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Multifactor association of job, individual and psychosocial factors in prevalence of distal upper extremity disorders and quantification of job physical exposure

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ABSTRACT

The objective of this study was to develop a multifactor model of job, individual and psychosocial factors in prevalence of distal upper extremity musculoskeletal disorders (DUE MSDs); and quantify job physical exposure to establish safe exposure limits. The study sample comprised of 525 workers who were part of a large prospective cohort study and represented a broad array of industrial practices and a wide range of job physical exposure. Only baseline data was considered for the analysis in the study. Workers underwent laptop administered questionnaires, structured interviews, two standardized physical examinations and nerve conduction studies to ascertain demographic, medical history, psychosocial factors and current DUE MSDs. All workers' jobs were individually measured for job physical exposure factors and videotaped. Binomial logistic regression was used to develop and test the multifactor association and quantification of job physical exposure for safe exposure limits. Results indicated that work-related DUE MSDs are multifactor in nature and are significantly affected by specific factors of (1) job physical exposure - percentage duration of exertion (PDOE), workers' subjective ratings of perceived effort or intensity of exertion (IOE) (using Borg CR-10), hand activity level measured by the American conference of Governmental Industrial Hygienists (ACGIH) threshold limit value for hand activity level (TLV for HAL), and presence of 2-point pinch grasps; (2) individual factors - female gender, diabetes, higher body mass index (BMI), and past and current smokers; (3) psychosocial factors - neither likely/unlikely or very unlikely to take up the current job again, divorced/separated, and presence of family problems. Quantification of job physical exposure indicated that prevalence of work-related DUE MSDs significantly increases with efforts per minute (Eff/min) >8 (OR = 1.69, p = 0.006) and woker's perceived effort based on Borg rating for IOE at the end of the shift >3 (OR = 2.46, p < 0.001). Further studies should be conducted to validate these safe exposure limit criteria.

1. Introduction

Musculoskeletal disorders (MSDs) are disorders of the muscles, nerves, tendons, ligaments, joints, cartilage, and spinal discs (BLS, 2008). The distal upper extremity (DUE) MSDs are disorders that are present on the distal side of the extremity, including elbow, lower arm, wrist, hand and fingers (Garg and Kapellusch, 2011). DUE MSDs are common in workplace and reportedly comprise of 4% of all state workers' compensation claims (BLS, 2008; Hales and Bernard, 1996), costing about $21,918 per claim in 2010–2011 and cost more than $2 Billion annually (National Safety Council, 2014). In 2011, DUE MSDs accounted for 32.5% of the injuries and illnesses with days away from work, transfer to another job, restricted duties of work or combination of these (BLS, 2014).

The most generic job or work-related risk factors identified for DUE MSDs are forceful exertion, repetitive work, awkward posture, lack of recovery time, vibration, type of hand grasp etc. (National Institute of Occupational Safety and Health, NIOSH, 1997). Individual factors like age, gender, obesity or body mass index, diabetes, smoking, anthropometry etc., also play a major role in prevalence of these disorders (NIOSH, 1997). Researchers have also placed an important emphasis on psychosocial factors e.g., job dissatisfaction, perceived stress/workload, monotonous work, limited social support, limited job control, felt depressed, time pressure, etc. (NIOSH, 1997). However, very few studies have considered the multifactor

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association of job, individual, and psychosocial factors in assessing the prevalence of DUE MSDs.

There existed a lack of consistency in methods used in quantifying job physical exposure and in defining the DUE MSD case definition (Garg and Kapellusch, 2011; NIOSH, 1997) in previous studies. For instance, job exposure measurements used in the literature ranged from very crude measure e.g., occupational title or self-reports (Melchior et al., 2006, Shiri et al., 2006; Forde et al., 2005; Gell et al., 2005; Punnett et al., 2004; Nahit et al., 2003; Shaw et al., 2002; Leclerc et al., 2001) to specific analytical techniques like video observation/plant walk through observations (Heuvel van den et al., 2006; Werner et al., 2005; Carey and Gallwey, 2002; Rosecrane et al., 2002; Abbas et al., 2001) and EMG/Electrogoniometer measurements (Thomsen et al., 2002).

Similarly, the case definition used in the literature varied based on presence of symptoms (Heuvel van den et al., 2006; Punnett et al., 2004; Huang et al., 2003; Bongers et al., 2002; Carey and Gallwey, 2002; Feveile et al., 2002; Shaw et al., 2002; Thomsen et al. 2002), symptoms and physical/clinical exams (Melchior et al., 2006; Shiri et al., 2006; Forde et al., 2005; Werner et al., 2005; Karpitskaya et al., 2002; Leclerc et al., 2001; Holness et al., 1998) to "objectively" demonstrable pathological processes (Symptoms and/or Physical Exam and Nerve Conduction Studies for CTS) (Gell et al., 2005; Bodofsky et al., 2004; Boz et al., 2004; Geoghegan et al., 2004; Moghtaderi et al., 2005; Liu et al., 2003; Becker et al., 2002; Thomsen et al., 2002; Kouyoumdjian et al., 2002, Leclerc et al., 2001; Rosecrane et al., 2002, Gorden et al., 1988, Leclerc et al., 1998). According to NIOSH, studies that directly observe or assess physical exposure factors and use specific diagnostic criteria, including physical examination techniques are less likely to misclassify exposure status and injury than any other methods of measurement and hence these studies are given greater weight (NIOSH, 1997).

Therefore, the main goal of this study was to objectively measure job physical exposure and use specific diagnostic criteria to develop a multifactor association model of job, individual and psychosocial factors in prevalence of DUE MSDs. Secondly, to establish acceptable safe exposure limits for job physical exposure variables that were significant in multifactor model.

2. Methods

2.1. Subjects

The current study was part of The WISTAH study which is a multicenter investigation of DUE MSDs conducted by the Center for Ergonomics at the University of Wisconsin– Milwaukee and the Rocky Mountain Center for Occupational and Environmental Medicine at the University of Utah with partial support from the National Institute of Occupational Safety and Health (NIOSH). The WISTAH study was approved by the University of Wisconsin–Milwaukee Institutional Review Board (#03.02.059). Details of the WISTAH study design and data collection methods are provided in Garg et al. (2012a; 2012b). The results reported in this study were for a subset of workers enrolled from 10 diverse manufacturing facilities located in the state of Wisconsin (USA) and consisted of the baseline data. A total of 525 (females: 68%; average age 42 years [sd = 11.3]) workers were selected performing a variety of operations including (a) poultry processing (cutting and packaging) (b) small engine manufacturing and assembly, (c) small electric motor and generator manufacturing and assembly, (d) commercial light assembly and warehousing, and (e) plastic and rubber automotive engine parts manufacturing and assembly. Many similarities existed between the industries and the jobs considered for the study in terms of forces, repetition and hand/wrist postures (e.g., meat cutting using hand knife, assembly using wrenches and power drives, manufacturing of small parts and handling using various manual and power tools, etc.), work shifts, gender and age distributions etc. Two different teams, blinded to one another, collected health outcomes and job physical exposure data at baseline.

2.2. Health outcomes and demographic data collection

At baseline, the health team consisting of trained occupational therapists and board certified medical physicians collected the health outcome data using standard procedures (Garg et al., 2012a). The health data collection was divided into two segments. First, all the subjects completed a laptop administered questionnaire that included demographics, hobbies, past medical history, and psychosocial factors. A structured interview was also administered on a laptop to determine past history of upper extremity health problems assisted with a sectioned body diagram for subjects in locating symptoms in the upper extremities. Secondly, all physical examination procedures, including nerve conduction test were performed on the subjects regardless of the presence or absence of symptoms.

A Board Certified Occupational Medicine Physician ("second examiner") conducted the second confirmatory physical examination. The potential disorders included in the morbidity assessment were (1) specific disorders: Carpal Tunnel Syndrome (CTS), Tendinitis (Extensor and Flexor), Tenosynovitis (Trigger Finger/thumb and deQuervain's Disease), Epicondylitis (Lateral and Medial), and (2) Non-specific pain (Measured on pain scale and recorded if the Pain Rating $\geq$3). Subjects with positive findings (presence of specific disorder and/or non-specific pain $\geq$3) represented a 'case' and subjects with negative findings (absence of specific disorder and non-specific pain $\geq$3) represented as 'referents' (refer to Garg et al., 2012a for diagnostic criteria).

2.3. Baseline job physical data

Baseline job physical exposure data was collected for each individual worker and for each hand separately by the job team consisting of trained ergonomics analysts using standardized methods (Garg et al., 2012b). At the beginning and at the end of shift, hand intensity of exertion (IOE) of the worker was measured by verbal anchor using Borg CR-10 (Borg, 1982). Workers and their supervisors were asked about different tasks each worker performed (job rotation) and the duration of each task. Tasks were video-recorded for later laboratory analyses. Tasks with cycle time $\leq$2 min were video recorded for at least 10 cycles and tasks with cycle time >2 min were recorded for 20–45 min, ensuring that at least one complete task cycle was recorded. Videos were recorded from three different camera angles using a single camera. For each of the three angles, a minimum of three cycles was recorded for tasks with cycle time $\leq$2 min, and a minimum 5 min was recorded for tasks with cycle times >2 min. Videos were analyzed frame by frame in the laboratory to determine analyst overall force rating, temporal exertion requirements, hand/wrist postures, and speed of work (Garg et al., 2012a; 2012b). An expert ergonomist estimated overall force ratings for each hand/wrist to assign an overall IOE rating (Moore and Garg, 1995) based on Borg scale. Three different temporal exertion requirements were measured: (a) the American conference of Governmental Industrial Hygienists (ACGIH) threshold limit value for hand activity level (TLV for HAL) rating using a verbal anchor scale (ACGIH, 2002; Latko et al., 1997), (b) number of efforts per minute (Eff/min), and (c) percentage duration of exertion (PDOE; Moore and Garg, 1995).

More than half of the workers (~54%) performed more than one task during their workday (i.e., job rotation: workers rotate to