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Exposure–response relationships for work-related neck and shoulder musculoskeletal disorders – Analyses of pooled uniform data sets

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ABSTRACT

There is a lack of quantitative data regarding exposure–response relationships between occupational risk factors and musculoskeletal disorders in the neck and shoulders. We explored such relationships in pooled data from a series of our cross-sectional studies.

We recorded the prevalence of complaints/discomfort (Nordic Questionnaire) and diagnoses (physical examination) in 33 groups (24 female and 9 male) within which the workers had similar work tasks (3141 workers, of which 817 were males). In representative sub-groups, we recorded postures and velocities of the head (N = 299) and right upper arm (inclinometry; N = 306), right wrist postures and velocities (electrogoniometry; N = 499), and muscular activity (electromyography) in the right trapezius muscle (N = 431) and forearm extensors (N = 206). We also assessed the psychosocial work environment (Job Content Questionnaire).

Uni- and multivariate linear meta-regression analysis revealed several statistically significant group-wise associations. Neck disorders were associated with head inclination, upper arm elevation, muscle activity of the trapezius and forearm extensors and wrist posture and angular velocity. Right-side shoulder disorders were associated with head and upper arm velocity, activity in the trapezius and forearm extensor muscles and wrist posture and angular velocity.

The psychosocial work environment (low job control, job strain and isostrain) was also associated with disorders. Women exhibited a higher prevalence of neck and shoulder complaints and tension neck syndrome than men, when adjusting for postures, velocities, muscular activity or psychosocial exposure.

In conclusion, the analyses established quantitative exposure–response relationships between neck and shoulder disorders and objective measures of the physical workload on the arm. Such information can be used for risk assessment in different occupations/work tasks, to establish quantitative exposure limits, and for the evaluation of preventive measures.

1. Introduction

A large number of studies have shown that intense manual work is a risk factor for neck and shoulder disorders (Andersen et al., 2003; David et al., 2008; Edling et al., 2012; Gallagher and Heberger, 2013; Palmer and Smedley, 2007). It involves repetitive work tasks, short cycles, high velocities (movements), high force, extreme postures (positions), and lack of recovery, Further, sex/gender (Arvidsson et al., 2006; Nordander et al., 2008) and the psychosocial work environment (high job demands and low job control) are associated with the prevalence of these disorders (Andersen et al., 2007; Edling et al., 2012; Menzel, 2007).

Almost all knowledge concerning work-related musculoskeletal disorders is based on self-reported or observed physical exposure (IJmker et al., 2007; Occhipinti and Colombini, 2007; Takala et al., 2010). However, such methods have serious limitations, for example, different methods are used in different studies, important characteristics such as posture, velocity and force are not sufficiently precise (Dale et al., 2011), or categorical exposure data are used. Furthermore, subjective assessments of exposure through self-reporting may not be reliable, and may lead to information bias (Hansson et al., 2001).

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For the past 25 years, research at our department has focused on the use of direct measurements of physical exposure with technical instruments. This is to obtain objective quantitative information expressed in physical units, regardless of the equipment or method employed. Using such methods, we have been able to establish quantitative exposure–response relationships between the physical work load (wrist angular velocity, measured by electrogoniometry, and lower arm extensor muscle activity, measured by electromyography), and the prevalence of musculoskeletal elbow and hand disorders (Nordander et al., 2013).

In the present study we have investigated the hypothesis that there are also quantitative exposure–response relationships between musculoskeletal disorders in the neck and shoulders, and measurements of velocities, postures and muscular activity.

2. Data collection and analysis

2.1. Study design

In a number of cross-sectional epidemiological studies we have collected data on disorders in many different occupational groups and working situations with large contrasts in physical exposure. The results of these studies have been published previously (Arvidsson et al., 2006, 2012; Balogh et al., 2006; Balogh et al., 2004; Hansson et al., 1997, 2000a; Nordander et al., 2009, 2008, 1999; Ohlsson et al., 1995; Ohlsson et al., 1994b; Unge et al., 2007; Åkesson et al., 2012, 1997, 1999, 2000). All these studies used the same methods for data collection, concerning both physical exposure and musculoskeletal complaints and diagnoses.

The present study pooled data from the previous ones. It involved an enormous amount of data. Thus, only a limited fraction, restricted to the statistically significant findings in uni- and/or multivariate analyses, is in the tables. Only complaints during the past seven days are presented, and not those during the past 12 months. The total data set and all analyses are presented in the Supplementary material.

2.2. Study groups

The study included twenty-four female occupational groups (N = 2324 workers) and nine male occupational groups (N = 817) engaged in industrial, office and other work (e.g. dentistry, hairdressing and cleaning). The work tasks ranged from repetitive and/or constrained, to varied/mobile tasks. Table 1a provides an overview of the occupational groups, and the measurements performed in each group.

The Ethics Committee of Lund University had already approved each of the separate studies from which the data were taken for this study.

2.3. Musculoskeletal disorders

2.3.1. Complaints

We recorded complaints (i.e. pain or discomfort) in the neck and shoulders during the past 12 months and the past seven days in all workers, including those on sick-leave (participation rates 92% among the women and 95% among the men), using the Nordic Questionnaire (Descatha et al., 2007; Kuorinka et al., 1987) (Table 1a; Supplementary Table S1a). The mean age and mean employment time in the present company, doing the present kind of work, was recorded for each group.

2.3.2. Diagnoses

In 23 of the 33 occupational groups (Table 1b; Supplementary Table S1b), an experienced physician or physiotherapist performed a standardized physical examination of the neck and arms (participation rates 95% and 95% among women and men, respectively), and made diagnoses according to predefined criteria (Supplementary Table S2) (Nordander et al., 2009; Ohlsson et al., 1994a). We considered nine specific diagnoses, and recorded the prevalence of diagnosed disorders in the neck and right shoulder. It was not possible to blind the examiners to the kind of task, as they performed all examinations at the workers' work place. (Supplementary Table S3 shows the correlations between the prevalences of complaints and diagnoses.)

2.4. Measurements of physical exposure

Workers within each occupational group performed identical or very similar work tasks. In a sub-sample of workers in each group, we recorded physical exposure to obtain representative group means (Table 2a–c; Supplementary Table S4a-c). In most groups, we recorded the full workday (excluding the lunch break). However, in the early studies, we only monitored representative work tasks, due to temporary technical limitations. As these work tasks were performed during most of the working day, measurements were representative of each job.

A large number of exposure metrics can be derived from the measurements. The properties of the metrics, e.g. distributions and correlations evaluated in previous studies (Hansson et al., 2009, 2010), guided our choices. Although mean power frequency has been suggested as "a generalised measure of repetitiveness" (Hansson et al., 1966), we chose velocity, since this metric represents the combination of the amplitude and repetition of the movement. We chose the activity of the forearm extensor muscles as a general measure of the force exerted by the hand and forearm.

2.4.1. Postures and velocities in the neck and right upper arm

We performed inclinometry measurements with triaxial accelerometers fixed on the forehead in 24 groups (N = 299), and on the outside of the upper arms in 22 groups (N = 304, right side reported here) (Hansson et al., 2001, 2010; Arvidsson et al., 2012). Data loggers collected information at 20 Hz (Logger Teknologi HB, Åkarp, Sweden). Before work we recorded reference postures, defined as 0° flexion of the head and 0° elevation of the arm. For each worker, we recorded seven summary exposure measures: the distribution of angle amplitude (1st, 50th, and 90th percentiles of head flexion, positive forwards, negative backwards; the 50th and 99th percentiles of arm elevation), and the angular velocities of the head and arm (50th percentiles) over the full working day.

2.4.2. Activity of the trapezius and forearm extensor muscles

To record the muscular load we used bipolar surface electromyography (EMG) on the right trapezius muscle, in 26 groups (431 workers), and on the forearm extensor muscles in 19 groups (206 workers) (Hansson et al., 2009, 2010, 2000b; Nordander et al., 2004; Nordander et al., 2000). We sampled data at 1024 Hz, and stored it in data loggers. To describe the muscular load, we used the root mean square value, calculated for epochs of 1/8 s. Data were normalized to the maximal EMG activity (maximal voluntary electric activity: MVE) recorded at 90° arm elevation and handgrip, respectively. We derived muscular activity in terms of 'the static load' (10th percentile of the amplitude distributions) and 'the peak load' (90th percentile). Muscular rest was defined as the fraction of time when the activity was <0.5% MVE. Hence, we calculated six summary measures describing muscular activity, for each worker.

2.4.3. Wrist posture and velocity

We measured right wrist posture and velocity in 30 groups (499 workers), using biaxial flexible electrogoniometers (Biometrics Ltd.,