"Tattoo Artist", March 4, 1944, By Norman Rockwell
Investigation of Musculoskeletal Discomfort and Ergonomic Risk Factors among Practicing Tattoo Artists

THESIS

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Abstract

Introduction. Tattoo artists as a population of workers may suffer from a high prevalence of musculoskeletal discomfort. Despite this finding, no detailed analyses of the work processes required in tattooing have been published in peer reviewed literature to date. The information gathered in the course of this study provides a base of knowledge for future research and intervention with this population of workers.

Methods. In Phase 1, a survey was conducted on worker and work characteristics and musculoskeletal discomfort, involving 34 professional tattoo artists. In Phase 2, workplace observations were conducted in order to gather data to perform postural analyses and assess muscle activation while performing typical tattooing tasks; 10 professional tattoo artists participated in this phase of the study.

Results. The findings in the current study concerning musculoskeletal discomfort in tattoo artists are consistent with the work of Grieshaber et al. (2012). Both studies support the conclusion that musculoskeletal discomfort is highly prevalent in several regions of the body in these workers. 12-month prevalence for musculoskeletal discomfort in the 8 regions of the body included in the questionnaire ranged from 38% for the legs/feet to 94% for the lower back, while the observation and muscle activity recording portions of the study show that the occupation is marked by prolonged
awkward postures (just under 50% of Rapid Upper Limb Assessment (RULA, McAtamney & Corlett, 1993) scores were between 5 and 6 which corresponds to action level 3 and indicates that investigation and changes are required soon) and high levels of static muscle activity (all 10 Phase 2 participants displayed 10th percentile muscle activity levels that exceeded 2-5% MVE limit recommended by Jonsson (1978) in at least one muscle or muscle group, particularly in the right and left upper trapezius muscles in which activity ranged from 3.4% to 16% MVE).

**Conclusions.** The present study found that tattoo artists experience high levels of discomfort in the neck, shoulders, elbows, hands/wrists, upper back, lower back, legs/feet, and eyes, and in many cases reported that their discomfort was made worse by performing their work tasks, primarily tattooing. Some tattoo artists may have to leave their chosen profession due to the extent of their discomfort, while many work in pain. In their experience of work-related musculoskeletal discomfort and its effects, this profession is similar to others, such as sonographers, surgeons, dentists, and dental hygienists, which have been recognized as needing attention from the ergonomics community and have begun to benefit from interventions that result in improvements to work area layout, furniture, and design of work tools.
For my mother, who taught me that girls can be doctors, pilots, and presidents too.
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Chapter 1: Introduction

Tattoo artists as a population of workers may suffer from a high prevalence of musculoskeletal discomfort. A prior survey of a sample of workers in this understudied population indicated that between 50% and 75% of the tattoo artists experienced musculoskeletal pain in the low back, neck, shoulder, or wrist at least weekly (Grieshaber, Marshall, & Fuller, 2012). Despite this finding, no detailed analyses of the work processes required in tattooing have been published in peer reviewed literature to date. We have begun to address that void with the research described in this thesis document, which describes a study conducted in two phases. In Phase 1, a survey was conducted on worker and work characteristics and musculoskeletal discomfort. In Phase 2, workplace observations were conducted in order to gather data to perform postural analyses and assess muscle activation while performing typical tattooing tasks (lining and shading of tattoos on clients).

The questionnaire (survey) portion of this study shows that tattoo artists suffer from a high prevalence of musculoskeletal discomfort while the observation and muscle activity recording portions of the study show that the occupation is marked by prolonged awkward postures and high levels of static muscle activity.
The information gathered in the course of this study provides a base of knowledge for future research and intervention with this population of workers. It has implications for manufacturers and developers of equipment used by tattoo artists and can be used as a guide for manufacturers of equipment used by tattoo artists. It could lead to better products in the future which allow tattoo artists to work in more natural, better supported postures and may help those who wish to set up tattoo shops in the future or modify their current work environments and practices to design with ergonomics in mind.

1.1 Background

Over the past few decades, tattoos have become an increasingly common form of adornment and self-expression. In fact, the 2006 Gen Next survey by the Pew Research Center found that people between the ages of 18 to 40 were more likely to have a tattoo than to have a ‘piercing other than earlobe’ or to have dyed their hair an unnatural color (PewResearchCenter, 2007). This 2006 study and its follow up study The Millennials: Confident. Connected. Open to Change found that between 36-38% of respondents age 18 to 29 and between 32-40% of respondents age 30 to 45 had at least one tattoo.

This growth in popularity and acceptability has led to an ever increasing number of people employed in the body modification industry in general and specifically as tattoo artists. Conservative estimates place the number of tattoo shops somewhere around 15,000 in 2007 and as a $2.3 billion industry it makes up a significant portion of the U.S. economy (Chafkin, 2007).
1.2 Regulatory History of the Tattoo

For thousands of years people have permanently marked their bodies or the bodies of others with tattoos. Egyptian women were tattooed with Bes, the Egyptian god of revelry (DeMello, 2000). A mummified iceman of the Alps was found with charcoal tattoos that are believed to have possibly been related to a form of acupuncture (Gilbert, 2000; Owen, 2013). The Greeks and Romans used tattoos to mark slaves (DeMello, 2000). Polynesian tattooing, which is where the modern word tattoo comes from, was thought to be the most intricate and skillful tattooing in the ancient world (Gilbert, 2000). Archeologists have discovered tools that were probably used for tattooing in Europe and Scandinavia as far back as 12,000 years ago (Bailey, 2012).

Since ancient times, the popularity and acceptability of tattoos has waxed and waned. When tattoos were very expensive and rare in the Western world they were considered something of a status symbol in Europe and were common among members of the aristocracy, including members of the royal courts (Broadwell, 1900). After the invention of the electric tattoo machine made tattoos affordable for the general population, they began to be associated with social and criminal deviance (Roberts, 2012). By the 1950s in the United States, tattooing was looked down upon, but back alley and boardwalk parlors continued to do quite a large amount of business with sailors and soldiers (Omori, 2003).
1.2.1 Needles and blood borne pathogens (BBP).

Although by 1961 most tattoo shops had sterilization machines, few used them and that year an outbreak of hepatitis occurred which further damaged the reputation of tattoo parlors. The New York City government offered to allow tattoo shops to self-regulate but they were unable to organize and subsequently a health code-related ban went into effect which caused many shops to shut down or relocate (Root, 2014).

In the 1970s traditionally trained fine artists began to embrace tattooing, studios began to be regulated by government health agencies, studios began to adopt equipment and procedures resembling those found in medical clinics, influential rock stars such as Janis Joplin and the Rolling Stones began flaunting their tattoos, and tattoos again began to become accepted by mainstream society (Levins, 1997).

Today most states have laws on the books that regulate tattoo facilities (American Red Cross, 2014). There is an intense focus on blood borne pathogens as both a risk to clients and as an occupational risk to the tattoo artists themselves. Perhaps due to this intense regulation, there has never been a documented case of HIV/AIDS transmitted through tattooing anywhere in the United States and only a small fraction of a percentage of cases of hepatitis have been associated with tattoo studios. Historically, more instances of HIV/AIDS or hepatitis transmission have been related to dental work than tattoos (CDC, 2012a, 2012b).

While it is important to continue to enforce training and regulations relating to blood borne pathogens, as tattoos grow in popularity and the population employed in the
industry continues to grow, it is increasingly important to address other occupational hazards such as noise exposure, exposure to vibrating tools, and ergonomics.

1.3 Population Overview

1.3.1 Growing in numbers.

As reported in Grieshaber et al. (2012) it is difficult to ascertain the number of tattoo artists in the US because there is no centralized licensing body and each state handles its own regulation of the industry. In addition to this, licenses are generally granted to shops rather than individual tattoo artists, making it even more difficult to estimate numbers. However, if the estimate (Chafkin, 2007) of 15,000 shops is assumed to be accurate and each shop is conservatively estimated to employ an average of just 4 to 5 tattoo artists it is possible that there are between 60,000 and 75,000 tattoo artists in the United States today. The number is likely growing due to the increasing popularity and acceptance mentioned previously.

1.3.2 Nature of the work.

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 may take half an hour or less to complete, whereas a larger tattoo such as a sleeve or back piece may take many hours over multiple sessions. Regardless of size, most tattoos follow the same general process.

Step 1: The artist meets with the client and comes up with a design. This could be as a walk in or a previously made appointment. The design could be anything from a
piece of flash (a predesigned tattoo) to an elaborate collaboration between artist and client.

Step 2: Preparation and application of stencil. The area that is going to be tattooed is shaved and cleaned thoroughly by the tattoo artist and a stencil of the design is applied.

Step 3: Set up. The artist will set up their work station with one or more machines, tubes, needles, inks, distilled water, and ointment.

Step 4: Application. This is the step that varies most in length. Each session could last anywhere from 15 minutes to 8 or more hours. The artist will often take short breaks after an hour or two during longer sessions. Typically the outline of the tattoo is applied first, followed by shading. During this step the tattoo artist reaches back and forth between client and work station to refill ink, get ointment, or change machines.

Step 5: Clean up. Once the session is finished the tattoo artist will clean off any excess ink, apply protective ointment and a bandage, and, once the client has gone, clean and sterilize the area.

More detailed information and videos of tattoo application can be found online at artist and tattoo shop websites as well as general information websites such as about.com or howstuffworks.com. There is even a slow motion, high definition recording of the tattoo process available on YouTube by SmarterEveryDay.
1.3.3 Other occupational risks.

While needle sticks and blood borne pathogens in tattooing are well covered areas of study (Armstrong, 2005; Lehman et al., 2010; Messahel & Musgrove, 2009) and the focus of the current research is primarily ergonomics, there are other areas of occupational risk to tattoo artists which are worth mentioning that should explored further in the future.

1.3.3.1 Shift work and extended hours.

Although it is by no means a hard and fast rule, tattoo artists tend to work at times that are convenient for the general public to visit the shop. This means that many tattoo artists work late into the evening as well as on weekends and some holidays. Tattoo artists may also work long hours, with many working between 10 and 12 hours per day. According to the Centers for Disease Control and Prevention, both shift work and long work hours have been associated with health and safety risks. For example, working a 12-hour shift increases risk for accidents and errors by 28% and is associated with a number of chronic illnesses (CDC, 2014).

1.3.3.2 Vibrating tools.

Similar to dentists and other occupational groups, tattoo artists may hold the vibrating tattoo machine for many hours on end. Artists may spend an average of 40% to 70% of their time holding their machines. Exposure to vibrating tools has been shown to significantly impair vibrotactile sensibility, strength, and motor performance in female dentists (Akesson, Lundborg, Horstmann, & Skerfving, 1995).
1.3.4 Ergonomics.

Little consideration has been given to the occupational risks tattoo artists face, particularly the ergonomic risks (Grieshaber et al., 2012). Yet from a biomechanical perspective, tattoo work appears to share several adverse characteristics with other professions that have been associated with musculoskeletal discomfort in workers. Those characteristics are long hours of seated work in awkward postures while performing fine detailed and forceful work with the hands. Professions that share those characteristics and are known to be high risk for musculoskeletal disorders include dentist and dental hygienist (Akesson, Hansson, Balogh, Moritz, & Skerfving, 1997) and sonographer (McCulloch, Xie, & Adams, 2002; A. C. Smith, Wolf, Xie, & Smith, 1997).

The occupational risks associated with dentistry have been extensively studied (Akesson, Balogh, & Hansson, 2012; Books & Klemm, 2012; Droeze & Jonsson, 2005; Finsen, Christensen, & Bakke, 1998; Hayes, Cockrell, & Smith, 2009; Rafeemanesh, Jafari, Kashani, & Rahimpour, 2013; Sakzewski & Naser-Ud-Din, 2013; Thornton, Stuart-Buttle, Wyszynski, & Wilson, 2004; Valachi & Valachi, 2003). This is appropriate given the high prevalence of musculoskeletal discomfort in these populations, with as much as 85% of dentists experiencing discomfort in the neck and 60% in the low back (Finsen et al., 1998; Hayes et al., 2009; Rafeemanesh et al., 2013).

For comparison, a 2012 study presented at the Annual Meeting of the Human Factors & Ergonomics Society reported levels of musculoskeletal discomfort of tattoo artists that in some cases exceeded discomfort reported in professions where workers are
exposed to similar ergonomic hazards (75% reported discomfort in the lower back compared to 60% of dentists) and called for further research in this area (Grieshaber et al., 2012).

In general, tattoo artists do not have a cultural tradition of addressing ergonomic issues. In the pilot episode of a reality television show featuring tattoo artists, an artist is berated for not prioritizing the client’s comfort over his own awkward posture and told by a judge that “We all are sitting hunched over because we've tattooed for 20 years.” (Warren, 2012) It is easy to find photos on the internet that accurately portray the awkward work postures that can be observed in any tattoo shop (Figure 1).
1.3.5 **Anecdotes on being an independent contractor, workers’ compensation, and control of work environments.**

Due to the fact that very little epidemiological research has been done on the body modification industry it is impossible to cite sound statistics that give an accurate overview of this population of workers. However, ergonomics deficiencies are acknowledged as an issue within the tattoo artist community (Fusco, 2013; Hardie, 2014; Hartman, 2013; Lenhard, 2012). Further, throughout the course of the current study the researchers had the opportunity to speak with many people who are currently or were
formerly employed in the industry. Their personal observations also help to shed light on areas where further research may be needed.

A complicating factor to understanding the issues and occupational hazards that tattoo artists face is the fact that many of them work as independent contractors in the same way that a hair stylist might rent a booth at a salon.

As independent contractors, tattoo artists are not eligible to receive workers compensation in the event that they are injured. Instead, they may have to find alternative jobs that give their bodies a break from the awkward postures, assumed during tattooing, that they believe are required to ensure that the client is comfortable. Alternatively they may leave the industry all together as their bodies start to wear. One artist observed that “you don’t see a lot of old tattoo artists, and it isn’t because they don’t want to do it anymore.”

Moreover, being a contractor means that tattoo artists may have very little control over the environment they work in and the tools with which they work. Tattoo artists often own their own tattoo machines, but depending on the shop in which they work, they may have little to no control over the furnishings such as client chairs and arm rests, the chairs available for the artist to use, or their work stations.

These items can vary widely in their comfort and adjustability and it is up to the shop owner to make decisions about whether or not to provide ergonomically sound furnishings and equipment. However, with tattoo artists largely employed on a
commission basis and shop owners not responsible for workers compensation there is little to no monetary incentive.

Further complicating the issue, some tattoo artists may travel to multiple tattoo conventions/festivals each year. At a convention the artist must use only what they can bring or what is provided which often equates to folding chairs with little to no padding or support for the tattoo artist and a folding massage table for the client.

1.4 The Importance of Ergonomics

Applying ergonomics principles is one approach to the design of work (aka fitting the machine or task to the human). According to the Occupational Safety and Health Administration (OSHA):

If work tasks and equipment do not include ergonomic principles in their design, workers may have exposure to undue physical stress, strain, and overexertion, including vibration, awkward postures, forceful exertions, repetitive motion, and heavy lifting. Recognizing ergonomic risk factors in the workplace is an essential first step in correcting hazards and improving worker protection (OSHA, 2000).

Although heavy lifting and forceful exertions are rare in the body modification industry, awkward static postures, repetitive motion, and exposure to vibration are common hazards that occur across the profession.
1.5 The Study of Similar Populations

Ergonomic risk factors have not been well studied in tattoo artists or in the body modification industry at large; but sustained awkward posture, repetitive motion, and exposure to vibration are not unique to this industry. Dentists and dental hygienists are exposed to many of the same risk factors and have been a population of interest to ergonomists for a number of years. Methods used successfully to assess musculoskeletal risk factors present in dentistry may also be appropriate for use in the study of tattoo artists’ work.

1.5.1 Assessment of musculoskeletal discomfort.

A number of studies of dental professionals utilized some variation of the Nordic musculoskeletal questionnaire (Kuorinka et al., 1987) to determine the prevalence of musculoskeletal discomfort (Akesson et al., 2012; Finsen et al., 1998; Hayes et al., 2009; Rafeemanesh et al., 2013).

Twelve month discomfort prevalence among dentists and dental professionals varies widely from study to study, reported percentages are as high as 60% in the low back, 85% in the neck, 65% in the shoulders, and 54% in the wrists for dentists (Finsen et al., 1998; Hayes et al., 2009; Morse, Bruneau, & Dussetschleger, 2010; Rafeemanesh et al., 2013). Dental hygienists report even higher rates of discomfort with as much as 83% of dental hygienists reporting discomfort in the neck and 76% in the shoulder (Morse et al., 2010).
Similarly high percentages of tattoo artists who responded to a self-administered questionnaire by Grieshaber et al. (2012) reported discomfort with 75%, 61%, 57%, and 51% reporting discomfort in the lower back, neck, shoulder, and wrist respectively.

1.5.2 Assessment of posture.

The Rapid Upper Limb Assessment (RULA) technique developed by McAtamney & Corlett (1993) is one possible contender for studying the ergonomic risk factors associated with a job. It allows for quick postural rating based on the position of the upper extremities and trunk and has been used to compare working postures of dentists (Chaikumarn, 2005) and micro-surgeons (Statham et al., 2010). Multiple studies have shown RULA scores to be significantly related to perceived discomfort (Fountain, 2003; Kilroy & Dockrell, 2000).

1.5.3 Assessment of muscle activity.

Several studies have used electromyography (EMG) to assess the muscle activity of dentists, dental hygienists, and surgeons during real and simulated work. Åkesson et al. found high levels of static (10th percentile between 3.5% and 7.1% MVE depending on muscle) muscle activity in the trapezius and forearm extensor muscles of female dental hygienists doing real work, particularly during manual scaling (Åkesson et al., 2012) and female dentists (10th percentile between 5.0% and 7.7% MVE depending on muscle) during drilling (Åkesson et al., 1997). A study published in 2014 that was carried out in a simulated environment found high levels of muscle activity in the upper trapezius to be related to working in a seated posture (Pope-Ford & Jiang, 2014).
Electromyography has also been used to record muscle activity of both dentists and surgeons in order to assess interventional supports. An ergonomically designed dental chair with chest and arm supports was found to reduce the EMG activity in the left and right trapezius muscles (Haddad, Sanjari, Amirfazli, Narimani, & Parnianpour, 2012) while a body support for surgeons was similarly found to reduce muscle activity in the in the erector spinae muscle (Albayrak et al., 2007).

1.6 Next Steps in the Study of Tattoo Artists

These studies have shown that aches and pains are common in both dental professionals and tattoo artists. The study of dental professionals has shown that this may be due to pervasive awkward postures and prolonged static muscle activity. It is expected that similar findings would result from a study of tattoo artists; however, such research has not been published in peer reviewed literature to date.

The purpose of the study discussed in the following sections was to confirm the results of the previous (Grieshaber et al., 2012) study and begin to document the ways in which tattoo artists work and how their bodies work during the process of tattooing. This research is meant to lay the foundation for future interventional work, such as the two studies mentioned in 1.5.3 Assessment of muscle activity.
Chapter 2: Methods

Participants

2.1.1 Recruitment.

Participants for this study were recruited in one of two ways. A group of participants were recruited from the Hell City Tattoo Convention (April, 2014) in Columbus, OH. Convention participants were approached and asked if they would be willing to complete a short questionnaire about their work practices and musculoskeletal pain. These participants were provided with an IRB-approved consent document. Because no identifying information was collected for these participants, they were not asked to sign the consent document and were instead asked to retain it for their records. The questionnaire was left with participants to fill out at a time that was convenient for them and picked up at a later time by a researcher. Return of the questionnaire was assumed to indicate consent.

In addition to the participants recruited from the convention, local participants were recruited from tattoo shops in Columbus, OH. Permission to recruit was granted by the shop owners prior to making contact with individual tattoo artists. Flyers were then delivered to the previously identified shops and a researcher followed up by visiting each shop to make contact with individual tattoo artists. Participants were asked to sign an IRB-approved written consent document which was completed before they were provided with the questionnaire. A subset of local questionnaire participants was asked to
participate in the electromyography (EMG) and observational portion of the study. These participants were screened for the presence of musculoskeletal disorder or adhesive allergies prior to being asked to participate to prevent the risk of injury. They were asked to review and resign the relevant portions of the consent document before the study began and were provided a $10 Starbucks gift card as a thank you for their participation.

Copies of each consent form can be found in Appendix A: Consent Form for Survey-Only Participants, Appendix B: Consent Form for Observation/EMG, and Appendix C: Consent Information for Tattoo Clients.

2.1.2 Participation.

Thirty-four questionnaires in total were collected from all recruiting efforts. A total of 20 questionnaires were returned either during the convention or later by mail of 37 that had been handed out (54% response rate). Of the 15 local tattoo artists who were approached, 14 questionnaires were returned. Twelve of the local artists were subsequently asked to participate in the EMG and observational portion of the study, 11 agreed but only 10 were able to participate due to one participant being injured in the interim.

2.2 Materials and Methods

2.2.1 Questionnaire.

The questionnaire was self-administered and took approximately 10 to 20 minutes to complete. It was made up of five sections:
- Work history
- Musculoskeletal health
- Hand health
- Eye health, headaches, and previous diagnoses
- Demographic information

The work history section of the questionnaire included questions about the length of time employed in the industry, secondary occupations, the number of days per week and hours per day worked, as well as questions relating to the breakdown of each day, average length of sessions, time without breaks, and job satisfaction. The full questionnaire can be found in Appendix D: Questionnaire.

The musculoskeletal health section of the survey was a modification of the Nordic Musculoskeletal Questionnaire (Kuorinka et al., 1987). Seven bodily regions were listed and accompanied by shaded graphics to further clarify the areas in question. Participants were asked if they had had any trouble (ache, pain, discomfort, burning, numbness, tingling, or other trouble) in any of the areas listed during the last 12 months. If the answer was yes, they were instructed to answer additional questions describing frequency, intensity, duration, and interference with normal activities, specifically for each body part in which trouble was experienced. All participants (those who answered yes, as well as those who answered no) were asked to answer questions about musculoskeletal disorder diagnoses and traumatic injuries.
The hand health section of the survey was closely related to the musculoskeletal health section. Participants had the option to skip this section if it was not applicable by checking a box labeled “No Hand Discomfort (skip to next page)”. Six regions of the right hand and six regions of the left hand were listed which were accompanied by shaded graphics for clarity. Participants were asked to indicate whether they had had any trouble (ache pain, discomfort, burning, numbness, tingling, or other trouble) in any of the areas listed, and if so to answer additional questions describing frequency, intensity, and duration.

The eye health, headaches, and previous diagnoses section of the survey asked participants questions related to their eye health and discomfort and its effect on their lives, as well as questions about headache frequency and diagnosis of disorders such as migraine headaches and arthritis.

The last section of the questionnaire included general demographic information such as year of birth, height and weight, sex/gender, handedness, smoking history, education, and exercise.

2.2.2 Electromyography (EMG).

The researchers worked with the tattoo artists to determine an appropriate time to schedule the recording session. The artists were asked to select a tattoo session that was expected to take at least 1 hour to complete so that an adequate amount of data could be collected and to leave 30-45 minutes free before the session for set up and reference contractions.
2.2.2.1 EMG equipment.

A Trigno™ Lab Wireless EMG System (Delsys, Inc., Boston MA) was used with eight wireless electrodes to sample muscle activity throughout the tattoo sessions. 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). Notch filters (at multiples of 60 Hz) were applied prior to exporting the data for analysis.

2.2.2.2 Electrode placement

Electrodes were placed over the muscle bellies of the extensor group of the left forearm, the flexor group of the right forearm, right and left mid-deltoid, right and left upper trapezius, and right and left erector spinae muscles. All areas were shaved, cleansed with alcohol, and marked prior to application of the electrode.

The position for the left extensor group electrode (Figure 2a) was located by instructing the participant to hold their arm by their side with a slight bend (~100°) in the elbow and palm fully pronated to mimic the position of the artist’s hand when ‘stretching’ the skin during a tattoo. The participant was then asked to make a fist and attempt to open it against pressure provided by the researcher and the participant’s forearm was palpated in order to find an appropriate location.
Figure 2a-b: left extensor electrode placement (left) and right flexor electrode placement (right).

The right flexor group electrode (Figure 2b) was placed 1/3 of the distance proximal from the medial epicondyle to the crease of the thenar eminence while the arm was held by the side with a slight (~100°) bend in the elbow and wrist in a neutral posture (Sommerich et al., 2012). Placement was confirmed by palpating the muscle while the participant intermittently gripped an object.

The right and left mid-deltoid electrodes were placed mid-way between the acromion and the deltoid tuberosity while the participant’s arm was resting by his/her side. Placement was confirmed by having the participant abduct the arm against manual pressure.

Right and left upper trapezius electrodes were placed 2 cm lateral to the midpoint between the 7th cervical vertebra and the acromion (Figure 3) (Jensen, Vasseljen, &
Westgaard, 1993). The participant was then asked to shrug and placement was confirmed by the researcher by palpating the muscle.

The participant was then asked to place an index finger at the top of each iliac crest (hip bone) with thumbs pointing back, to identify the appropriate level for electrode location. The participant was then asked to bend forward slightly at the hips and to move a weighted object towards and away from the body while the researcher palpated the muscle in order to identify the appropriate distance from the midline for electrode location. The bilateral locations were then marked and the electrodes placed (Figure 3).
After placement, all electrodes were turned on and the participant was asked to make a tight fist and squeeze with the right hand, try to extend the left fingers against pressure, and grasp hands in front of the body pull outwards to visually inspect the signals before data collection.

2.2.2.3 Reference contractions.

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 MVE was attempted twice per muscle, participants were asked to exert “as hard as you can without hurting yourself – these are maximum voluntary exertions” for 5 seconds (timed by the researcher using a stopwatch) and given 2 minutes of rest in between exertions (Mathiassen, Winkel, & Hägg, 1995). Participants were seated for all exertions except for trapezius muscle.

The reference contraction for the left extensor group was obtained by asking the participant to rest the left elbow and forearm on an arm rest with palm fully pronated and fingers wrapped around the front of the arm rest. The participant’s fingers were manually restrained by the researcher and the participant was instructed to attempt to extend fingers and wrist and also to attempt to deviate the wrist radially.

While the left extensor group was in its two minute rest period, the right flexor group’s reference contraction was obtained by instructing the participant to grip an NK Digit-Grip sensor as hard as possible without injury with the upper arm vertical, elbow
bent 90°, and forearm in a neutral posture. Grip strength measured by the sensor was
documented.

A deltoid-exertion device was fashioned using a non-stretch vehicle grade tie-down
strap and PVC pipe for handles which allowed the right and left deltoid MVEs to be
recorded simultaneously by instructing the participant to grip the handles and pull
outwards as hard as possible without injury.

Similarly, the trapezius muscle’s MVEs were obtained using a non-stretch vehicle
grade tie-down strap which was gripped in both hands by the participant. The participant
was then instructed to stand on the middle portion of the strap and wrap any excess length
around their hands until the length of the strap was barely too short to stand up fully with
arms vertically oriented and elbows fully extended. Participants were then instructed to
shrug their shoulders towards the ceiling as hard as possible against the resistance from
the straps, without injury.

As a reference exertion for the right and left erector spinae muscles, participants
were instructed to sit with both feet flat on the floor with hands clasped in front of them
(not supporting themselves with their arms), bent 30° at the waist and hold for 10
seconds. These reference exertions were repeated before breaks during the tattoo session,
and were designed specifically to assess development of muscle fatigue in the erector
spinae over the course of the data collection/tattooing session.
In addition to the maximum voluntary contractions and reference contractions, a baseline/resting EMG file was recorded with the participant standing quietly with arms resting vertically along the side of the body. Participants were instructed to clear their minds and relax during this time.

2.2.2.4 Data collection.

Data was collected for 15 seconds every three minutes throughout the tattoo session. For each 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 prior to each session, some sessions did not include both lining and shading.

2.2.2.5 EMG processing and normalization.

EMG data were processed using Matlab. All files were visually inspected during this process. For reference contractions, the portion of the file during which the reference contraction took place was manually selected. Issues such as large spikes and heart beats in test files were removed manually. The EMG signal was smoothed with a moving average window of 75 ms followed by application of a Hanning filter. The EMG data for the right extensor, left flexor, bilateral mid-deltoids, and bilateral upper trapezii were then normalized to the 95th percentile of the higher MVE for the upper extremity and shoulder muscles. EMG data for the erector spinae muscles were normalized to the 5th percentile of a resting baseline. The 10th, 50th, and 90th percentiles of the normalized, processed EMG data for each muscle, for each data file, were written into separate files for later analysis. Median frequency was also determined for the Erector Spinae muscles, for each
repetition of the reference posture trials, to look for indications of fatigue development over the course of the tattoo session.

2.2.3 Postural observation.

Postural observations were carried out concurrently with EMG collection, though the timing was not coordinated. One observation was carried out every 5 minutes during the course of each tattoo session and posture was recorded using a Rapid Upper Limb Assessment worksheet (McAtamney & Corlett, 1993; Middlesworth, 2012). 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.

2.3 Analysis

Separate univariate analyses were performed for the questionnaire, EMG, and postural data prior to considering the combined data. Analysis was completed using Microsoft Excel 2010 and Stata/SE 12.

2.3.1 Questionnaire.

Mean and standard deviations were calculated for items within the work history and demographic sections of the questionnaire. For the musculoskeletal health, hand health, and eye health portions of the questionnaire, counts were calculated and graphed.

Two new variables were created for analysis. BMI was calculated and used to compare the overall sample (all those who participated in the questionnaire) to the subset
that was observed (EMG and observational data). A new variable was also created by combining the intensity, duration, and frequency variables from the musculoskeletal health and hand health portions of the questionnaire (Hales et al., 1992).

2.3.2 Electromyography (EMG).

The median frequency for both erector spinae muscles, for each reference trial were compared within each participant for the low-back reference postures 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, 50th, and 90th percentile EMG data. The number of participants who exceeded recommended static and mean muscle activity level recommendations according to Jonsson (1978) was calculated for each muscle. Regression analysis was performed on EMG data within each participant to determine if any trend across time was present; increase in amplitude of surface EMG (sEMG) over time can be an indicator of fatigue development.

2.3.3 Postural observation.

Means, ranges, and counts were calculated within each participant for scores from the postural observation; distribution of scores was graphed and visually inspected.

2.3.4 Comparisons across data.

The cumulative discomfort scores for each body part (calculated previously from frequency, duration, and intensity of the trouble/discomfort) were compared with mean RULA scores for that body portion and the mean 10th percentile muscle activity level for the relevant muscles. For example, the cumulative shoulder discomfort score from the
survey was compared to the upper arm score from RULA and the mean 10th percentile muscle activity of the trapezius and deltoid muscles.
Chapter 3: Results

3.1 Questionnaire

3.1.1 Demographics

Twenty-eight male and six female tattoo artists participated in the study. Male participants (n = 28) were between 165 and 196 cm tall (mean = 181 cm, sd = 8 cm) and weighed between 63 and 130 kg (mean = 87 kg, sd = 18 kg) while female participants (n = 6) were between 157 and 171 cm tall (mean = 164 cm, sd = 5 cm) and weighed between 53 and 82 kg (mean = 67 kg, sd = 11 kg). Participants were primarily white (82%, 28 of 34) with a small number identifying as black, Hispanic, or multi-racial (15%, 5 of 34) and one individual not reporting. They were between 26 and 54 years of age at the time of study (mean = 36 years) and had been tattooing for between one and 22 years (mean = 11 years).

Eight participants (23.5%) reported that they had completed a college degree, 18 (52.9%) reported some college, trade school, or vocational training, and eight (23.5%) reported high school or below as their highest level of formal education. Eight were current smokers (23.5%), 4 had quit smoking within the last 12 months (11.8%), 14 had quit smoking more than 12 months ago (41.2%) and 8 had never smoked (23.5%). Participants reported exercising an average of 2.5 to 3 days per week.
Participants were primarily right handed (94%, 32 of 34) with one left handed and one ambidextrous convention participant. All participants who answered the question reported holding the tattoo machine with their right hand (n = 32). Most participants reported that tattooing was their sole source of income (91%, 31 of 34).

3.1.1.1 Survey-Only Participants vs. Observation/EMG Participants

A subset of 10 individuals who participated in the survey (Phase 1) also participated in the observation/EMG portion (Phase 2) of the study. Overall, survey-only participants and observational/EMG participants did not differ significantly in work history and practices or in the demographic categories of sex, age, height, weight, education, or smoking history.

However, when participants were categorized based on sex, observation/EMG (Phase 2) males had significantly greater BMIs (mean = 29.5) than survey-only (Phase 1) males (mean = 25.6) (t = 2.24, p = 0.02), but also exercised significantly more times per week (4.1 and 2.4, respectively) (t = 2.02, p = 0.03).

3.1.2 Work History and Practices

The 34 participants had been in the body modification industry for between 2 and 22 years (mean = 11.4, sd = 5.2) and had been tattooing for between 1 and 22 years (mean = 11.0, sd = 5.3). Four out of the 34 reported having secondary occupations (12%). These participants were also employed as a tattoo machine builder, a fine artist, and a painter, while the fourth did not report a specific occupation. Overall, participants worked
as tattoo artists between 2 and 7 days per week (n = 32; mean low\(^1\) = 4.8, sd = 1.3; mean high = 5.1, sd = 1.3) for between 3 and 14 hours per day (n = 33; mean low = 7.7, sd = 2.0; mean high = 9.3, sd = 2.4). The following figures provide additional information on task breakdown (Figure 4), length of average tattoo sessions (Figure 5), and time spent tattooing without break (Figure 5).

![Average Task Breakdown (% workday)](image)

Figure 4: Average time as a tattoo artist spent carrying out specific tasks as a percentage (%) of the workday.

\(^1\) Participants could provide a single number or a low number and a high number to describe a range of days worked per week and hours worked per day.
3.1.3 Musculoskeletal Health & Discomfort

Twelve month prevalence for musculoskeletal discomfort in the 8 regions of the body included in the questionnaire ranged from 38% for the legs/feet to 94% for the lower back (Figure 6) while 7-day prevalence ranged from 9% for the elbow to 50% for the lower back (Figure 7). Those with previous injuries accounted for between 3% and 26% of the total 12-month prevalence, and between 0% and 15% of the total 7-day prevalence.

Figure 5: Average length of time respondents spent tattooing per session and without a break.
Cumulative discomfort scores were calculated for each region of the body by combining the scores on questions related to frequency, duration, and intensity of discomfort.
discomfort. Possible scores ranged from 1 to 5 for frequency, 1 to 7 for duration, and 1 to 4 for intensity, resulting in a total possible cumulative discomfort score of between 3 and 16 for those reporting discomfort. Mean cumulative discomfort scores ranged from 7.6 in the elbows to 10 in the lower back (Figure 8).

![Mean cumulative discomfort scores by region of body](image)

**Figure 8:** Mean cumulative discomfort scores by region of body.

Fourteen out of 34 participants (41%) reported having seen a health care provider in the last 12 months due to discomfort in at least one region of the body.

Twenty-seven out of 34 participants (79%) reported that work activities related to tattooing make discomfort worst in one or more regions of the body (Figure 9).
Figure 9: Percentage of total respondents who reported discomfort was made worse by work activities related to tattooing compared to percentage of total respondents who reported discomfort by region.

3.1.4 Hand Health & Discomfort

Sixty-five percent of respondents reported experiencing some type of hand discomfort. Reported discomfort in specific regions of the hand ranged from 9% in the left thumb and palm to 44% in the right thenar eminence. See Figure 10 below.
Cumulative discomfort scores were calculated for each region of the hand by combining the scores on questions related to frequency, duration, and intensity. Possible scores ranged from 1 to 5 for frequency, 1 to 7 for duration, and 1 to 4 for intensity, resulting in a total possible cumulative discomfort score of between 3 and 16, for those reporting discomfort. Mean cumulative scores for the hand ranged from 7 for the right palm and left base to 9.5 for fingers 4&5 in the left hand (Figure 11).
Figure 11: Mean cumulative discomfort scores by region of hand.

### 3.1.5 Headaches and Previous Diagnoses

Eighty-eight percent of respondents reported experiencing headaches at least once every 6-months; over half reported experiencing headaches at least once a month (Figure 12). Previous diagnoses included migraine headaches ($n = 2$), arthritis ($n = 3$), and thyroid problems ($n = 1$).
3.2 Rapid Upper Limb Assessment (RULA)

3.2.1 Overall Scores: MSD Risk Level, Wrist/Arm Score, Neck, Trunk, Legs Score

The Rapid Upper Limb Assessment (McAtamney & Corlett, 1993) yielded overall scores between 2 (action level 1: posture acceptable if not maintained or repeated for long periods) and 7 (action level 4: investigation and changes required immediately). Just under 50% of scores were between 5 and 6 which corresponds to action level 3 and indicates that investigation and changes are required soon (Figure 13).
The action level is calculated based on a combined score for the wrist and arm and a combined score for the neck, trunk, and legs; each combined score accounts for posture and muscle use, the latter being repetitive or static. Each of the two combined scores have a possible range from 1 to 10. In the current study, the most frequently occurring combined scores for the upper extremities were between 3 and 4, while the most frequently occurring combined scores for the neck, trunk, and legs were between 5 and 6.

Individual participant’s action level/level of risk, upper extremity scores, and neck, trunk, leg scores varied with some displaying a wide range of scores and others clustered at one end of the scale. See Figure 14 below for examples and

Appendix E: RULA Risk Levels for all individual score breakdowns.
3.2.2 Frequency of Scores by Region

In the same way that the overall Level of MSD Risk is derived from the upper extremity combined score and the neck, trunk, legs combined score; these combined scores are calculated from individual scores on each constituent body part. The combined upper extremity score is based on individual scores for the upper arm, lower arm, wrist, wrist twist, and upper extremity muscle. The combined neck, trunk, and leg score is based on individual scores for the upper extremity, neck, trunk, legs, and trunk muscle use.

Figure 14: RULA Observations for Participants 21 (left) and 34 (right).
Figure 15 shows the frequency of each body part score for all participants across all 195 observations. In the figure, the possible ranges of scores are listed below each body segment, in parentheses. Muscle use was only scored as 0 or 1; where 1 indicated repetitive use or sustained static holding. For an explanation of the joint angles that correspond to each score as well as the method of calculating overall scores, the worksheet used to record scores can be found on ergo-plus.com (McAtamney & Corlett, 1993; Middlesworth, 2012). RULA score frequency for each study participant can be found in Appendix F: Frequency of RULA Scores by Region.

3.2.3 Change Over Time

Static or repetitive postures were pervasive across the majority of participants.

Graphs of each participant’s RULA scores documented serially over the period of
observation for upper arm, lower arm, wrist, wrist twist, upper muscle use, neck, trunk, legs, and trunk muscle use are provided in Appendix G: RULA Scores over Time. Some participants show very little variation in scores across long periods of time while others vary widely. As an example, for participant 29 each of the scores that contribute to the hand/arm score were unchanged from observation 13 to 16 which equates to approximately 20 minutes in time (see Figure 16). However, in Figure 17, it can be seen that participant 33’s neck, trunk, legs, and muscles use scores are rarely the same from one observation to the next.

Figure 16: Participant 29 Upper Extremity RULA Component Scores over Time. One observation – every 5 minutes in time.
3.3 Electromyography (EMG)

All 10 Phase 2 participants displayed 10th percentile muscle activity levels that exceeded 2-5% MVE limit recommended by Jonsson (1978) in at least one muscle or muscle group (Table 1). Affected muscles include the left extensor group (n = 2), left upper trapezius (n = 9), right upper trapezius (n = 6), and right mid-deltoid and flexor group (n = 1).

Six participants also had 50th percentile muscle activity levels higher than the 10-14% MVE limit recommended by Jonsson (1978) in at least one muscle or muscle group (Table 2). Muscles or groups exceeding this limit included the left extensor group (n = 1), left upper trapezius (n = 3), right upper trapezius (n = 5), and right flexor group (n = 2).
Table 1: 10th Percentile EMG by participant, mean and sd. Values are normalized to a muscle-specific maximum voluntary exertion. Muscle activity levels that exceed recommended limits from (Jonsson, 1978) are bolded and highlighted. Female participant ID numbers are marked by □.

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Table 2: 50th Percentile EMG by participant, mean and sd. Values are normalized to a muscle-specific maximum voluntary exertion. Muscle activity levels that exceed recommended limits from (Jonsson, 1978) are bolded and highlighted. Female participant ID numbers are marked by □.

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<td>24</td>
<td>3.3% ± 1.0%</td>
<td>1.7% ± 1.4%</td>
<td>14.2% ± 2.1%</td>
<td>18.0% ± 3.5%</td>
<td>6.7% ± 5.3%</td>
<td>14.3% ± 3.3%</td>
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<td>26</td>
<td>1.8% ± 0.5%</td>
<td>2.0% ± 0.5%</td>
<td>8.5% ± 5.3%</td>
<td>23.6% ± 6.1%</td>
<td>3.8% ± 1.8%</td>
<td>2.9% ± 0.5%</td>
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<td>28</td>
<td>2.9% ± 1.4%</td>
<td>1.5% ± 0.9%</td>
<td>9.1% ± 7.5%</td>
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<td>5.9% ± 3.7%</td>
<td>8.8% ± 4.2%</td>
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<td>5.8% ± 3.1%</td>
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</tr>
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<td>9.9% ± 3.3%</td>
<td>6.2% ± 3.7%</td>
<td>2.9% ± 1.1%</td>
<td>2.3% ± 0.7%</td>
</tr>
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<td>34</td>
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<td>12.8% ± 3.2%</td>
<td>16.4% ± 5.7%</td>
<td>2.4% ± 1.1%</td>
<td>9.1% ± 3.6%</td>
</tr>
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</table>

Electromyographic signal for the erector spinae was normalized to the 5th percentile of a resting baseline. Tenth percentile EMG values for the erector spinae (right and left) ranged from 0.71 ± 0.07 times the resting baseline value to 3.04 ± 3.35 times the
resting baseline while 50th percentile EMG values for the erector spinae (right and left) ranged from $0.86 \pm 0.08$ times the resting baseline to $5.13 \pm 5.05$ times the resting baseline (Table 3).

Table 3: Erector Spinae EMG by Participant, mean and sd. Values are normalized to a muscle-specific exertion in a resting posture. Female participant ID numbers are marked by [F].

<table>
<thead>
<tr>
<th>SUB</th>
<th>10th Percentile</th>
<th>50th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left ES</td>
<td>Right ES</td>
</tr>
<tr>
<td>21</td>
<td>1.08 ± 0.01</td>
<td>1.04 ± 0.01</td>
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<tr>
<td>22</td>
<td>1.75 ± 0.99</td>
<td>0.97 ± 0.67</td>
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<tr>
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<td>1.37 ± 0.26</td>
<td>1.24 ± 0.33</td>
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<tr>
<td>26</td>
<td>1.36 ± 0.35</td>
<td>1.38 ± 0.38</td>
</tr>
<tr>
<td>28</td>
<td>1.51 ± 0.97</td>
<td>1.31 ± 0.83</td>
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<tr>
<td>29</td>
<td>0.98 ± 0.18</td>
<td>0.71 ± 0.07</td>
</tr>
<tr>
<td>[30]</td>
<td>1.30 ± 0.69</td>
<td>2.51 ± 1.20</td>
</tr>
<tr>
<td>[32]</td>
<td>1.27 ± 0.42</td>
<td>1.23 ± 0.33</td>
</tr>
<tr>
<td>33</td>
<td>2.17 ± 1.83</td>
<td>3.04 ± 3.35</td>
</tr>
<tr>
<td>[34]</td>
<td>1.24 ± 1.66</td>
<td>1.38 ± 1.12</td>
</tr>
</tbody>
</table>

3.4 Inter-Modality Comparisons

No significant correlations were found between mean RULA scores, muscle activity levels, and reported discomfort levels for those who participated in the observational portion of the study.
Chapter 4: Discussion

This is the first study that has assessed the muscle activity and posture of the trunk and upper extremities of tattoo artists during real or simulated work. In this section of the report, the study will be reviewed in light of its strengths and limitations and in the context of prior research on tattoo artists as well as sedentary workers more broadly. It will conclude with suggestions for next steps in research and practice with the goal of improving working conditions for tattoo artists who experience work-related musculoskeletal discomfort.

While small, the sample size for observation/EMG (Phase 2) was fairly typical of electromyographic research and was sufficient for the exploratory type of research that this study falls under. Although the EMG and observational data were collected in only one city, observations were collected from three unique tattoo shops of various sizes.

The greater BMIs of males in the observational and EMG portion (Phase 2) of the study in comparison with males in the survey-only portion of this study is a more complicated issue. While in general subpopulations should resemble parent populations as much as possible, this disparity has greater implications for EMG data quality than for RULA data quality. For EMG signal validity it is important that subcutaneous adipose tissue under detection sites is less than 4 cm. A detection site located above more than 4
cm of subcutaneous adipose tissue could result in poor EMG to baseline ratio (Konrad, 2005). It is of note that the average number of days exercised per week was also greater for the observational subsample. Even if this difference is ignored and it is assumed that the subset was in fact more obese than the overall population, this should bias results towards the null.

4.1 Findings

4.1.1 Discomfort and posture.

The findings in the current study concerning musculoskeletal discomfort in tattoo artists are consistent with the work of Grieshaber et al. (2012). Both studies support the conclusion that musculoskeletal discomfort is highly prevalent in several regions of the body in these workers. In most cases the 12-month prevalence of discomfort exceeded the levels found previously among tattoo artists as well as those reported in similar populations such as dentists and dental hygienists (Figure 18).
A large percentage of tattoo artists (79%) in the current study reported that work activities related to tattooing make discomfort worst in one or more regions of the body and many (41%) had sought the attention of a health care provider in the last 12 months due to discomfort in at least one region of the body. The difference in discomfort prevalence between the present study and Grieshaber et al. (2012) may be due to differences in the reported proportion of work time spent tattooing between the two samples (Figure 19).
The Rapid Upper Limb Assessment showed that the prolonged awkward postures held by tattoo artists during work place them at an elevated risk for developing musculoskeletal problems. Elevated, unsupported arms, forward head posture, and an unsupported trunk were common among participants of this study and are also known risk factors in the dental community (Morse et al., 2010). Figure 20 demonstrates the similarities in work postures between dentistry and tattooing.

Figure 19: Difference in task breakdown between (Grieshaber et al., 2012) and the present study.
4.1.2 Muscle activity.

As with dentists, the postures held by tattoo artists during their work contribute to high levels of static (10th percentile) and mean (50th percentile) muscle activity. According to Pope-Ford & Jiang (2014), “Seated postures, preferred by dentists as a way to relieve back stress, may contribute to the development of shoulder or neck MSDs due to elevated upper trapezius exertions.”

The 2013 study found mean (50th percentile) activity levels in the upper trapezius muscles during simulated dental work to be as high as 15-20% MVE while standing and 30-35% MVE in seated postures (Pope-Ford & Jiang, 2014).
Fiftieth percentile (mean) muscle activity levels in the upper trapezius muscles of tattoo artists ranged from ~6% to 25% MVE depending on the participant and were more comparable to the standing work values from Pope-Ford & Jiang. Nonetheless these levels were troublingly high; half exceeded the 10%-14% recommended limit in Jonsson (1978) in either the right, left, or both trapezii, and all participants exceeded in either the right, left, or both trapezii the mean 50th percentile muscle activity levels found in dentists and dental hygienists during real work (Åkesson et al., 2012; Åkesson et al., 1997). See Figure 21 above for comparison between these studies.
At between 3.4% and 16% MVE, the 10th percentile muscle activity levels of the right and left upper trapezius among tattoo artists in the present study were more troubling still (Figure 22). All participants exceeded the 2-5% recommended limit in Jonsson (1978) in either the right, left, or both trapezii and well exceeded levels found in dentists and dental hygienists, which ranged from just 1.2 to 3.3% MVE (Akesson et al., 2012; Akesson et al., 1997).

Figure 22: A comparison of the mean 10th percentile muscle activity in the present study with the muscle activity of dentists (Akesson et al., 1997) and dental hygienists (Akesson et al., 2012).

* Dashed lines represent the 2%-5% recommended limit (Jonsson, 1978).

** Participant 21’s mean 10th percentile flexor muscle activity was considered an outlier and excluded from this comparison.

Recommended 10th or 50th percentile muscle activity limits were also exceeded in a small number of participants in the left extensor muscle group (n = 2), right flexor
muscle group (n = 2), and right mid-deltoid (n = 1). Overall, 10\textsuperscript{th} percentile muscle activity for the left extensor and right flexor groups were approximately comparable to dentists (extensor: 2.6% MVE, flexor: 2.5% MVE) (Akesson et al., 1997) and dental hygienists (extensor only: 1.4% MVE) (Akesson et al., 2012). The muscle activity in the right and left erector spinae muscles did not appear to be particularly high in any of the participants in this study, suggesting that back discomfort is likely related to holding the posture for long periods of time rather than particularly high levels of exertion. Lack of change in median frequency may have been an accurate reflection or may have been due to differences in activation level (lack of repeatability of the reference exertion method. Future studies should consider employing more reliable methods for eliciting a reference exertion for these muscles, given the high prevalence of discomfort experienced in this region of the body by tattoo artists and the prolonged trunk flexion observed in the current study.

4.1.3 **Influence of workstations.**

The heightened muscle activity levels and poor posture are influenced in large part by the workstations at which tattoo artists spend a significant amount of their workdays. The two largest influences of the overall working position of the tattoo artists in this study seem to be the location of tools (i.e. inks, water, ointment, machines) and the location of the client.
Tools were located directly to the right or behind the artist and often required spinal twisting and full reach to access. Clients were seated in chairs or laying on either massage-style tables or more adjustable dental-style chairs (Figure 23). In some instances adjusting the height is either impossible or cumbersome, resulting in the tattoo artist working at an inappropriate height and hunching or bending over to get close enough to see. As is also the case with dentists, tattoo artists who use dental-style chairs sometimes positioned patients too high, allowing the artist to straighten their spines but resulting in elevated, unsupported arms (Valachi & Valachi, 2003).

The quality of the chair used by the artist varied, but the presence or absence of a backrest seemed to be largely irrelevant as there were no tattoo artists in the present study who were positioned such that they were able to use a back rest. Each artist sat forward
between 0° and 60°, with many artists spending extended periods of time between 20° and 60° in order to be in close visual proximity to their work.

4.2 Future Research

Little research has been done on the occupational hazards of tattoo artists beyond those related to blood-borne pathogens. The current study was the first to assess the muscle activity and working posture of tattoo artists, but it was not inclusive of all hazards. Research is needed to further elucidate the full spectrum of occupational hazards to which tattoo artists are exposed.

4.2.1 Vibration.

Similar to dentists and other occupational groups, tattoo artists may hold their vibrating hand tool (a vibrating tattoo machine) for many hours on end. Participants in the current study reported spending an average of 68% of their time holding their machines. While some types of machines produce less vibration than others, the most commonly used machine is the coil type, which vibrates and is somewhat heavier than the less common rotary or pneumatic types of machines. Exposure to vibrating tools has been shown to significantly impair vibrotactile sensibility, strength, and motor performance in female dentists (Akesson et al., 1995), but the effects have not been studied in tattoo artists. This is an important next step in characterizing the musculoskeletal risks associated with work in the body modification industry.
4.2.2 Noise exposure.

There is anecdotal evidence suggesting that noise levels in tattoo shops may be near the 8-hour time-weighted average sound level (TWA) of 85 dBA. Noise is emitted by the tattoo machine, which is in close proximity to the ear of the tattoo artist. Noise may also be present from a sound system or television in the shop. Previous studies of dental clinics in New Zealand found that while background noise levels were occasionally as high as 98 dBA, these excessive levels were intermittent and thus still within the TWA limit (Al-Dujaili, Thomson, Meldrum, & Al-Ani, 2014). Further research should be conducted to determine exposure patterns and levels in tattoo shops.

4.2.3 Recommendations and interventions.

Locating tools such as inks, water, ointment, and tattoo machines closer to the artist will allow for easier access and less repetitive reaching and twisting. Increased use of dental-style chairs for tattoo artists would allow for more adjustability in the positioning of the client but as the present study and those of dentists have shown, this is not enough to eliminate awkward work postures. It is recommended that dentists employ positioning strategies that include avoiding static postures, alternating between sitting and standing, repositioning the feet, positioning patients at the proper height, and avoiding twisting (Valachi & Valachi, 2003). Particularly in the case of appropriate patient/client positioning, dentists are assisted greatly by the proper use of magnification which allows for healthier postures and has been associated with decreased neck and low back pain (Chang, 2002). Alternative viewing aids for dental work were investigated by Smith,
Sommerich, Mirka, & George (2002) and something similar may also prove useful in tattooing.

Since tattoo artists are unable to effectively use back supports on chairs, providing support from the front may be a viable alternative. Combined chest and arm supports have been found to be effective at reducing muscle activity levels in the trapezius muscle of dentists during seated work (Haddad et al., 2012) while a prototype chest support reduced the activity levels in the erector spinae muscles of (standing) surgeons by 44% (Albayrak et al., 2007). An ergonomic sitting device of this type was developed with tattoo artists in mind by Nelson Hardie, a tattoo artist turned Industrial Designer in Sweden and warrants further investigation (Hardie, 2014).

While the work of tattoo artists does share some characteristics with that of dentists, dental hygienists, surgeons, and other static occupations, research into possible interventions should be conducted in a partnership between researchers and tattoo artists as this field has many of its own unique requirements and challenges. The tattoo shop owners and individual artists who participated in this study were very receptive and many expressed an interest in future research. However, experience gained during the course of this study indicates that this is not a population of workers that responds to fliers or e-mails and in person recruitment would be most effective.
Chapter 5: Conclusion

A large segment of the U.S. population has tattoos and more are getting them every day. As tattoos become widely accepted, more and more people are employed as tattoo artists. This population of workers has been marginalized, stigmatized, and ignored. They are working in pain and without the safety net of workers compensation.

The present study found that tattoo artists experience high levels of discomfort in the neck, shoulders, elbows, hands/wrists, upper back, lower back, legs/feet, and eyes, and in many cases reported that their discomfort was made worse by tattooing. Prolonged awkward postures are common during tattooing and place the artists at an elevated risk for musculoskeletal problems, and muscle activity levels often exceed recommended limits. Further research on additional hazards such as noise and vibration exposure is needed, but intervention is needed now to prevent the development of and reduce the experience of MSDs and musculoskeletal discomfort in this group of workers.
References


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Appendix A: Consent Form for Survey-Only Participants
The Ohio State University Consent to Participate in Research

Study Title: Investigation of Musculoskeletal Discomfort in Tattoo Artists
Researcher: Carolyn M. Sommerich
Sponsor: none

Please read the information on this form, to help you decide whether or not to participate in this study:

You have been invited to participate in a research study concerning work as a tattoo artist. Your participation will involve completing a questionnaire.

Your participation in this study is voluntary, and there is no requirement for you to participate in this study.

The questionnaire is expected to take 15-20 minutes to complete. You will be asked some questions about how you do your work, work history, musculoskeletal and eye health, and basic demographic information (age, height, etc.). You may skip any questions with which you are uncomfortable.

Your answers will be treated confidentially. They will be pooled with those of other respondents, and no reference will be made in oral or written reports which could link you to this study.

If you are interested in receiving a summary of the results from the questionnaire, please provide your email address to the researcher.

If you change your mind about participating, you may withdraw from the study at any time. If there is anything about the study or your participation that is unclear or that you do not understand, if you have questions or wish to report a research related problem, you may contact Carolyn Sommerich via phone or email: 614-292-9965 or sommerich.1@osu.edu, respectively.

This project was approved by the Institutional Review Board (IRB) of The Ohio State University. For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in OSU’s Office of Responsible Research Practices at 1-800-678-6251.

If you have read and you understand the information above, and you agree to participate in this study, please turn the page to begin the questionnaire. If you do not want to participate, please return this form and the attached questionnaire to the researcher.
Appendix B: Consent Form for Observation/EMG
The Ohio State University Consent to Participate in Research

Study Title: Investigation of Musculoskeletal Discomfort in Tattoo Artists

Researcher: Carolyn M. Sommerich

Sponsor: none

This is a consent form for research participation. It contains important information about this study and what to expect if you decide to participate.

Your participation is voluntary.

Please consider the information carefully. Feel free to ask questions before making your decision whether or not to participate. If you decide to participate, you will be asked to sign this form and will receive a copy of the form.

Purpose:
The purpose of this study is to determine the extent of musculoskeletal discomfort (stiffness, ache, pain, etc.) among tattoo artists and identify possible sources.

Procedures/Tasks:

Questionnaire: If you decide to take part in this study, you will complete a questionnaire in which you will be asked some questions about how you do your work, work history, musculoskeletal and eye health, and basic demographic information (age, height, etc.).

Other parts of this study: If the box(es) below are checked, you are also being asked to consider participating in one or two other parts of this study, which are described below.

☐ Observation: At a time that is convenient for you, a researcher will arrive at your place of work to observe and video record you performing a single tattoo session. Small reflective stickers will be placed along your arm and on your torso to help the researcher describe your work methods when the video is analyzed by the researchers who are conducting this study.

The session will be video- and audio-recorded specifically to record your work methods and provide a record of the data collection session to provide points of reference during data analysis. Place your initials here (____) to indicate your consent to be recorded.

☐ Muscle Activity Recording: Small surface EMG (electromyography) electrodes will be placed on your skin, over muscles in your arm and back, to record the electrical activity of the muscles when they are activated (i.e. while you are tattooing). Please indicate by placing your initials here (____) that you do not have any known skin sensitivities to rubbing alcohol or adhesive tape (such as that on band-aids).

Next, you will participate in a series of brief tests designed to measure the strength of the muscles we are monitoring with the surface electrodes. These tests are referred to as “Maximum Voluntary Exertions” or MVEs. You will be asked to perform 2 exertions per muscle, separated by 1-2 minutes of rest. You will receive instructions on how to perform each exertion, and each will be demonstrated to you. You will be asked to grip,
push, or pull against an immovable object and exert with the specific muscle being tested as hard as you can, without hurting yourself. This is why these are referred to as maximum voluntary exertions. You should exert as hard as you can, safely. Each MVE lasts for 4 seconds. For each, you will be asked to gradually increase your gripping, pushing, or pulling effort up to your maximum level over a 2 second interval, then continue to exert at your maximum level for 2 seconds. You will then rest for 1-2 minutes before performing the next MVE.

You will then perform a tattoo session exactly as you normally would while the researcher records your muscle activity.

Duration:

The questionnaire portion of this research is expected to take 15-20 minutes to complete.

The observation and muscle activity recordings will take between 1 and 3 hours, depending on the length of the tattoo session you are performing that we would study. Observation and muscle activity recording may be performed simultaneously or in separate sessions.

You may leave the study at any time. If you decide to stop participating in the study, there will be no penalty to you, and you will not lose any benefits to which you are otherwise entitled. Your decision will not affect your future relationship with The Ohio State University.

Risks and Benefits:

Questionnaire: There are minimal risks if you decide to participate in this study. The questionnaire you will be asked to fill out contains questions about your work history and health, as well as demographic questions. Your participation is voluntary and you have the option of providing only the information you are willing to share with us. You will not be pressured to provide any information that you do not feel comfortable sharing.

Observation and muscle activity recordings: During the observation and muscle activity recording, risks will be similar to those you encounter in your daily work activities. You may experience some residual muscle soreness as a result of the EMG normalization process.

Results from the observational and muscle activity recording portions of the study will be made available to you if you wish, and may help you to be more aware of your work methods.

This information gained from this study may be used to produce better products and work practices in the future to help you and your work colleagues have a more pain free experience.

Confidentiality:

Your name will be removed from all data collected and will be replaced with a unique ID number. A document will be maintained during the course of the study that links your name with your ID number and will be stored separately on a password protected computer in a locked, limited access lab. After the completion of the study, this document will be destroyed.

Efforts will be made to keep your study-related information confidential. However, there may be circumstances where this information must be released. For example, personal information regarding your participation in this study may be disclosed if required by state law. Also, your records may be reviewed by the following groups (as applicable to the research):

- Office for Human Research Protections or other federal, state, or international regulatory agencies;
The Ohio State University Institutional Review Board or Office of Responsible Research Practices;
The sponsor, if any, or agency (including the Food and Drug Administration for FDA-regulated research) supporting the study.

Incentives:

Questionnaire: If you are interested in receiving a summary of the results from the questionnaire, please provide your email address here: ________________________________

Observation and muscle activity recordings: Although you will not be paid to participate in the study, you will receive a $10 Starbucks gift card to thank you for participating in the observational and muscle activity recording portions of the study.

Participant Rights:

You may refuse to participate in this study without penalty or loss of benefits to which you are otherwise entitled. If you are a student or employee at Ohio State, your decision will not affect your grades or employment status. If you choose to participate in the study, you may discontinue participation at any time without penalty or loss of benefits. By signing this form, you do not give up any personal legal rights you may have as a participant in this study.

An Institutional Review Board responsible for human subjects research at The Ohio State University reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

Contacts and Questions:

For questions, concerns, or complaints about the study, or you feel you have been harmed as a result of study participation, you may contact Carolyn M. Sommerich, 614-292-9965 or sommerich.1@osu.edu.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.
CONSENT
Behavioral/Social Science

IRB Protocol Number: 2014B0125
IRB Approval date: 4/07/2014
Version: 1.0

Signing the consent form

I have read (or someone has read to me) this form and I am aware that I am being asked to participate in a research study. I have had the opportunity to ask questions and have had them answered to my satisfaction. I voluntarily agree to participate in this study.

I am not giving up any legal rights by signing this form. I will be given a copy of this form.

Printed name of subject
Signature of subject
Date and time
AM/PM

Printed name of person authorized to consent for subject (when applicable)
Signature of person authorized to consent for subject (when applicable)
Date and time
AM/PM

Relationship to the subject

Investigator/Research Staff

I have explained the research to the participant or his/her representative before requesting the signature(s) above. There are no blanks in this document. A copy of this form has been given to the participant or his/her representative.

Printed name of person obtaining consent
Signature of person obtaining consent
Date and time
AM/PM

FOR LATER USE:
If you participate in the observation or muscle activity recordings parts of this study, we will first ask you to review this consent form again, and then sign below to indicate your willingness to continue your participation in the study.

Observation:

Signature of subject date
Signature of person obtaining consent date

Muscle Activity Recording:

Signature of subject date
Signature of person obtaining consent date

Page 4 of 4 Form date: 02/11/13
Appendix C: Consent Information for Tattoo Clients
The Ohio State University Tattoo Artist Research Information

Hello, my name is Dana K. and I am a graduate student at The Ohio State University, in the Department of Integrated Systems Engineering.

I am conducting a research study that has been approved by OSU’s Institutional Review Board, which reviews all studies in which people are being studied by OSU researchers. In my study I am trying to learn more about the extent of musculoskeletal discomfort among tattoo artists and identify possible sources. This information gained from this study may be used to produce better products and work practices in the future so that tattoo artists have a more pain free work experience.

With your permission, we would like to video and audio record the tattoo artist as he/she applies your tattoo today. We are interested in the work methods of the tattoo artist as he/she works on your tattoo. Efforts will be made not to include your face in the video. In circumstances where this is not possible due to the placement of your tattoo or when you may be able to be recognized by your tattoo, any portions of your face or tattoo that are visible will be blurred before any of the images will be seen by people other than the researcher.

There will be no penalty to you if you prefer not to have your tattoo session filmed.

Do you have any questions for me before you decide whether or not you will allow us to record your tattoo session?

May we record your tattoo session today?

   Yes __________________________ (please initial here) Date __________________________

If you change your mind after the tattoo session begins, just let us know and we will stop the observation.

The Ohio State University Tattoo Artist Research Information

Contacts and Questions:

For questions, concerns, or complaints about the study, or you feel you have been harmed as a result of study participation, you may contact Carolyn M. Sommerich, 614-292-9965 or sommerich.1@osu.edu.

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.
Appendix D: Questionnaire
Tattoo Artist Survey 2014

Please try to answer all the questions that are presented to you. Your answers are confidential and will be closely guarded.

Section A. Work History: Please tell us about your work history and job duties

1. How long have you been working in the body modification industry? __________

2. How long have you been employed as a tattoo artist? __________

3. Is it your sole source of income?
   □ Yes (skip to question 6)
   □ No, I am also employed as a(n) ____________________________

4. How many days per week do you spend working in a different occupation? __________

5. … of these days, how many hours per day do you typically work? __________

6. How many days per week do you spend working as a tattoo artist? __________

7. … of these days, how many hours per day do you typically work? __________

8. During an average day, what percentage (%) of your time as a tattoo artist is spent carrying out the following activities:
   ______% Tattooing
   ______% Drawing
   ______% Sterilization/Set up
   ______% Administrative
   ______% Piercing
   ______% Other

9. During an average day, what percentage (%) of your time as a tattoo artist is spent:
   ______% Holding Tattoo Machine
   ______% Standing
   ______% Holding Piercing Tool

10. On average, how long do you spend tattooing per session?
    □ < 1 hour   □ 1 to 3 hours   □ > 3 to 5 hours   □ > 5 to 8 hours   □ 8+ hours

11. How long do you typically tattoo without taking a break?
    □ < 1 hour   □ 1 to 3 hours   □ > 3 to 5 hours   □ > 5 to 8 hours   □ 8+ hours

12. How satisfied are you with your job as a tattoo artist?
    Not at all  Somewhat  Extremely
    0  1  2  3  4  5  6  7  8  9  10
### Tattoo Artist Survey 2014

#### Section B. Musculoskeletal health: Please tell us about any musculoskeletal discomfort you have experienced in the last 12 months or musculoskeletal injuries you have incurred...

For each question, please circle a response for each area of the body.

<table>
<thead>
<tr>
<th>Areas:</th>
<th>Neck</th>
<th>Shoulder</th>
<th>Elbow/Forearm</th>
<th>Wrist/Hand</th>
<th>Upper Back</th>
<th>Lower Back</th>
<th>Legs/Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. During the last 12 months, have you had any trouble (ache pain, discomfort, burning, numbness, tingling, or other trouble) in any of the areas listed?</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes, right</td>
<td>Yes, left</td>
<td>Yes, both</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>Yes</td>
</tr>
</tbody>
</table>

If you answered "Yes", just above, to experiencing any trouble, please answer all the remaining questions on this page for the affected body region(s). Otherwise, please skip to question #10 near the bottom of this page.

2. How often during the last 12 months have you had this trouble? | Daily | Once a week | Once a month | Every 2-3 months | Every 6 months |
| 1... | 2... | 3... | 4... | 5... |

3. How long does the trouble usually last? | Less than 1 hour | 1 hour to 1 day | 1 day to 1 week | 1-2 weeks | 2-4 weeks | 1-3 months | Longer than 3 months |
| 1... | 2... | 3... | 4... | 5... | 6... | 7... |

4. Describe the intensity of the trouble. | Mild | Moderate | Severe | Worst imaginable |
| 1... | 2... | 3... | 4... |

5. In the last 12 months, has the trouble prevented you from doing your normal activities (on the job or off)? | No | Yes | No | Yes | No | Yes | No | Yes |
| 6. In the last 12 months, has the trouble caused you to see a health care provider? | No | Yes | No | Yes | No | Yes | No | Yes |

7. Do work activities related to tattooing make the trouble worse? | No | Yes | No | Yes | No | Yes | No | Yes |

8. Have you lost any time from work due to the trouble? | No | Yes | No | Yes | No | Yes |

9. Have you had any trouble during the past 7 days? | No | Yes | No | Yes |

10. Have you been diagnosed with a musculoskeletal disorder (such as tendonitis/tendinosis, back pain, etc.) in an area? What was the diagnosis and when did you receive it? | Dx: | Dx: | Dx: | Dx: | Dx: | Dx: |
| Year: | Year: | Year: | Year: | Year: | Year: |

11. Have you ever had a traumatic (sudden) injury? | No | Yes, right | Yes, left | Yes, both | No | Yes, right | Yes, left | Yes, both | No | Yes, right | Yes, left | Yes, both |
| 03Feb2014 | 2 | THE OHIO STATE UNIVERSITY | 74 |
### Section C. Hand health: Please tell us about any hand discomfort you have experienced in the last 12 months

#### No Hand Discomfort (skip to next page)

For each question, please circle a response for each area of the hand.

<table>
<thead>
<tr>
<th>Right Hand</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### During the last 12 months, have you had any trouble (ache pain, discomfort, burning, numbness, tingling, or other trouble) in any of the areas shaded?

If you answered "Yes", just above, to experiencing any trouble, please answer all the remaining questions on this page for the affected body region(s). Otherwise, please skip to question #10 near the bottom of this page.

<table>
<thead>
<tr>
<th>2. How often during the last 12 months have you had this trouble?</th>
<th>Daily</th>
<th>Once a week</th>
<th>Once a month</th>
<th>Every 2-3 months</th>
<th>Every 6 months</th>
<th>Every 12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1...</td>
<td>2...</td>
<td>3...</td>
<td>4...</td>
<td>5...</td>
<td>6...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. How long does the trouble usually last?</th>
<th>Less than 1 hour</th>
<th>1 hour to 1 day</th>
<th>1 day to 1 week</th>
<th>1-2 weeks</th>
<th>2-4 weeks</th>
<th>1-3 months</th>
<th>Longer than 3 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1...</td>
<td>2...</td>
<td>3...</td>
<td>4...</td>
<td>5...</td>
<td>6...</td>
<td>7...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Describe the intensity of the trouble.</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Worst imaginable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1...</td>
<td>2...</td>
<td>3...</td>
<td>4...</td>
</tr>
</tbody>
</table>

#### Left Hand

<table>
<thead>
<tr>
<th>Left Hand</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### During the last 12 months, have you had any trouble (ache pain, discomfort, burning, numbness, tingling, or other trouble) in any of the areas shaded?

If you answered "Yes", just above, to experiencing any trouble, please answer all the remaining questions on this page for the affected body region(s). Otherwise, please skip to question #10 near the bottom of this page.

<table>
<thead>
<tr>
<th>2. How often during the last 12 months have you had this trouble?</th>
<th>Daily</th>
<th>Once a week</th>
<th>Once a month</th>
<th>Every 2-3 months</th>
<th>Every 6 months</th>
<th>Every 12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1...</td>
<td>2...</td>
<td>3...</td>
<td>4...</td>
<td>5...</td>
<td>6...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. How long does the trouble usually last?</th>
<th>Less than 1 hour</th>
<th>1 hour to 1 day</th>
<th>1 day to 1 week</th>
<th>1-2 weeks</th>
<th>2-4 weeks</th>
<th>1-3 months</th>
<th>Longer than 3 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1...</td>
<td>2...</td>
<td>3...</td>
<td>4...</td>
<td>5...</td>
<td>6...</td>
<td>7...</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Describe the intensity of the trouble.</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Worst imaginable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1...</td>
<td>2...</td>
<td>3...</td>
<td>4...</td>
</tr>
</tbody>
</table>
Tattoo Artist Survey 2014

Section D. Eye health, headaches, and previous diagnoses

1. During the last 12 months, have you had any eye discomfort (burning, itching, aching, watering, blurring, tired, dry, etc.)?
   □ Yes  □ No (skip to question 7 on this page)

2. Within the last 12 months, has this eye discomfort resulted in your seeing a health care provider?
   □ Yes  □ No

3. When did your eye discomfort begin?
   □ Before I started work as a tattoo artist  □ After I started work as a tattoo artist

4. In the last 12 months, has your eye discomfort prevented you from doing your normal activities (on the job or off)?
   □ Yes  □ No

5. Do work activities related to tattooing make your eye discomfort worse?
   □ Yes  □ No

6. Have you had any eye discomfort during the past 7 days?
   □ Yes  □ No

7. Have you ever had a traumatic (sudden) injury to your eye(s)?
   □ Yes  □ No

8. Have you had your eyes examined by an optometrist or ophthalmologist within the last 12 months?
   □ Yes  □ No

9. Describe any eye glasses or contact lenses that you wear. Mark all that apply.
   □ Contact lenses  □ Bi-focals
   □ Single lens glasses for distance (near-sighted)  □ Tri-focals
   □ Single lens glasses for reading (far-sighted)  □ "Granny" half-lens reading glasses
   □ Single lens glasses specifically for computer work  □ I do not wear glasses or contacts

10. On average, how often do you experience headaches?
    □ Never  □ Sometimes (once a month)
    □ Almost never (every 6 months)  □ Frequently (once a week)
    □ Rarely (every 2-3 months)  □ Almost always (daily)

11. Have you been diagnosed with any of the following disorders? Mark all that apply.
    □ Arthritis  □ Lupus
    □ Thyroid problems  □ Fibromyalgia
    □ Diabetes  □ Gout
    □ Cervical spine disease  □ None of the above
    □ Migraine headaches
Tattoo Artist Survey 2014

Section E. Demographic Information

1. In what Year were you born? __________

2. Your height and weight: Provide your answer in the unit of measure you prefer.
   2a. How tall are you?  
   Height, in feet and inches: __________
   Or, Height in centimeters: __________

   2b. How much do you weigh?  
   Weight, in pounds: __________
   Or, Weight in kilograms: __________

3. Indicate your race/ethnic origin. Mark all that apply.
   - African-American/Black
   - Asian
   - Caucasian/White
   - Hispanic/Latino
   - Inuit/Alut/Alaskan Native
   - Native American
   - Pacific Islander
   - Other

4. Are you predominately right-handed, predominately left-handed, or use both equally well?
   - Right-handed
   - Left-handed
   - Both equally well

5. With which hand do you hold the tattoo machine?
   - Right-handed
   - Left-handed
   - I switch or can use either

6. Your sex?
   - Female
   - Male

7. Which statement best describes your history of smoking?
   - Never smoked
   - Smoked previously, but quit more than 12 months ago
   - Smoked previously, but quit within the last 12 months
   - Current smoker

8. What is your highest level of formal education?
   - High school or below
   - Trade or vocational school
   - Some college
   - College graduate
   - Advanced degree

9. How many times per week do you exercise? __________

10. Of the following activities what do you most often do for exercise? (check all that apply)
    - Lift weights
    - Aerobic (walking, running, etc.)
    - Play a team sport
    - Other: ______________________

   Thank you for taking the time to fill out this questionnaire!
Appendix E: RULA Risk Levels

Figure 24: Participant 21 RULA observations.

<table>
<thead>
<tr>
<th>Level of MSD Risk</th>
<th>1 to 2</th>
<th>3 to 4</th>
<th>5 to 6</th>
<th>7+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Extremities</td>
<td>0</td>
<td>15</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Neck, Trunk, Legs</td>
<td>1</td>
<td>23</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Participant 21 RULA Observations

Figure 25: Participant 22 RULA observations.

<table>
<thead>
<tr>
<th>Level of MSD Risk</th>
<th>1 to 2</th>
<th>3 to 4</th>
<th>5 to 6</th>
<th>7+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Extremities</td>
<td>0</td>
<td>10</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Neck, Trunk, Legs</td>
<td>0</td>
<td>13</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>
Figure 26: Participant 24 RULA observations.

Figure 27: Participant 26 RULA observations.
Figure 28: Participant 28 RULA observations.

Figure 29: Participant 29 RULA observations.
Figure 30: Participant 30 RULA observations.

![Subject 30 RULA Observations](chart1)

Figure 31: Participant 32 RULA observations.

![Participant 32 RULA Observations](chart2)
Figure 32: Participant 33 RULA observations.

Figure 33: Participant 34 RULA observations.
Appendix F: Frequency of RULA Scores by Region

RULA scores in this appendix are displayed by body part, muscle use score is either 0 or 1, where 1 indicates either repetitive or static use. Ranges of scores for other body parts are provided in parentheses.

Figure 34: Participant 21 RULA scores by body part.
Figure 35: Participant 22 RULA scores by body part.

Figure 36: Participant 24 RULA scores by body part.
Figure 37: Participant 26 RULA scores by body part.

Figure 38: Participant 28 RULA scores by region of body.
Figure 39: Participant 29 RULA scores by body part.

Figure 40: Participant 30 RULA scores by body part.
Figure 41: Participant 32 RULA scores by body part.

Figure 42: Participant 33 RULA scores by body part.
Figure 43: Participant 34 RULA scores by body part.
Appendix G: RULA Scores over Time

For graphs in this appendix, one observation is equal to approximately five minutes in time.

Figure 44: Participant 21 Upper Extremity RULA Component Scores over Time.

Figure 45: Participant 21 Neck, Trunk, Legs RULA Component Scores over Time.
Figure 46: Participant 22 Upper Extremity RULA Component Scores over Time.

Figure 47: Participant 22 Neck, Trunk, Legs RULA Component Scores over Time.
Figure 48: Participant 24 Upper Extremity RULA Component Scores over Time.

Figure 49: Participant 24 Neck, Trunk, Legs RULA Component Scores over Time.
Figure 50: Participant 26 Upper Extremity RULA Component Scores over Time.

Figure 51: Participant 26 Neck, Trunk, Legs RULA Component Scores over Time.
Figure 52: Participant 28 Upper Extremity RULA Component Scores over Time.

Figure 53: Participant 28 Neck, Trunk, Legs RULA Component Scores over Time.
Figure 54: Participant 29 Upper Extremity RULA Component Scores over Time.

Figure 55: Participant 29 Neck, Trunk, Legs RULA Component Scores over Time.
Figure 56: Participant 30 Upper Extremity RULA Component Scores over Time.

Figure 57: Participant 30 Neck, Trunk, Legs RULA Component Scores over Time.
Figure 58: Participant 32 Upper Extremity RULA Component Scores over Time.

Figure 59: Participant 32 Neck, Trunk, Legs RULA Component Scores over Time.
Figure 60: Participant 33 Upper Extremity RULA Component Scores over Time.

Figure 61: Participant 33 Neck, Trunk, Legs RULA Component Scores over Time.
Figure 62: Participant 34 Upper Extremity RULA Component Scores over Time.

Figure 63: Participant 34 Neck, Trunk, Legs RULA Component Scores over Time.