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An Electromyographic Study of the Forearm and Upper Trapezius Musculature while Typing at Different Keyboard Heights

Karianne M. Sekiya

University of North Dakota

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AN ELECTROMYOGRAPHIC STUDY OF
THE FOREARM AND UPPER TRAPEZIUS MUSCULATURE
WHILE TYPING AT DIFFERENT KEYBOARD HEIGHTS

by

Karianne M. Sekiya
Bachelor of Science in Physical Therapy
University of North Dakota, 1997
Bachelor of Arts in Psychology
Lewis and Clark College, 1993

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine and Health Sciences
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
1998
This Independent Study, submitted by Karianne M. Sekiya in partial fulfillment of the requirements for the degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title: An electromyographic study of the forearm and upper trapezius musculature while typing at different keyboard heights.

Department: Physical Therapy

Degree: Master of Physical Therapy

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Signature

Date December 9, 1997
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Dedicated to my family
whose encouragement, support, and sacrifices
have been immeasurable,
And to Adam,
my best friend and soulmate,
for his unconditional love and patience.
ABSTRACT

Purpose: Ergonomics involves adapting the job and work environment to fit the worker and maximize safety and efficiency in the workplace. To minimize the stresses on the musculoskeletal system, ergonomic guidelines have been established for visual display terminal workstations. The 90 degree angle position of the elbow is considered an industry standard, however available literature has not adequately established that this angle represents the optimal elbow position. The purpose of this study is to add to the current knowledge of ergonomics and reduce the risk of upper extremity cumulative trauma disorders in the workplace by determining the optimal elbow position during typing.

Methods: Thirteen female employees of a regional insurance company participated in the study. Surface electromyography (sEMG) was used to examine muscle activity in four upper extremity muscle groups (upper trapezius, extensor digitorum, extensor carpi radialis brevis and longus, and flexor superficialis) during typing at three different angles of elbow flexion (70, 90, and 110 degrees). Analysis of the data was performed using two different methods: 1) using the maximum voluntary contraction as the normative value, and 2) using the 90 degree angle trial as a reference. A repeated measures analysis of variance was used to compare the muscle activity of the four muscles between the three positions. Post-hoc analysis was examined by applying the Scheffe’s
Results: Significance was established between elbow position in the extensor digitorum and extensor carpi radialis brevis and longus muscles. However, muscle groups that do not display significance at varying positions should not be ruled out because of the repetitive nature of the typing activity.

Conclusion: The 90 degree angle of elbow flexion while typing may indeed represent the overall optimal position. However, the 70 and 110 degree angles may be considered for workers who would benefit from less tension or load on a particular muscle group.
CHAPTER 1

Introduction

The use of visual display terminals (VDTs) in the everyday workplace is increasing rapidly. By the year 2000, it is expected that more than 50% of workers will interface with computers daily. The introduction of the computer and VDT has allowed for an increase in worker productivity and efficiency. However, technological advancement has not come without a price. The expanding use of computers in the workplace has created an environment with an increased risk for occupational injuries. This problem is considered to be so serious that it is being called the “epidemic of the 90’s,” “the industrial injury of the Information Age,” and “the occupational disease of the 90’s.”

Working at a computer can lead to cumulative trauma disorder (CTD). CTD is an umbrella term encompassing musculoskeletal injuries resulting from high speed, repetitive activities for lengthy, uninterrupted periods of time. The result is cumulative inflammation and damage to muscles, tendons, tendon sheaths, nerves, bursae, and blood vessels. CTDs are also referred to as repetitive strain injuries, occupational overuse syndromes, repetitive motion injuries, chronic trauma disorders, repetitive trauma disorders, ergonomic disorders, and work related musculoskeletal disorders. The concept of CTDs is not new. The recognition of CTDs was recorded over 200 years ago by an
Italian physician named Bernardo Ramazzini. In the 17th century, he documented "certain violent and irregular motions and unnatural postures of the body, by reason of which the natural structure of the vital machine is so impaired that serious diseases gradually developed from them." He also described strains on the hands and arms of scribes and notaries which led to weakness of the hand.

With the advent of computers and the push of productivity, injuries in the workplace have escalated immensely. CTDs were the fastest growing occupational illness in the 1980's. The Occupational Health and Safety Administration recorded an increase in reported cases from 18% in 1981 to over 50% in 1989, a growth of 537% in this time frame. The prevalence of CTDs continues to rise today. The Bureau of Labor Statistics reports that 332,000 cases of repeated trauma were logged by private industry in 1994, growing more than 64% since 1990, and 770% in the last decade (Figure 1).

The cost of CTDs is large. The impact on the employer includes medical costs (worker's compensation), temporary disability costs, the decrease in productivity, and time required to train a new employee for the job, attorney and litigation fees, settlements, and administration costs. It has been estimated that CTDs of upper extremities cost the United States over $42 billion per year in lost wages, medical expenses, and administration fees. CTD worker's compensation claims average $21,453 per case in California. In British Columbia, worker's compensation claim costs exceeded $150 million and involved approximately
Figure 1. New CTD Cases in Private Industry, 1982-1994
1.2 million days of lost work time. In addition to financial woes, CTDs can also lead to a worker's poor self esteem, and poor productivity at work and in society. Permanently disabled workers may lose the ability to provide and care for themselves and their families.

CTDs can occur in any area of the body subjected to repeated use for prolonged uninterrupted periods of time in a relatively fixed posture, however, the upper extremity is primarily affected. VDT operators commonly complain of neck, shoulder, arm, wrist, and hand symptoms after hours of prolonged keyboarding. VDT tasks commonly include prolonged static postures in awkward positions and highly repetitive movements of the fingers, hands, and wrists. Pain, injury, muscle stress, and fatigue soon follow. Thus, people using computers are particularly at risk for developing CTDs.

Unlike many injuries, CTDs are a product of months or years of chronic strain. CTDs may initially present as intermittent discomfort and go unnoticed for quite some time. Help is sought only when extreme pain persists or function is limited. By this time, severe damage has already occurred. On a positive note, CTDs are almost entirely preventable. Ergonomics has been widely accepted as a primary contribution to the prevention of musculoskeletal occupational stresses.

The term 'ergonomics' originates from the Greek words, 'ergos' - meaning work and 'nomos' - meaning laws. Ergonomics is now defined as "an applied science concerned with the design of workplaces, tools, and tasks to match the physiologic, anatomic, and psychological characteristics and capabilities of the
worker, "a multidisciplinary science which studies the mental, physiological, emotional, and behavioral costs incurred by humans in their interaction with their work environment," and "an applied science that coordinate the physical features, devices, and working conditions within a selective job, along with the capacities of the people working within that environment." More simply, ergonomics involves evaluating and adjusting the work environment to fit the worker. Ergonomics can be used to design equipment, environments, and tasks to increase productivity, relieve stress, and reduce the potential for injury.

At the computer terminal, ergonomics concentrates on task orientation, lighting, and operator and equipment positioning. Task orientation involves incorporating rest periods and exercises, and intermingling activities other than typing throughout the work day to minimize repetitive stresses. Lighting in computer ergonomics consists of the correct position and brightness of overhead lighting, terminal brightness and contrast, and even the reflections off surrounding areas (floor, tabletops, etc.). Operator and equipment positioning describes the optimal position of the user in the VDT work station. This includes seated posture, knee angle, seat depth, screen height, angle, and distance, leg clearance, and elbow angle of the worker. The arrangement of the workstation is also important. The placement of the keyboard and monitor, telephone, writing surfaces, and other necessary items must be considered.

Despite the emergence of ergonomics, upper extremity CTDs are still common among VDT workers. Bergqvist et al discovered that 62% of VDT workers complained of neck and shoulder discomforts while 30% reported arm
and hand discomforts. These ailments were attributed to static work postures, repetitive motions, and the position of the keyboard. Most ergonomists advise VDT users to set their work stations with the upper arms vertical to the floor and the elbow in a 90 degree angle while the user is seated erect. Although many acknowledge this positioning as a standard, there is little research to support the 90 degree elbow position. Recent studies have indicated that this may not be the most beneficial position to decrease musculoskeletal injuries related to keyboarding.\textsuperscript{15,16,17}

This study was designed to add to the current knowledge of ergonomics and reduce the risk of upper extremity CTD in the workplace by determining the optimal elbow position during typing. Using electromyography (EMG), the muscle activity in the upper trapezius (upper back), and extensor digitorum, extensor carpi radialis brevis and longus, and flexor superficialis (forearm) musculature were studied while the operator typed at different elbow angles. The optimal elbow angle was indicated by the position which resulted in the least muscle activity in the upper back and forearm musculature.
CHAPTER 2

Literature Review

Typing at a computer terminal may seem like a passive activity. However, a day at the keyboard can be the equivalent of walking ten miles with your fingers. Typing 60 words per minute for seven hours leads to about 126,000 repetitive keystrokes with the upper extremity in awkward static postures. These repetitive motions and fixed positions can lead to upper extremity cumulative trauma disorders (CTDs). In addition, upper extremity CTDs of visual display terminal (VDT) users can also be attributed to improper keyboard heights.

Ergonomic positioning of the keyboard has been established. Most ergonomists agree that the keyboard should be separate from the computer to allow for necessary adjustment. Keeping wrists in a neutral position (15 degrees of wrist extension) during typing is another important factor in the prevention of CTDs. It is also agreed upon that the upper arms should remain perpendicular to the floor. However, the elbow angle of the user is debatable. Most ergonomists encourage a 90 degree angle for the elbow, and thus the forearms parallel to the floor during typing. The rationale is that this represents the neutral position of the elbow, and thus, the position of comfort.
this recommendation is based on early non keyboard studies which determined that performance, discomfort, and energy expenditure was minimized at this position. Keyboard studies relating to elbow positioning have not adequately established the ninety degree elbow angle as the optimal position while typing.

Much of the available literature uses imprecise terms in describing elbow angles. Bergqvist et al recommends that keyboards are “to be placed somewhat below elbow height.” Other studies advise, “the keyboard (home row) should be positioned at elbow height or perhaps slightly lower,” “When you use the keyboard, ...(keep)your lower arm somewhat parallel to the floor,” and “forearms should be 90 degrees or a bit more.” Yet others use the keyboard height measured from the floor, instead of elbow angle, as an indicator for correct positioning. Measurements are taken from the ground to the home row of the keyboard, without considering the size of the operator. The VDT Manual states that the keyboard height should not exceed 75 cm. Anderson also provides guidelines for the keyboard/desk height, recommending 24.5 to 27 inches from the ground for women and 26 to 29 inches for men.

Studies have revealed that the 90 degree angle may not be the best position while keyboarding. Most often, workers preferred an elbow angle of greater than ninety degrees (thus, a higher keyboard) while working at a VDT station. When allowed to select their own keyboard height, VDT operators prefer elbow angles between 95 degrees and 120 degrees with an average of 100 degrees. Fewer hand and arm complaints were noted among operators working at these higher keyboard heights. Consistently, no
differences in muscle activity were found for keyboarding at a 90° elbow angle or greater. 26,27

Still other researchers propose smaller elbow angles with a lower placed keyboard as optimal. They suggest that a below elbow height positioning allows greater performance and comfort. 28 Prevalence of neck and shoulder discomfort were lower with a lower keyboard and smaller elbow angle. 14 EMG studies of the upper trapezius musculature while typing confirms this by showing decreased activity with the lower placed keyboard. 26 Furthermore, EMG activity increases significantly as keyboard heights increased. 29 However, EMG activity was not shown to be at the lowest at the preferred keyboard height.

The available literature suggests that there is little significant evidence to support the 90° elbow angle positioning while typing. The literature suggests that neck and shoulder discomfords increase and arm and hand discomfords are decreased, as the keyboard is raised above the level of 90 degrees. 14,20,26,28 However, EMG research that relate both the upper trapezius and forearm musculature is lacking. This study proposes to determine the optimal keyboard height and elbow angle while typing by examining the EMG activity of the upper trapezius and forearm musculature. In determining this position, this study hopes to provide information to decrease the prevalence of upper extremity CTDs at the VDT workstation.
Subjects

Fifteen female subjects volunteered to participate in this study. Each participant was employed by a regional insurance company and was allowed work time to be a part of this study. Subjects were experienced typists, with at least one year of experience using a visual display terminal (VDT). Subjects were also screened for prior upper extremity musculoskeletal injuries. To participate, subjects must have been symptom-free for at least one year prior to initiation of this study.

Two volunteers were excluded from participation in this study. One volunteer reported shoulder pathology and was undergoing arthroscopic surgery in a few days. Another volunteer was extremely allergic to adhesives. She reported that her skin would not tolerate the adhesive material used to attach the electrodes to the skin. Therefore, a total of thirteen subjects were available for participation. Table 1 depicts the subject characteristics of this study.

Each participant signed a letter of informed consent (Appendix A) prior to participation. A questionnaire (Appendix B) was also filled out at this time. The questionnaire was used as a screening tool and to gather information about the
subject. Prior to starting this research, the project was approved by the University of North Dakota’s Institutional Review Board (Appendix C).

**Table 1.** Subject Characteristics (n=13, unless [*] noted).

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Range</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (in years) *</td>
<td>29.4</td>
<td>21-41</td>
<td>7.7</td>
</tr>
<tr>
<td>Height (in inches)</td>
<td>65.4</td>
<td>63-70</td>
<td>1.9</td>
</tr>
<tr>
<td>Weight (in pounds)</td>
<td>171</td>
<td>135-225</td>
<td>24.9</td>
</tr>
<tr>
<td>Years worked</td>
<td>6.1</td>
<td>1-20</td>
<td>5.9</td>
</tr>
<tr>
<td>Hours per day typing</td>
<td>6.2</td>
<td>4-8</td>
<td>1.3</td>
</tr>
<tr>
<td>Words per minute</td>
<td>50.8</td>
<td>35-65</td>
<td>8.3</td>
</tr>
</tbody>
</table>

* n=11

**Instrumentation**

Electromyographic (EMG) signals were used to determine the activity of the upper trapezius and forearm muscles. A Noraxon Telemyo8 telemetry unit (Noraxon USA, 13430 North Scottsdale Road, Scottsdale, AZ 85254) was used to collect the EMG data. The Noraxon Telemyo8 receiver collected the telemetried information from the surface electromyographic (sEMG) electrodes and the wafer footswitch. This information was then digitized by a DT2801-Analog to digital interface board installed in a NET 486DX computer. The Myosoft data collection software that accompanies the Telemyo8 EMG system was used to analyze the digitized EMG signals.
Procedure

Surface EMG (sEMG) was utilized to monitor the amount of activity in four upper quadrant muscles: upper trapezius (UT), extensor digitorum (ED), extensor carpi radialis longus and brevis (ECR), and flexor superficialis (FS). Electrode placement was set according to the motor points of the selected muscles. Motor points used for this study were those described by Basmajian (Figure 2). These points represent the area of the muscles that elicited the greatest amount of isolated muscle contraction.

As recommended by authors of prior EMG studies, each subject's skin was prepared with isopropyl alcohol and shaved of hair when necessary prior to the application of self adhesive, paired electrodes. This preparation was necessary to reduce skin impedance and ensure optimal electrode contact. Two surface electrodes were centered over a single motor point of each individual muscle. The paired electrodes were placed parallel to the direction of the selected muscle fibers, as recommended for optimal motor unit recording. To maximize the EMG signal amplitude and minimize the amount of volume conduction from extraneous muscles, the paired electrodes were placed a half inch apart of each other. A single ground electrode was situated over the olecranon.

To establish a baseline of muscle activity, maximal voluntary contractions (MVC) were elicited. Manual muscle testing procedures described by Daniels and Worthingham were used to elicit MVCs for each of the muscles. All MVCs were elicited with the subject in a seated position. The MVC for the UT was
Figure 2: Motor Points.  
A) Upper Trapezius: center the electrodes half-way between the angle of the acromion and the spine of the C7 vertebra.  
B) Extensor Digitorum: center electrodes at the ¼ point on a line drawn from the lateral epicondyle to the ulna's styloid process.  
C) Extensor Carpi Radialis Brevis and Longus: on the fully pronated forearm, center the electrodes a third of the way on a line drawn from the lateral end of the elbow crease to the middle of the wrist.  
D) Flexor Superficialis: center the electrodes halfway between a line extending from the medial epicondyle to the styloid process of the ulna.
obtained by having the subject elevate her shoulders and isometrically resisting manual depression. The ED and ECR musculature were evoked simultaneously. With her forearm pronated, the subject extended her wrist and isometrically resisted manual pressure into wrist and metacarpal flexion. For the FS, the subject supinated her forearm and flexed her interphalangeal joints. Isometric resistance to manual extension of the interphalangeal joints was elicited. Each isometric contraction was sustained for six seconds.

The MVCs established a baseline used to normalize the data. Normalization of sEMG data is necessary because the muscle activity recorded by the electrodes is not absolute. Several factors affect the quality of the signal received by the electrodes. For example, impedance by subcutaneous tissue located between the electrodes and the target muscle may alter the amplitude of the signal. Large quantities of subcutaneous tissue diminishes the signal. In contrast, the signal may be magnified if little subcutaneous tissue is present or by volume conduction from adjacent muscles. To normalize the data, the EMG activity is expressed as a percentage of the activity obtained during the MVC of the muscle being monitored.

The experiment consisted of typing two sentences ("Your statement was submitted to the Milane Insurance Company on 10/05/93. You were not given coverage for the itemization listed below.") for two trials at each of three different elbow angles. The same two sentences were used throughout the study. No training session was provided. It was felt that because the subjects were experienced typists, a learning curve would not be a factor. Two trials were
recorded to ensure attainment of at least one valid set of data wherein all the collecting devices were working properly.

A footswitch was attached to the return key of the keyboard. Generally footswitches are used in examining gait. They indicate when the heel, fifth metatarsal head, first metatarsal head, and great toe are in contact with the ground. However, in this experiment, an indicator of the beginning and ending of the test was necessary. Therefore, affixing a footswitch to the return key of the keyboard was a logical way to obtain this information. The great toe footswitch was used because it required the least amount of force to establish a signal. Subjects were instructed to firmly press the return key at the start and at the end of each two sentence trial. The footswitch was used to detect the start and stop of each trial.

To record the EMG and footswitch activity, the signals were transmitted from the surface electrodes and footswitch to the receiver unit, and into a computer for display. The EMG data for each subject was recorded by the computer and stored on disk for later analysis.

Subjects were tested at elbow angles of 70, 90, and 110 degrees (Figure 3,4,5). Each angle was manually measured with a universal goniometer. Goniometric measurement procedures were modified from Norkin and White. Each subject was measured in the seated position with their forearms pronated. This positioning was used because it mimicked the typing posture used throughout this study. In measuring the elbow angle, the center of the fulcrum was placed over the lateral epicondyle of the humerus. The proximal arm
Figure 3. Subject Set-up for the 70 Degree Angle Trial
Figure 4. Subject Set-up for the 90 Degree Angle Trial
Figure 5. Subject Set-up for the 110 Degree Angle Trial
followed the lateral midline of the humerus, using the center of the acromion process for reference. The distal arm followed the lateral midline of the forearm and used the styloid of the ulna as a reference point. Interrater reliability of the measurements were controlled; only one person did the measuring.

The experimental testing procedure consisted of typing at three different angles (70, 90, 110) for 2 trials each. Subjects randomly selected the angle order in which they were tested. Participants were set up at the VDT workstation according to ergonomic recommendations by the National Institute of Occupational Safety and Health (NIOSH). This included operator positioning and monitor placement. Each subject completed two trials of typing at three different angles. Each subject was instructed to type as normally as possible, not worrying about speed or accuracy. To maintain consistency between subjects, use of the numeric pad on the keyboard was not allowed.

Two sentences were typed during each trial. Subjects were asked to depress the return key with the attached footswitch at the start and end of each trial. To ensure that the subject was indeed in the appropriate angle, subjects were measured and adjusted to attain the corresponding angle prior to each trial. Adjustments of chair height, footrest levels, and the hospital bed tray (for the 110 degree angle) were used to assist in achieving the desired position. The 90 degree angle exercise was performed at desk level. A wrist rest was used to mimic their normal manner of typing. To achieve the 70 degree angle, subjects placed keyboards on their laps. The 110 degree angle was performed on a
hospital bed tray. This tray was vertically adjustable and allowed for easy adaptation.

After completing the experiment, electrodes were removed and each participant was instructed on stretches that could be performed at the workstation. The stretches reviewed were a variety of upper extremity exercises. These included shoulder, forearm, neck, and hand stretches. These particular stretches were selected because they represented some of the muscle groups that experience fatigue while typing.

Data Analysis

A comparison between the three elbow angles while typing was made by analyzing muscle activity. The Norquest software program averages 100 peaks of integrated EMG activity within a specific time interval specified by the researcher. In this case, the beginning and end of the collection of EMG data was signified by pressing the return key with the attached footswitch. These were the markers used to indicate the starting and ending point of the time interval. One of the two trials performed for each angle was selected to be used for data analysis. The first trial was consistently used unless difficulties with equipment and/or EMG recording occurred. In these cases, the second trial was utilized.

The data was analyzed using two different methods: 1) MVC as a normative value, and 2) 90 degree elbow position as the reference. The method using the MVC was chosen because the trend of EMG studies generally uses the MVC data as a normalizer. However, the MVC represents a static, isometric
strength that may not carryover into the dynamic activity of typing. Therefore, I have also chosen to analyze the data using the 90 degree angle as the reference activity. Because the available literature considers this position a standard, the muscle activity at variable angles can be compared to the 90 degree angle to determine if the muscle activity increases or decreases.

Maximum Voluntary Contraction (MVC)

The EMG data for each of the four muscles (upper trapezius, extensor digitorum, extensor carpi radialis brevis and longus, and flexor superficialis) were normalized individually for each subject. The maximal EMG signal intensity was first calculated, in mV, for each subject from the maximal voluntary contraction. For the MVC comparison measure, a three second time interval within the six seconds obtained, was analyzed. The MVC was defined as the mean of the 100 peaks amplitudes during this time interval.

To normalize the data, the average EMG activity obtained for each muscle during typing was expressed as a percentage of that person’s MVC for that specific muscle. An average of the data for all thirteen subjects for each trial was calculated. These averages were used to compare the EMG activity during typing at the various elbow angles.

Ninety Degree Angle as a Reference

The same collection and analyzing method was used to gather and calculate the data for this method. The only difference is that the MVC data was not used. Instead of using the MVC, the 90 degree angle was used as the comparison muscle activity. The muscle activity from the other two angles
(70 degrees and 110 degrees) were compared to the activity generated at the 90 degree angle. Because typing is a dynamic activity, the analysis of the data using this method may provide a more accurate comparison of the muscle activity.

Statistics

The data was then input into the Statistical Package for the Social Sciences (SPSS) software (444 North Michigan Avenue, Chicago, IL 60611) and analyzed using a repeated measures analysis of variance (ANOVA). Post-hoc analysis was examined by applying the Scheffe's test. Significance was determined as p<0.05.
CHAPTER 4

Results

Maximum Voluntary Contraction (MVC)

The average muscle activity expressed in a percentage of the MVC (%MVC) while typing at the three different elbow angles (70, 90, and 110 degrees) for the four muscles is presented in Table 2 and Figure 6.

In reference to %MVC, the greatest amount of muscle activity for the upper trapezius (UT) was found at the 110 degree angle at 79%, followed by the 90 degree angle (53%), while the least amount of activity (40%) was at the 70 degree angle. The % MVC values for the flexor superficialis (FS) muscles were the greatest at the 110 and 70 degree angles at 80% and 79% respectively, while the 90 degree position elicited a 68% MVC. According to these values, there is no significant difference in muscle activity in regards to position for the UT and FS musculature.

The mean %MVC activity of the extensor carpi radialis brevis and longus (ECR) musculature was found to be 37%, 29%, and 22% for the 70, 90, and 110 elbow angles, respectively. This muscle group did display a significant difference in muscle activity, f(2,12)=26.75, p<0.05. Significance was found
between all three positions. When comparing the 70 degree to the 90 degree position, a significance of \( p=0.003 \) was found, while the 90 degree versus 110 degree angles elicited a \( p=0.008 \).

The greatest muscle activity for the extensor digitorum (ED) was found to be at the 70 degree position (62%). The next highest activity was calculated as 53% at the 90 degree angle, while the lowest activity was represented by the 110 degree angle at 51%. This muscle group also demonstrated a significant difference between positions \( (p=0.019) \). This significance was calculated between the 70 degree and the 110 degree positions. No significance was found, however, when comparing the 70 versus 90 degree angles, or the 90 versus 110 degree angles.

Table 2. Average %MVC while typing.

<table>
<thead>
<tr>
<th></th>
<th>70 degrees</th>
<th>90 degrees</th>
<th>110 degrees</th>
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<tr>
<td><strong>Upper Trapezius</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Mean</td>
<td>39.47</td>
<td>53.32</td>
<td>79.42</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>27.52</td>
<td>40.20</td>
<td>78.02</td>
</tr>
<tr>
<td><strong>Extensor Digitorum</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>62.34</td>
<td>53.25</td>
<td>51.15</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>19.38</td>
<td>14.10</td>
<td>12.25</td>
</tr>
<tr>
<td><strong>Extensor Carpi Radialis Brevis &amp; Longus</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>37.03*</td>
<td>29.25*</td>
<td>22.39*</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>11.32</td>
<td>8.76</td>
<td>7.63</td>
</tr>
<tr>
<td><strong>Flexor Superficialis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>79.41</td>
<td>68.75</td>
<td>80.28</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>44.72</td>
<td>35.88</td>
<td>52.79</td>
</tr>
</tbody>
</table>

* significance established, \( p<0.05 \)
Figure 6. EMG activity in %MVC while typing

Upper Trapezius
Extensor Digitorum
Extensor Carpi Radialis Brevis &
Flexor Superficialis

% MVC

- 70 degrees
- 90 degrees
- 110 degrees
Ninety Degree Elbow Position as a Reference

The average muscle activity expressed in mV while typing at three different elbow angles (70, 90, and 110 degrees) for the four muscles is presented in Table 3 and Figure 7.

Compared to the 90 degree position (85mV), the UT showed a decrease in activity during the 70 degree trial (66 mV), while the 110 degree trial elicited an increase in activity (111 mV). A significant difference of UT muscle activity was noted in regards to position (p=0.022). However, this significance was between the angles of 70 and 110 degrees. No significance was found between the 70 degree versus the 90 degree or the 90 degree versus the 110 degree angles.

The average activity of the ECR musculature while typing was least at the 110 degree position (117mV), followed by the 90 degree angle of 155 mV. The 70 degree position exhibited the greatest amount of activity at 196mV. The ECR muscle group was noted to show a significant difference between positions (p=0.000). Significance was found between the 70 versus 90 degree positions (p=0.018) as well as between the 90 versus 110 degree angles (p=0.028).

As with the ECR musculature, the greatest amount of activity for the ED was generated at the 70 degree angle (386mV), while the least activity was noted at the 110 degree position (311mV). The 90 degree angle again maintained the middle ground at 326mV. A significant difference between positions was also found for the ED musculature (p=0.003). Although significance was not found between 90 and 110 degrees, the 70 versus 90 degree analysis did display a significant difference between positions (p=0.029).
The FS musculature exhibited the greatest amount of activity in the 110 degree position (163mV), followed by the 70 degree angle (139mV). The 90 degree trial generated the least activity with a value of 130 mV. A significant difference in relation to position was not found with this muscle group.

Table 3. Average muscle activity (mV) while typing.

<table>
<thead>
<tr>
<th></th>
<th>70 degrees</th>
<th>90 degrees</th>
<th>110 degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upper Trapezius</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>65.49</td>
<td>85.09</td>
<td>111.25</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>40.26</td>
<td>64.69</td>
<td>61.75</td>
</tr>
<tr>
<td><strong>Extensor Digitorum</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>385.52*</td>
<td>326.25</td>
<td>311.24</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>148.61</td>
<td>120.94</td>
<td>99.03</td>
</tr>
<tr>
<td><strong>Extensor Carpi Radialis Brevis and Longus</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>195.73*</td>
<td>155.01</td>
<td>116.82*</td>
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<tr>
<td>Standard Deviation</td>
<td>111.50</td>
<td>91.05</td>
<td>67.19</td>
</tr>
<tr>
<td><strong>Flexor Superficialis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>138.99</td>
<td>129.46</td>
<td>162.95</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>56.74</td>
<td>64.23</td>
<td>105.37</td>
</tr>
</tbody>
</table>

*Significance established, p<0.05.
Figure 7. EMG activity in mV while typing.
CHAPTER 5
Discussion

Electromyographic (EMG) Normalization

To compare the EMG signal intensity between subjects, muscle groups, and position, the EMG activity must be quantified. In this study, quantification was performed in two ways: 1) using the maximum voluntary contraction (MVC), and 2) using the 90 degree angle as a reference point. Normalization of EMG signals from a maximal voluntary contraction is a common procedure used in many studies.\textsuperscript{33,37} This method is based on the assumption that a MVC elicits maximum firing levels of all motor units in a muscle. This assumption, however, has been questioned by other authors.\textsuperscript{38} Problems with this assumption include the fact that the ability to perform a true MVC may depend on previous muscle training, physical conditioning, posture, and body awareness.\textsuperscript{39} Contradicting results to the theory that human muscle produces the greatest force during an isometric contraction has been established by testing muscle activity using an eccentric isokinetic dynamometer.\textsuperscript{40} In addition, normalized values may be higher than the MVC values due to the difficulty in the standardization of test contractions.\textsuperscript{41} Also, because the MVC is accomplished by performing a static muscle contraction, it may not accurately correlate with the muscle activity
elicited while performing a dynamic exercise.\textsuperscript{37} Considering these inconsistencies, the EMG normalization using the MVC in this study was applied to indicate the magnitude of muscle activation rather than absolute values of muscle activity.

Because this study involves a dynamic activity, the use of the MVC to normalize the data may not provide the most functionally applicable results. The MVC uses a static, isometric contraction to elicit the MVC, while typing is a dynamic, isotonic exercise. For this purpose, alternative procedures for normalization have been reported in the literature. Some authors use one of the activities being studied as the reference contraction. For example, Janda et al\textsuperscript{42} compared the muscle activity during gripping using the open grip position as the reference activity. Therefore, the results of this study was also analyzed using the 90 degree typing position as a reference point. This position represents the industry standard. Although it does not provide a 100\% reference as maximum effort is not obtained, it does allow for an appropriate comparison measure.

**EMG Activity**

Analysis of the EMG recordings in this study was completed using the two methods described above. Both methods revealed similar trends in EMG activity. Although small differences were found in regards to significance, the analyzed data essentially revealed the same information. Therefore, the data will be interpreted together.

Significance levels were calculated for each muscle group at each position. The upper trapezius (UT) and flexor superficialis (FS) musculature did
not display significance in regards to position, while significance was found in the extensor carpi radialis brevis and longus (ECR), \( p=0.000 \) for both MVC and 90 degree reference and extensor digitorum (ED), \( p=0.019 \) for MVC and \( p=0.003 \) for 90 degree reference. In this study, however, significance may not provide the best indication of the muscle activity. Muscle groups that do not display significance may also be of importance because of the repetitive nature of the typing activity. Because many people work at a keyboard for 6-8 hours a day, a significance level calculated during a 30 second time period may not accurately represent the effects of typing for long periods of time. Since ergonomics involves awkward static positioning and repetition for prolonged time periods, significant differences may be less important than the actual sum of the muscle activity itself. Therefore, the remainder of the results will be interpreted based on the muscle activity analyzed as well as the significance of the tests.

Generally, the most appropriate keyboard position is the one that elicits the least amount of EMG activity in the respective muscles. EMG data relates to the amount of force a muscle elicits in a certain time frame. An EMG level of “zero” refers to a muscle’s resting state where no muscle activity occurs. Therefore, a low EMG recording indicates a lesser amount of work being generated by the muscle. The best position is the angle that requires the lowest amount of activity in the muscles. In contrast, a higher EMG level signifies a greater amount of muscle activity being generated.

The results of this study suggest that the 90 degree elbow position may indeed be the most appropriate position for typing. Although this position did not
exhibit the least amount of activity in any of the studied muscle groups (except the FS), it represented the position that was a compromise and considered all muscle groups in conjunction. For example, the UT exhibited less activity at the 70 degree angle, however, more activity was generated in the ED and the ECR at this angle.

Although the 90 degree angle position may represent the optimal overall position for typing, the 70 and 110 degree angles may be indicated for patients who require rest or a reduction of muscle activity and load on a particular muscle group. The next sections will discuss each of the studied muscles and the clinical implication of the results.

*Upper Trapezius*

The activity of the UT musculature exhibited the least activity in the 70 degree elbow position, indicating the optimal position for this muscle group. Although no significant difference between positions was found, this position may be indicated for persons with neck or shoulder discomfort. Patients who exhibit tension in the upper back may wish to drop their keyboards to the 70 degree angle while working at the keyboard to minimize the muscle activity of the upper trapezius, thereby possibly reducing the strain on this muscle group. It is important to note that this position would not be recommended for those with forearm problems, particularly in the extensor group, as the muscle activity in the extensors are increased at the 70 degree level.
Extensor Digitorum and Extensor Carpi Radialis Brevis and Longus

The forearm extensors displayed the greatest muscle activity at the 70 degree angle, thus this angle should be avoided for those with discomfort to this area. The 110 degree position represents the least amount of activity and a possible position for patients exhibiting forearm extensor strain, such as lateral epicondylitis. A higher keyboard position may alleviate tension in the forearm extensor musculature. It must be noted, however, that this higher keyboard position may aggravate discomfort in the UT region as muscle activity is increased in the UT muscle group.

Flexor Superficialis

The FS muscle group displayed very little variability in muscle activity in regards to elbow positioning. The 90 degree angle exhibited the least activity, thus representative of the optimal keyboard position for this muscle group. However, no significant difference was found between positions.

Limitations

Because a small sample size was utilized, the results of this study cannot be accurately interpreted to represent an entire population. In addition, participants were all females. It is suggested that future investigations include a larger sample size and include both genders.

Another limitation may be the equipment used to create the elbow positions while typing. The adjustable hospital bed tray for the 110 degree position, and the subject’s lap for the 70 degree position did not provide for an optimal typing posture. Changes in angles could not be controlled for at the
70 degree angles as participants could move their legs after measured. The keyboard resting on the subject's lap also created some concern that the keyboard may slide off the subject's thighs. Future studies may wish to devise a better way to alter the angles.

Subject's were not given any learning period to become comfortable typing at the 70 and 110 degree angles. Many participants expressed awkwardness while typing at these positions. It may be beneficial to allow subjects to familiarize themselves with the angles that differ from what they are used to.
CHAPTER 6
Conclusion
In summary, the following findings may provide some guide for clinical practice and ergonomic intervention:

1. When considering muscle activity for the upper trapezius, extensor digitorum, extensor carpi radialis brevis and longus, and flexor superficialis, the 90 degree elbow angle may represent the optimal keyboarding position.

2. The 70 degree angle may be indicated for individuals who require decreased tension on the upper trapezius musculature. Patients with neck or shoulder discomforts may experience some relief by typing in this position. It should be noted that this position should not be suggested for persons with aggravated forearm extensor musculature.

3. The 110 degree position may decrease muscle activity in the forearm extensors, thereby possibly a preferable position for keyboarders with forearm extensor discomfort. This position, however, is not recommended for those with aggravated shoulder or neck musculature.

4. Literature supports job rotation as a means of decreasing tension on particular muscles. Integrating other job duties between typing tasks may be helpful in reducing repetition. It may also be beneficial for all computer users to
vary their elbow position while typing according to the discomforts they experience. The dramatic increase in cumulative trauma disorders in the workplace and the sky-rocketing costs of workers compensation and lost wages have encouraged businesses, labor groups, and health care professionals to recognize the application of ergonomics in the computerized office. It is essential that employers understand that ergonomics is a productivity and quality issue since an increase in morale and turnover reduction contributes to increased efficiency and productivity and thus an improved bottom line. Contrary to public sentiment, ergonomic improvement does not require the purchase of expensive equipment, often small dollar expenditures can be quite effective. Education in proper posture and body mechanics, altering chairs and computer monitors, and rearrangement of desktop items represent much of the work environment adaptation necessary. Both employers and employees should be educated in the benefits of applying ergonomic principles to their work environments. Education is essential to solving the problem of understanding the advantages of ergonomics and its relationship to decreasing the incidence of CTDs in the workplace.

Ergonomics, however, is not a cure-all to decreasing the risk of CTDs in the workplace. Everything we do has an impact on our health. Our bodies do not delineate between an activity performed for play and one that is done at work. Keeping our bodies in good health by participating in regular exercise, maintaining a proper diet, and utilizing proper posture and body mechanics can reduce our chances of injury.
APPENDIX A
Information and Consent Form
INFORMATION AND CONSENT FORM

TITLE: An Electromyographic Study of the Forearm and Upper Trapezius Musculature During Typing at Different Keyboard Heights.

You are being invited to participate in a study conducted by Karianne Sekiya, a physical therapy student at the University of North Dakota. The purpose of this study is to study muscle activity in your forearms and shoulders while you are typing. We hope to describe the optimal ergonomic elbow position while typing on a keyboard. Determining this position will assist in the prevention of cumulative trauma in occupational settings. Only normal, healthy subjects will be asked to participate in this study.

You will be asked to type a given paragraph for six (6) trials consisting of the following: 1) 2 trials with your elbows at a ninety (90) degree angle, 2) 2 trials with your elbows at a seventy (70) degree angle, and 3) 2 trials with your elbows at a one-hundred and ten (110) degree angle. Each trial will last approximately 30 seconds. You will be given a short rest period between trials. Following the completion of the trials, you will be instructed on a stretching routine that may decrease the discomfort of everyday work.

The study will take approximately one half hour of your time. You will be asked to report to the predetermined site within your workplace at an assigned time. You will then be asked to wear or change into a short sleeved tee shirt (or tank top) for the experiment. During the experiment, we will be recording the amount of muscle activity you have while typing on keyboards of different heights.

Although the process of physical performance testing always involves some degree of risk, the investigator in this study feels that the risk of injury or discomfort is minimal to none. In order for us to record the muscle activity, we will be placing electrodes on your forearms and shoulders. Before we can apply the electrodes, we will use a small stimulator to electrically stimulate the muscles to locate the best spot to place the electrodes. The stimulator will cause a mild tingling sensation. The recording electrodes are attached to the surface of the skin with an adhesive material. We will also attach a measuring device to your forearms and elbows with adhesive material. These devices only record information from your muscles and joints, they do not stimulate the skin. After we get the electrodes attached, we will begin the experiment. You will be asked to type the given paragraph in your normal manner.

Your name will not be used in any reports of the results of this study. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. The data will be
identified by a number known only be the investigator. The investigator or participant may stop the experiment at any time. Your decision whether or not to participate will not prejudice your future relationship with the Physical Therapy Department, the University of North Dakota, or Blue Cross Blue Shield of North Dakota. If you decide to participate, you are free to discontinue participation at any time without prejudice.

The investigator involved is available to answer any questions you have concerning this study. In addition, you are encouraged to ask any questions concerning this study that you may have in the future. Questions may be asked by calling *Karianne Sekiya or Beverly Johnson at (701) 777-2831*. A copy of this consent form is available to all participants in the study.

**MY SIGNATURE INDICATES THAT, HAVING READ THE ABOVE INFORMATION, I HAVE DECIDED TO PARTICIPATE IN THE RESEARCH PROJECT.**

---

**Participant's Signature**  
**Date**

---

**Witness (not the scientist)**  
**Date**
APPENDIX B
Questionnaire
QUESTIONAIRRE

Date:_______

Name:_____________________

Age: _______ Sex: M F Dominant Hand: R L

Please answer the following:

Approximate number of years typing at a computer (on the job): ______

Average number of hours spent typing per day: ______

Do you have or have you ever been treated for injuries to your arms, shoulders, or neck? (circle): yes no

If yes, please describe:___________________________________________________________

___________________________________________________________

Estimated typing speed: _____ words per minute

Are you allergic to rubbing alcohol? (circle) yes no

Are you allergic to adhesive tape? (circle) yes no

Thank you for agreeing to participate in this study. A copy of the results will be made accessible to you when complete. If you have any questions or comments, please feel free to contact me or the UND Physical Therapy Department

Karianne Sekiya
3711 University Ave #201
Grand Forks, ND 58203
(701)777-9780
sekiya@prairie.nodak.edu

University of North Dakota
Physical Therapy Department, Box 9037
Grand Forks, ND 58202
(701)777-2831
Attn: Karianne Sekiya or Beverly Johnson
X EXPEDITED REVIEW REQUESTED UNDER ITEM _3_ (NUMBER[S]) OF HHS REGULATIONS
__ EXEMPT REVIEW REQUESTED UNDER ITEM ___ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA
HUMAN SUBJECTS REVIEW FORM
FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED
PROJECTS INVOLVING HUMAN SUBJECTS

PRINCIPAL
INVESTIGATOR: Karianne Sekiya TELEPHONE: (701)777-9780 DATE: 03/20/97

ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: 3711 Univ. Ave #201, Grand Forks, ND 58203

SCHOOL/COLLEGE: University of North Dakota DEPARTMENT: Physical Therapy PROPOSED
PROJECT DATES: 4/15/97-12/01/97

PROJECT TITLE: An Electromyographic Study of the Wrist Extensors and Upper Trapezius Musculature During Typing at Different Keyboard Heights.

FUNDING AGENCIES (IF APPLICABLE): _ N/A

TYPE OF PROJECT:
___ NEW PROJECT ___ CONTINUATION ___ RENEWAL ___ THESIS RESEARCH ___ STUDENT
RESEARCH PROJECT
___ CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER: Beverly Johnson

PROPOSED PROJECT: ___ INVOLVES NEW DRUGS (IND) ___ INVOLVES NON-APPROVED USE OF DRUG ___

IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATIONS, PLEASE INDICATE THE CLASSIFICATION(S):
___ MINORS (<18 YEARS) ___ PREGNANT WOMEN ___ MENTALLY DISABLED ___ FETUSES ___ MENTALLY RETARDED
___ PRISONERS ___ ABORTUSES ___ UND STUDENTS (>18 YEARS)

IF YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE ___

1. ABSTRACT: (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.

Fifteen experienced typists currently performing keyboarding activities on the job will be tested to determine muscle activity of the wrist extensors and upper trapezius while keyboarding. Three different keyboard heights will be used: 70 degrees, 90 degrees, and 110 degrees. Muscle activity will be measured using surface electromyography (EMG). It has long been accepted that the 90 degree elbow angle is optimal position. However,
the available literature regarding the 90 degree elbow position is lacking. Recent studies have also indicated that this may not be the most beneficial position to decrease musculoskeletal injuries related to keyboarding. This study hopes to add to the current knowledge of ergonomics by determining the optimal elbow position during typing. This would serve to reduce the risk of cumulative trauma disorder in the workplace.

2. PROTOCOL:
EMG electrodes will be placed on the subjects upper trapezius and wrist extensors. The workstation will be adjusted to the proper ergonomic set up as specified by Occupational Safety and Health Administration (OSHA) guidelines. The subject will perform a maximum voluntary contraction against the testers resistance for each muscle tested. This will allow for a comparison measure. The subject will then type a predetermined paragraph in each of the three positions: elbow angles at 70 degrees, 90 degrees, and 110 degrees. Following the activity, the subject will be instructed to stretch the used muscles.

3. BENEFITS:
This study will provide further information to the fast growing field of ergonomics. The results should add to the current knowledge of ergonomics and assist in the prevention of cumulative trauma in occupational settings. The subject will also gain experience and knowledge of becoming part of a research team. We also hope to expand the subjects knowledge of office ergonomics and stretching techniques to minimize the risk of occupational injury.

4. RISKS:
The risks to the subject in this study should not exceed that of a regular work day. The activity itself (typing) may contribute to cumulative trauma that occurs secondary to repetitious movements. These however, would not be any greater than what would be experienced in a normal work day. The subjects will be instructed to stretch the respective muscles after completing the tasks. In rare instances, irritation from the surface EMG electrodes may occur. This will be minimized by adequate preparation of the skin surface. The subject has the option to halt the study at any time for any reason.

5. CONSENT FORM: A copy of the CONSENT FORM to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no CONSENT FORM is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

Signed consent forms will be kept in Beverly Johnson's office at the University of North Dakota School of Medicine and Health Sciences Physical Therapy Department from collection until December 31, 2002. Confidentiality will be maintained at all times.

6. For FULL IRB REVIEW forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:
The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.

SIGNATURES:

Principal Investigator DATE: ____________

Project Director or Student Adviser DATE: ____________

(Revised 8/1992)
REPORT OF ACTION: EXEMPT/EXPEDITED REVIEW
University of North Dakota Institutional Review Board

DATE: April 1, 1997 PROJECT NUMBER: IRB-9704-239

NAME: Karianne Sekiya Department/College: Physical Therapy

PROJECT TITLE: An Electromyographic Study of the Wrist Extensors and Upper Trapezius Musculature During Typing at Different Keyboard Heights

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on April 2, 1997 and the following action was taken:

☐ Project approved. EXPEDITED REVIEW No. 3
Next scheduled review is on April 1998

☐ Project approved. EXEMPT CATEGORY No. __________ No periodic review scheduled unless so stated in the Remarks Section.

☐ Project approved PENDING receipt of corrections/additions. These corrections/additions should be submitted to ORPD for review and approval. This study may not be started until final IRB approval has been received. (See Remarks Section for further information.)

☐ Project approval deferred. This study may not be started until final IRB approval has been received. (See Remarks Section for further information.)

☐ Project denied. (See Remarks Section for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairperson or ORPD.

cc: B. Johnson, Adviser Dean, Medical School
Signature of Designated IRB Member
UND's Institutional Review Board

If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 310 Form may be required. Contact ORPD to obtain the required documents.

(3/96)
APPENDIX D
Consent for Taking and Publication of Photographs
Consent for Taking and Publication of Photographs

Name: Donna Wood              Date: 9/18/97

Place: Blue Cross Blue Shield of North Dakota
       Medicare Operations Building
       Fargo, North Dakota

In connection with Karianne M. Sekiya’s independent study project entitled, An Electromyographic Study of the Forearm and Upper Trapezius Musculature During Typing at Different Keyboard Heights, I consent that photographs may be taken of me and may be published under the following conditions:

1. The photographs shall be used if the researcher, Karianne M. Sekiya deems that medical research, education, or science will be benefited by their use. Such photographs may be published and republished, either separately or in connection with each other, in professional journals or medical books; provided that it is specifically understood that in any such publication or use I shall not be mentioned by name.

2. The aforementioned photographs may be modified or retouched in any way that the researcher, Karianne M. Sekiya may consider desirable.

Signed Donna R. Wood
Print name 9/18/97 Donna R. Wood

Witness Myndi Frey
Print name Myndi Frey
REFERENCES


