically 20 kg for 1-2 minutes while drilling a hole in the ceiling. Hundreds of these holes can be drilled during a day for hanging pipes, electrical trays and sheet metal ducts.

This paper reviews the steps involved in developing a device for overhead drilling into concrete and compares differences in usability and risk factors between the final device and the usual method for overhead drilling.

Method

This six-year project involved developing and testing six different drilling interventions, which were designed to reduce the hand force and non-neutral shoulder postures associated with overhead drilling. The design process was supported by participatory feedback from over 100 commercial construction workers (Rempel 2007; Rempel 2009; Rempel 2010). This paper presents the overall process and the findings from the field evaluation of the final design (Rempel 2010).

During their regular overhead drilling, 23 commercial construction workers used the usual method and the final intervention design (Figure 1) - each for 3 hours – order randomized. Afterwards, subjects rated fatigue in 5 body regions (Figure 2) and usability on 12 items (Figure 3). The work was videotaped for productivity (N=19) and inclinometers were used to measure shoulder posture and head inclination (N=16). Peak upward hand forces during drilling with the

Figure 1. Final device design for overhead drilling. Large crank wheel is for advancing the drill and saddle column to the ceiling using a linear gear. The drill saddle tilts to easily change bits and adjust depth stop. The column adjusts to vertical (where operator's hands are) so that drilling marks can be made on the floor instead of the ceiling. Large locking castors make it easier to move the device over dirty floors.

usual method were 25.0 (SD=1.1) kg-force compared with 2.7 (SD=0.3) kg-force for the intervention device.

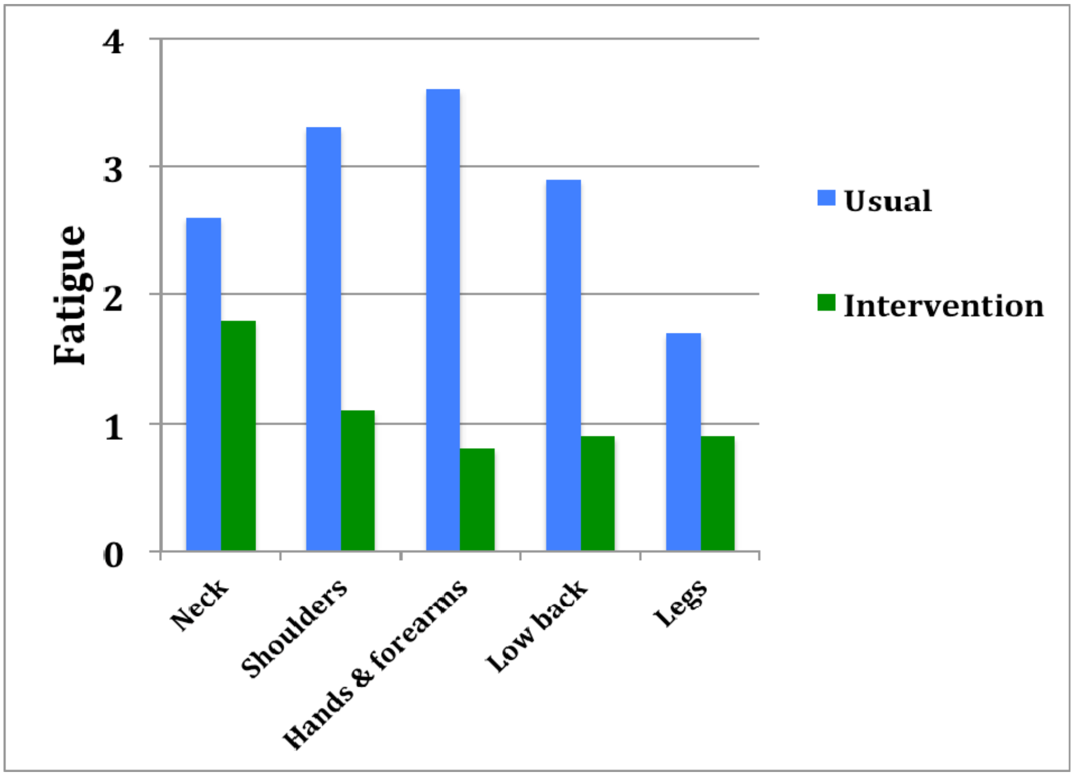

Figure 2. Regional body fatigue (scale 0= no fatigue; 5=very fatigued) after drilling with the usual method compared to drilling with the intervention. All differences were statistically significant.

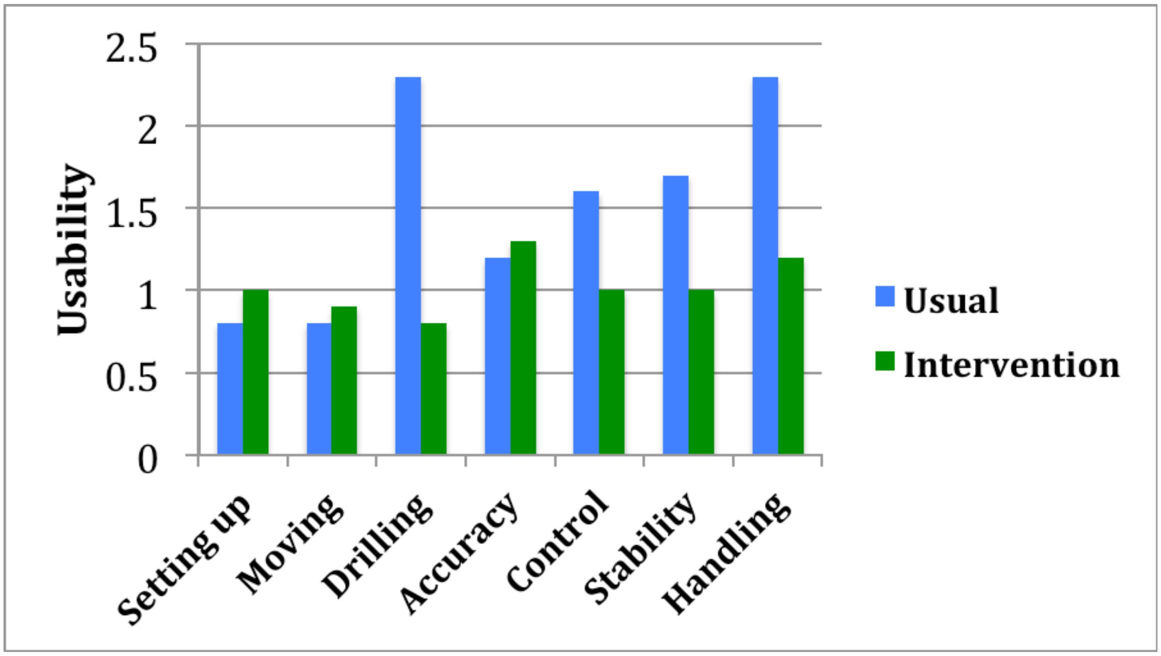

Figure 3. Usability comparison between usual method and intervention method (0=excellent; 5=poor). The differences for Drilling, Control, Stability, and Handling are statistically significant.

Discussion

An intervention device, compared to the usual method for overhead drilling, was associated with less upper extremity fatigue. This improvement was supported by reductions in the objective risk factors of applied force and percent time in non-neutral shoulder posture. Repeated field-testing by experienced construction workers and their feedback on design was vital to the development of this new intervention device.

Applications

The processes used in this study may be useful for evaluating health and safety elements of other tools used by workers. A novel element of the study was the participatory process, in the field, involving construction workers in the improvement of the tool design. In addition, new inclinometers were used in the field to continuously record arm and head postures.

The important design elements for minimizing fatigue included design features that reduced the required hand forces (hand wheel with linear gear); reduced shoulder flexion/abduction especially during the high force drilling (height of the hand wheel); and the reduced time performing the high force drilling.

Acknowledgements

The other researchers involved in this project were Demetra Star, Alan Barr, Steven Robinovitch, and Ira Janowitz. We wish to thank the construction workers, supervisors, and site owners who participated in the project. This research was made possible by the Center for Construction Research and Training (CPWR) as part of a cooperative agreement (U54-OH008307) with the National Institute of Occupational Safety and Health (NIOSH). The author has no commercial interest in the device design presented.

Bibliography

CPWR - The Center for Construction Research and Training. The Construction Chart Book. Silver Spring, MD: CPWR, 2008.

National Institute for Occupational Safety and Health (NIOSH): *Proceedings of a Meeting to Explore the Use of Ergonomics Interventions for the Mechanical and Electrical Trades* (DDHS Pub. No. 2006-119). Cincinnati, Ohio: NIOSH, 2002.

Miranda, H., L. Punnett, E. Viikari-Juntura, M. Heliovaara, and P. Knekt: Physical work and chronic shoulder disorder. Results of a prospective study. Ann. Rheum. Dis. 2008: 67:218-223.

Rempel D, Star D, Gibbons B, Barr A, Janowitz I. Development and evaluation of a new device for overhead drilling. Prof Safety 2007: 52(11):30-35

Rempel D, Star D, Barr A, Gibbons B, Janowitz I. A new method for overhead drilling. Ergonomics 2009: 52(12):1584-1589.

Rempel D, Star D, Barr A, Janowitz I. Overhead drilling: Comparing three bases for aligning a drilling jig to vertical. J Safety Research 2010: 41:247-251.

Rempel D, Star D, Barr A, Blanco MM, Janowitz I. Field evaluation of a modified intervention for overhead drilling. J Occup Environ Hygiene 2010: 7(4):194-202.

Rosecrance, J.C, T.M. Cook, and C.L. Zimmermann: Work related musculoskeletal disorders among construction workers in the pipe trades. Work 1996: 7:13–20.