Investigation of musculoskeletal discomfort, work postures, and muscle activation among practicing tattoo artists

Dana L. Keester, Carolyn M. Sommerich*

Department of Integrated Systems Engineering, The Ohio State University, USA

**Abstract**

Tattoo artists are an understudied worker population with respect to investigation of work-related musculoskeletal (MSK) discomfort and associated risk factors. Results from one discomfort survey has been published; no analysis of worker biomechanics has been published. As such, a study was conducted to begin exposure assessment of tattoo artists to work factors that could result in MSK discomfort. Consistent with the prior survey, the current study showed an elevated prevalence of MSK discomfort. Twelve month discomfort prevalence exceeded 50% in the neck, shoulders, hands/wrists, and upper and lower back (range: 53\textdegree{}94\%). Seventy-one percent of postures evaluated during 16 h of observation had total RULA scores of 5, 6, or 7 (investigation and changes are required soon or immediately). Static muscle activity levels in the left, right, or both upper trapezius muscles in each study participant exceeded the 2\%5\% MVE limit recommended in the literature. Intervention concepts are also discussed.

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**1. Introduction**

According to polls conducted in the United States, about 40\% of millennials (people reaching adulthood around the year 2000) have one or more tattoos, while percentages of tattooed adults in other age groups range from 5 to 30\% (Harris Interactive: Harris Polls, 2012; Pew Research Center, 2010). The growth in popularity and acceptability of tattooing has led to increasing numbers of people working in the body modification industry in general and specifically as tattoo artists. There were estimated to be about 55,000 people employed in the tattoo industry in the US in 2015, and that number is expected to increase to about 77,500 by 2020 (IBISWorld, 2015). As reported by Grieshaber et al. (2012) it is difficult to ascertain the exact number of tattoo artists in the US because there is no centralized licensing body and each state handles its own regulation of the industry. State regulation of tattoo facilities is focused primarily on blood borne pathogens as both a risk to clients and as an occupational risk to the tattoo artists. While it is important to continue to enforce training and regulations relating to blood borne pathogens, as tattooing grows in popularity and the population employed in the industry continues to grow and age, it is important to consider other occupational hazards to which tattoo artists are exposed, including risk factors for musculoskeletal disorders (MSD). As discussed by Grieshaber et al. (2012), from casual observation it would appear that tattoo artists may be exposed to MSD risk factors that are similar to dentists and dental hygienists. Both dental professionals and tattoo artists appear to sit for prolonged periods of time in awkward postures while grasping small vibrating tools that they use to perform fine, detailed visually-guided work on a client who is often in a recumbent position (Fig. 1).

The length of time that it takes to apply a tattoo can vary widely depending on the size, location, and complexity of the design. A small piece can take half an hour or less to complete, whereas a larger tattoo, such as a sleeve (a tattoo that covers the arm) or back piece, can take many hours over multiple sessions. Grieshaber et al. (2012) reported prevalence of MSK discomfort exceeding 50\% in several regions of the body, including low back, neck, shoulder, and hand-wrist, based on their survey results from 79 tattoo artists attending a tattoo convention in Toronto. This survey appears to still be the only published, formal ergonomics-related assessment made in this population of workers prior to the current study described herein. By contrast, work-related MSD risks associated with dentistry have been extensively studied (Akesson et al., 2012; Books and Klemm, 2012; Droese and Jonsson, 2005; Finsen et al., 1998; Hayes et al., 2009; Rafeemannesh et al., 2013; Sakzewski and Naser-Ud-Din, 2014; Thornton et al., 2004; Valachi and Valachi, 2008).
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2.1.1. Questionnaire

Given the limited attention to date to tattoo artists as a worker population that appears to be at some risk of exposure to MSD-related risk factors and subsequent development of MSDs, a study was conducted with the following specific aims: 1) conduct a survey similar to that of Grieshaber et al. (2012) to determine if tattoo artists in another geographical region experience a similar or different prevalence of MSK discomfort, 2) gather objective data to begin to characterize the biomechanics of tattooing, 3) provide initial recommendations for intervention to reduce problematic exposures.

2. Methods

The study was observational in design, and consisted of the administration of a questionnaire followed by collection of postural and muscle activity data from a subset of questionnaire respondents. Both parts of the research protocol were approved by The Ohio State University’s Institutional Review Board. Participants provided informed consent prior to involvement in each part of the study.

2.1. Materials and methods

2.1.1. Questionnaire

The questionnaire was self-administered and took 10–20 min to complete. It consisted of five sections: work history (including time employed in tattooing industry, hours worked per day and week, break patterns, job satisfaction), musculoskeletal health (modified Nordic Questionnaire (Kuorinka et al., 1987)), hand health (hand diagram, specific symptoms, frequency and intensity of symptoms), other health issues (including eye health, headaches, arthritis), and demographic information (including age, height, weight, gender, handedness, exercise participation).

2.1.2. Electromyography (EMG)

A Trigno™ Lab Wireless EMG System (Delsys, Inc., Boston MA) was used with eight wireless electrodes to sample muscle activity throughout the tattoo session. This system has a fixed sampling rate of 2000 Hz and an internal DAC filter bandwidth DC-500 Hz, 160 dB/Dec. The system was coupled with the Motion Monitor Data acquisition software (Innovative Sports Training, Inc. Chicago IL). A 10 Hz high pass filter and notch filters at multiples of 60 Hz were applied prior to exporting the data for analysis. Electrodes were placed over the bellies of the extrinsic finger extensor muscle group of the left forearm, the extrinsic finger flexor muscle group of the right forearm, and right and left mid-deltoid, right and left upper trapezius, and right and left erector spinae muscles. All areas were shaved and cleaned with alcohol prior to application of electrodes.

For purposes of normalization, muscle-specific maximum voluntary exertions (MVEs) were obtained for all muscles except for the right and left erector spinae, for which reference contractions (RVCs) were obtained. Each exertion was performed twice, with 2 min of rest between repetitions. EMG data were collected for 15 s every 3 min throughout the tattoo session; recording sessions lasted from 1 to 3 h depending on the stage of the particular tattoo. For each EMG data sample, the researcher marked whether the tattoo artist was currently in the process of lining or shading and took notes. Depending on the stage of the tattoo, some sessions did not include both lining and shading.

The median frequency of the erector spinae muscle activity was compared over time through a series of reference posture trials, with subjects in a static flexed torso posture similar to those seen while tattooing, to inspect for evidence of muscle fatigue. For the upper extremity and shoulder muscles, means and standard deviations were calculated overall and per participant for 10th and 50th percentile EMG data. The number of participants whose muscle activity exceeded recommended static and mean muscle activity level recommendations according to Jonsson (1978) was calculated for each muscle.

2.1.3. Postural observation

Postural observations were carried out concurrently with EMG collection, though the timing was not coordinated. One observation was carried out every 5 min during the course of each tattoo session and posture was recorded using a Rapid Upper Limb Assessment worksheet (McAtamney and Corlett, 1993). Just prior to recording the posture, a photograph was taken that could be referenced in case of lost data or to confirm joint angles during later analysis. The observations were made from both the right and left sides of the participant. Observations were not made during breaks.

2.2. Participants

Study participants were recruited in one of two ways, both involving convenience sampling. Some participants were recruited from a tattoo convention held in Spring 2014 in Ohio. In addition to
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