Pooling sub-task physical exposure data to study work-related carpal tunnel syndrome and epicondylitis

Stephen Bao[a], Jay Kapellusch[b], Andrew Merryweather[c], Arun Garg[b], Barbara Silverstein[a], Matthew Thiese[c], Kurt Hegmann[c]

[a]Washington State Department of Labor and Industries, Olympia, WA, USA, [b]University of Wisconsin-Milwaukee, Milwaukee, WI, USA, [c]University of Utah, Utah, USA

1. Introduction

Workplace distal upper extremity musculoskeletal disorders (DUE MSDs) are prevalent, disabling and expensive(Silverstein and Adams 2007). While many risk factors have been suggested for carpal tunnel syndrome (CTS), job physical exposure risk factors are not well quantified (Nathan *et al.* 2005). For lateral and medial epicondylitis (LEPI and MEPI), job physical risk factors are even less well documented than for CTS. Several problems have contributed to limitations and inconsistencies in the literature, such as reliance on cross-sectional studies (NIOSH 1997); use of job titles or imprecise job physical exposure estimates; imprecise techniques to quantify complex physical exposures for tasks with varying forces and/or job rotation (e.g., using average force); use of small and/or non-representative samples of workers and industries; and lack of objective outcomes measures, such as physical maneuvers and nerve conduction studies (NCS).

Three research institutions conducted three independent prospective studies on work-related DUE MSDs. All three institutions measured: job physical exposure on each individual worker, including demographics, medical history, psychosocial factors, and detailed health outcome data for CTS, LEPI and MEPI. Biomechanical factors for job physical exposure were measured and quantified at the sub-task level. Recently, the three research institutions received funding to pool these data to quantify exposure-response relationships.

This paper presents the processes used for pooling biomechanical factors at sub-task levels, integrates sub-task level data to quantify exposures at job levels, and finally integrating exposures at job levels to quantify job physical exposure at worker levels.

2 Method

Three prospective cohorts of the physical exposure data were pooled from the three research institutions. After a detailed examination of biomechanical exposure data, a list of biomechanical factors available from all three institutions was prepared.

Sub-task level variables included measures of: (1) magnitude of hand force, (2) duration of hand force, (3) number of exertions at that force level, and (4) hand/wrist posture. The sub-task data were collected on site in workplaces through observations and video recordings. Video processing/observations were subsequently completed in laboratories. An overall force level was self-reported by workers and also estimated by analysts. Repetition was estimated using the scale from the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) for Hand Activity Level (HAL) (Latko *et al.* 1997, ACGIH 2001) and also quantified from frequency of exertions with video analyses. These measures of force and repetition were used to quantify the sub-task biomechanical exposure data. Two different exertions were defined: (1) any exertions including very low force exertions, and (2) forceful exertions when the analyst rated the force level was greater than or equal to 2 using the Borg scale (Borg 1982).

Task-level data collected included: (1) number of distinct subtasks performed, (2) cycle time, and (3) duration of task/day. Job level data collected included: (1) number of tasks in a job and (2) duration of job/day. The task-level and job level information was used to reduce the sub-task level exposure to task-level and job level exposure respectively.

Three commonly used data reduction approaches were employed to obtain job-level exposure variables: (1) time-weighted averaging (TWA) – weights were assigned based on the amounts of time that sub-tasks have in a task and job and exposure value was calculated by time-weighted averaging of all sub-task exposures, (2) typical approach – value of the exposure corresponding to the sub-task with the longest duration in a task and job was used, (3) peak value approach – the highest sub-task exposure value in a task or job was used. These different approaches obtained several job-level exposure variables quantifying the same exposure dimensions (forceful exertion level, repetition of exertion, duration of exertion, and hand/wrist postures) but with different methodology accordingly.

In order to quantify job-level physical exposures by considering the combined effects of forceful exertions, repetition of exertion, duration of exertion and hand/wrist postures, the Strain Index (Moore and Garg 1995) and ACGIH TLV for HAL methods (ACGIH 2001) were used. Several variant calculations were performed by using TWA, peak and typical values of required exposure variables respectively.

3 Results

In the pooled physical exposure dataset from the three research institutions, there were 1881 subjects at the baseline. Table 1 shows the descriptive statistics results of the job-level physical exposure variables.

Table 1. Summary results of biomechanical exposure variables – N, mean, median, range, skewness, kurtosis.

Variable	N	Mean	Median	Range	Skewness	Kurtosis
HAL TLV calculated using 90th%ile force and verbal anchor HAL, TWA of tasks	1881	0.431	0.373	7.999	8.17	117.42
ACGIH TLV for HAL calculated using 90th%ile force and verbal anchor HAL, peak of tasks	1881	0.565	0.429	7.999	4.44	35.68
ACGIH TLV for HAL calculated using 90th%ile force and verbal anchor HAL, typical tasks	1881	0.535	0.429	8.000	4.99	46.15
The 95 Strain Index using TWA force	1881	4.992	2.563	80.750	4.38	29.64
The 95 Strain Index using peak force	1881	7.118	3.000	116.750	3.31	17.48
The 95 Strain Index using typical force	1881	6.603	3.000	116.750	3.54	20.00
Overall force using peak from all jobs	1881	2.315	2.000	8.990	0.88	1.12
Peak force using peak from all jobs	1881	2.873	3.000	9.990	0.40	0.27
HAL using TWA calculation	1881	4.466	4.000	10.000	0.18	-0.03
HAL using peak from all jobs	1881	4.927	5.000	10.000	0.25	-0.23
Effort per min, force >=2 Borg, TWA Task Summary	1881	6.142	3.223	52.637	2.02	4.36
Effort per min, force >=2 Borg, Typical Task Summary	1881	8.428	3.871	103.652	2.74	9.75
Duty Cycle, force >=2 Borg, TWA Task Summary	1881	19.416	13.617	92.081	1.05	0.48
Duty Cycle, force >=2 Borg, Peak Task Summary	1881	26.009	19.214	100.000	0.85	-0.33
Duty Cycle, force >=2 Borg, Typical Task Summary	1881	24.808	17.692	100.000	0.91	-0.19

4 Discussion

This presentation discusses the process used to quantify physical exposure at the sub-task level, integration of sub-task level exposures to quantify physical exposure at the task level, and then assigning exposure to a worker who performs multiple tasks during a work shift (job rotation). Advantages and disadvantages of other approaches, such as simple average, time-weighted-average, and peak exposure, etc., for assigning exposure at the worker level are also performed.

The results show that with larger number of subjects were obtained through pooling data from multiple research institutions. Large exposure spectrum is likely obtained from the variety types of jobs that the three research institutions could offer. Most of the exposure variables are not normally distributed. This requires attention in future statistical modelling.

Acknowledgements

This study was partially supported by a NIOSH grant (grant number: 1R01OH010474-02) and by Washington State Department of Labor and Industries.

References

ACGIH, 2001. "Hand activity level. *TLVs and BEIs - threshold limit values for chemical substances and physical agents."* Cincinnati, Ohio: ACGIH, 110-112.

Borg, G., 1982. Psychophysical bases of perceived exertion. *Med Sc Spt Exer,* 14 (5), 377-381.

Latko, W.A., Armstrong, T.J., Foulke, J.A., Herrin, G.D., Rabourn, R.A. & Ulin, S.S., 1997. "Development and evaluation of an observation method for assessing repetition in hand tasks." *American Industrial Hygiene Association Journal,* 58 (4), 278-285.

Moore, J.S. & Garg, A., 1995. "The strain index: A proposed method to analyze jobs for risk of distal upper extremity disorders." *Am Ind Hyg Assoc J,* 56 (5), 443-58.

Nathan, P.A., Istvan, J.A. & Meadows, K.D., 2005. "A longitudinal study of predictors of research-defined carpal tunnel syndrome in industrial workers: Findings at 17 years." *J Hand Surg Br,* 30 (6), 593-8.

NIOSH, 1997. "*Musculoskeletal disorders and workplace factors: A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back."* Cincinnati, USA, Publication No. 97-141.

Silverstein, B. & Adams, D., 2007. "*Work-related musculoskeletal disorders of the neck, back and upper extremity in Washington State."* Olympia, Washington: Washington State Department of Labor and Industries.