FINAL REPORT

PREVENTION OF MUSCULOSKELETAL DISORDERS AMONG VDT USERS

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TABLE OF CONTENTS

LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
BMI	Body mass index
cm	Centimeter
CPU	Central processing unit
GT	Georgia Tech
H/A	Hand/arm
L/R	Left/Right
MSD	Musculoskeletal disorder
N	Number
NIOSH	National Institute for Occupational Safety and Health
N/S	Neck/shoulder
OSHA	Occupational Safety and Health Administration
p	Probability
PC	Personal computer
UEMSD	Upper extremity musculoskeletal disorder
VDT	Video display terminal
wpm	Words per minute

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

We performed the first randomized trial of specific ergonomic and postural interventions among persons using computer keyboards for more than 15 hours per week. Two specific sets of postural interventions were studied: 1) postural interventions based on the results of a major prospective study of musculoskeletal disorders among VDT users (RO1 OH 03160) and 2) postural interventions based on recommendations of OSHA, NIOSH, and several computer manufacturers. The incidence of neck/shoulder symptoms and hand/arm symptoms during six months of follow-up among individuals in these two intervention groups was compared to the incidence in a third group of computer users who did not receive any intervention.

Approximately 440 individuals agreed to participate in the study, signed informed consent forms and completed a screening questionnaire designed to determine eligibility for randomization. Approximately 90 individuals were ineligible due to existing musculoskeletal symptoms at entry into the study. A total of 376 individuals were randomized into one of three intervention groups: the Emory/GT intervention (group A), the OSHA/conventional intervention (group B), and a group with no intervention (group C). For individuals in the intervention groups, study staff adjusted workstations, where possible, and trained individuals to assume the intervention postures. Individuals reported musculoskeletal symptoms on a weekly diary. Participants who reported discomfort intensity of 6 or greater on a 0-10 visual analog scale or who reported musculoskeletal symptoms requiring use of analgesic medication were considered symptomatic. Compliance with all components of the intervention was attained for only 25% of individuals in group A and for only 38% of individuals in group B. Difficulty in attaining compliance was largely due to the inflexibility of workstation configurations.

There were no significant differences in the incidence of musculoskeletal symptoms among the three groups. The number of individuals who developed arm or hand symptoms was 22 (18.3%) in group A, 25 (20.2%) in group B and 25 (21.7%) in group C. The number of individuals who developed neck or shoulder symptoms was 38 (33.3%) in group A, 36 (31.9%) in group B and 33 (30.3%) in group C.

Postural interventions are difficult to implement because of the inflexibility of workstations commonly in use. This study provides evidence that workplace postural interventions are unlikely to reduce the risk of upper extremity musculoskeletal symptoms among computer users.

INTRODUCTION

Upper extremity musculoskeletal disorders (UEMSDs) are painful conditions affecting tendons, tendon sheaths, muscles, nerves, bursae, and blood vessels of the hands, arms, shoulders, and neck. Examples of specific upper-extremity musculoskeletal disorders frequently considered to be potentially work-related include carpal tunnel syndrome, tendonitis of the hand and wrist, shoulder disorders, and chronic neck muscle pain [Gerr et al., 1991]. The prevalence of work-related upper extremity musculoskeletal disorders reported in the United States appears to have increased dramatically during the past two decades. In 1982, they accounted for approximately 18% of all reported occupational illness in the US; in 2002, they accounted for approximately two-thirds of all reported occupational illness in the US [US BLS, 2003]

Computers and computer workstations (also called video display terminals – VDTs) have become increasingly common in both workplaces and private residences over the past 20 years. According to the United States Census Bureau, about 92 million adults in the United States used a computer in 1997, 37% of all American households had computers and half of all employed adults in the US used a computer on the job in 1997 [US Census Bureau, 1999]. OHSA has recently estimated that nearly 100 million Americans use computers at work [OSHA, 1997] and The World Health Organization [1998] has estimated that 150 million computers are in use worldwide. It is likely that these estimates are lower than actual use at this time. Because of such widespread use, even relatively small risks associated with their use would have important public health implications and interventions that result in decreased risk would have great public health benefits.

Reports in the scientific literature and lay press have suggested that computer users are at increased risk of upper extremity MSDs [Horowitz, 1992; Tittiranonda et al., 1999; Gerr et al., 1996]. Early studies often found elevated risks of MSD among keyboard users when compared to non-users. Attention soon focused on specific aspects of keyboard work that might be responsible for the increase in observed risk. In this review, the epidemiological evidence examining associations between upper extremity MSDs and computer user posture and keyboard use intensity (hours of computer use per day or per week) will be examined. Methodological issues that may have lead to inconsistencies in the literature will be discussed. The review is limited to field-based epidemiological investigations published in the peer-reviewed biomedical literature with sample sizes of 20 or more computer (VDT) users.

Review of the epidemiological literature

The English language peer-reviewed epidemiological literature includes nearly two dozen field-based observational studies of musculoskeletal disorders among video display operators. In most of these studies either comparisons were made between VDT users and non-VDT users or exposure-effect relationships are explored using hours-per-day spent keying or years of typing work as the primary exposure metric [Bergqvist et al., 1992 Bergqvist et al., 1995a Bergqvist et al., 1995b, Bernard et al., 1994; Canadian Labor Congress, 1982; Evans and Patterson 2000; Fahrbach and Chapman, 1990; Faucett and Rempel 1994; Hales et al., 1994; Hunting et al., 1981; Katz et al., 2000; Knave etl al., 1985; Marcus et al., 2002; Nelson and Silverstein, 1998; Polanyi et al., 1997; Rossignol et al., 1987; Sauter et al., 1983; Sauter et al., 1991; Smith et al., 1984; Smith et al., 1981; Starr et al., 1985; Stellman et al., 1987]. Review of this literature suggests that VDT use is a risk factor for UEMSDs. However, the majority of these studies

provide little basis for primary prevention efforts, as few or no specific risk factors other than VDT use *per se* or duration of VDT use (hours per day or duration of use in years) were examined individually.

A subset of epidemiological studies in which the investigators examined specific operator postures as potential risk factors for UEMSDs among VDT users can be distinguished from the larger body of literature in which specific risk factors were not examined. Despite widespread acceptance that MSDs among computer users can be prevented by modification of worker posture and use of specific hardware such as adjustable chairs [OSHA, 1997], scientific demonstration that MSDs are, in fact, prevented by these interventions is lacking.

Posture and musculoskeletal outcomes among computer users

Review of the English language peer-reviewed literature identified six field-based, observational epidemiologic studies in which measures of operator posture were used as exposure variables in analyses relating VDT use to upper extremity MSDs. Only one study followed a cohort with a prospective design; the remaining five were of cross-sectional design. These six studies are described below.

Hunting et al., [1981] performed a cross-sectional study of 162 workers using VDTs and 133 non-VDT using comparison subjects. Evaluations included responses to questions about musculoskeletal discomfort, measurement of VDT operator posture, and performance of upper extremity physical examinations. Analyses of musculoskeletal symptoms were restricted to participants reporting pain on a daily basis. Ulnar deviation greater than 20° was significantly associated with abnormalities on physical examination for some sub-categories of VDT work but not for others. A negative association between keyboard height and musculoskeletal discomfort of the neck, shoulder, and arms was observed (i.e., lower keyboard height was associated with more complaints of discomfort). Greater head rotation angle and greater head inclination were associated with greater reporting of discomfort and findings of clinical abnormality. The ability to work with hands and forearms supported was associated with decreased reporting of neck, shoulder and arm pain.

Starr et al., [1985] performed a cross-sectional investigation of the relationship between upper limb posture and symptoms of back and upper limb discomfort among 100 VDT operators. Monitor viewing angle, neck angle, trunk angle, upper arm angle, forearm angle, hand angle, and elbow angle were estimated from photographs taken while participants were keying. Musculoskeletal discomfort of the upper back, neck, shoulders, upper arms, elbows, and wrists was assessed with a self-administered questionnaire. Each exposure/outcome association was tested individually (adjustments were not made for covariates). Back discomfort was reported statistically significantly more frequently with downward monitor viewing angle.

Sauter et al., [1991] examined associations between MSD symptoms and both computer user posture and workstation dimensions among 40 VDT users. Measures were made once while the participant was working at his/her VDT workstation. While controlling for potential confounding, right arm discomfort was associated with shoulder flexion (greater angles were associated with more frequent discomfort), relative keyboard height (lower keyboard height with respect to elbow height was associated with less frequent discomfort), and right hand ulnar

deviation (greater ulnar deviation was associated with more frequent discomfort). Shoulder abduction, forearm angle, and extension of the right wrist were not associated with right arm discomfort. Left arm discomfort was associated with relative keyboard height (in the same manner as for the right arm) and relative document distance (greater document distance was associated with greater frequency of discomfort).

A cross-sectional study of the relationship between MSD symptoms and both computer user posture and psychosocial factors was performed among 70 employees of a newspaper editorial department [Faucett and Rempel, 1994]. MSD outcomes and psychosocial factors were obtained with a questionnaire and VDT workstation configuration was assessed by direct measurement. In multivariate analyses, none of the postural variables were significantly associated with upper extremity symptom severity. Head rotation and keyboard height above elbow height were significantly associated with upper torso pain and stiffness severity, however. Significant interactions were observed between posture and some psychosocial work factors. When musculoskeletal outcomes were dichotomized, none of the postural variables were significantly associated with MSD status.

A cross-sectional study of the relationships between individual, organizational, and ergonomic factors and MSD outcomes was performed among 260 VDT users [Bergqvist et al., 1995b]. Health outcomes included symptoms and clinical diagnoses. Neck/shoulder outcomes were significantly associated with "too highly placed keyboard". Arm/hand discomfort was non-significantly associated with low keyboard placement. While controlling for potential confounders, "non-neutral position" of the wrists was significantly associated with arm/hand symptoms but not arm/hand diagnoses. Some paradoxical associations were observed, including odds ratios significantly *below* unity for the associations between table "inadjustability" and shoulder disorders and for frequent overtime and cervical diagnoses.

Marcus et al., [2002] performed a prospective epidemiological investigation of 632 newly hired computer users to evaluate associations between computer use variables (posture, work organization including keyboard use intensity, psychosocial factors, and others) and neck or shoulder (N/S) and hand or arm (H/A) MSD outcomes. Associations between posture and MSD outcomes were of modest magnitude. After controlling for confounding variables, keying with an inner elbow angle >121°, greater downward head tilt, placement of the keyboard >17 cm from the edge of the desk, and presence of armrests on the participants chair were each associated with lower risk of N/S outcomes. Keying with elbow height below the height of the "J" key and the presence of a telephone shoulder rest were associated with a greater risk of N/S outcomes. Horizontal location of the "J" key >12.5 cm from the edge of the desk was associated with a lower risk of H/A outcomes. Use of a keyboard with the "J" key >3.5cm above the table surface and radial wrist deviation of >5° while using a mouse were associated with a greater risk of H/A outcomes.

Summary of epidemiological studies examining posture and musculoskeletal outcomes
Results from the cross-sectional epidemiological investigations of associations between posture and musculoskeletal symptoms and disorders are inconsistent. Among the cross sectional studies, Hunting et al. [1981] found an association between MSD outcomes and ulnar deviation greater than 20° only in some job categories while Sauter et al., [1991] found this association

only for the right hand. Neither Faucett and Rempel [1994] nor Starr et al. [1985] found associations between hand posture and MSDs while Bergqvist et al., [1995b] reported that work with the hand in a "non-neutral position" was associated with discomfort but not examination confirmed disorder. Hunting et al. [1981] found that lower keyboard height (with respect to the elbow height) was associated with increased risk of neck, shoulder and arm discomfort while Sauter et al., [1991], Bergqvist et al., [1995b], and Faucett and Rempel [1984], found the opposite relationship for at least some musculoskeletal outcomes. Bergqvist et al., [1995b] concluded that some paradoxical relationships observed in their investigation may be explained by cause-effect reversal problems associated with cross-sectional study designs.

In the one observational study in which posture was assessed prior to the development of symptoms and disorders (Marcus et al., [2002]), lower relative keyboard height, greater inner elbow angle, use of a chair with armrests, and greater horizontal distance between the operator and the keyboard were modestly associated with decreased risk of N/S discomfort and N/S disorders. Not all associations were statistically significant. Risks of H/A symptoms and disorders were reduced with greater horizontal distance between the operator and the keyboard and "J" key heights of 3.5 cm or less above the desk surface. Radial deviation of the wrist while using a mouse increased the risk of H/A disorders. In combination with the results from the cross-sectional studies, these observations suggest that supporting the arms on either the desk or chair armrests is associated with reduced risk of N/S symptoms and disorders.

Prevention of MSDs among computer users

In summary, over 20 studies have examined associations between occupational computer use and musculoskeletal disorders. Only a few have examined posture as a contributor to risk among computer users and their results are heterogeneous. Despite the inconsistency in results, recommendations for reduction of MSDs risk among computer users are frequently based on recommended postural changes. We are aware of no controlled clinical trials of postural interventions among computer users. The current study was designed to test the effects of two postural interventions for reduction of MSD risk among computer users. One posture was selected on the basis of results obtained in a prospective epidemiological investigation [Marcus et al., 2002] and the other was selected because of its common inclusion in recommendations by government and other agencies [OSHA, 1997].

MATERIALS AND METHODS

The Materials and Methods section is organized into four major sections, 1) overview of study design, 2) study participant eligibility and recruitment procedures, 3) data collection instruments and procedures, and 4) analyses.

OVERVIEW OF STUDY DESIGN

This was an intervention study of musculoskeletal symptoms among newly hired persons working with personal computers or computer terminals in office settings. Participants were recruited from among several large employers in the metropolitan Atlanta area. The Emory University Human Investigations Committee approved the study protocol and written informed consent was obtained from all participants at the time of enrollment.

Immediately after informed consent was obtained, potential study participants completed a brief symptoms questionnaire designed to gather information about the location and intensity of musculoskeletal symptoms experienced during the week prior to study enrollment. Subjects who reported discomfort intensity of 6 or greater on a 0-10 visual analog scale or who reported musculoskeletal symptoms requiring use of analgesic medication were excluded from the study. Participants also were asked to complete a questionnaire that solicited information about demographic characteristics and personal health history. Also at enrollment, study participants were given a questionnaire that collected information about occupational psychosocial stress.

Study participants were randomly assigned to one of three postural intervention groups, the Emory/GT intervention (Group A), the "conventional" intervention (Group B), and the "no intervention" group (Group C). A trained study staff member conducted an ergonomic assessment of the individual's workstation configuration. This evaluation included: 1) an assessment of physical workstation characteristics using a checklist, 2) linear measurement of workstation dimensions using a tape measure, and 3) measurement of postural angles using manual goniometers. If necessary, the workstation was, to the extent possible, reconfigured to facilitate the assumption and maintenance of the assigned posture for groups A and B. Individuals assigned to groups A and B received instructions as to the posture that they should maintain. Compliance with the posture assigned at enrollment was evaluated by performing two rechecks, at three days and one week after the intervention. Participants in the Group C, the control group, were instructed to continue in their usual keying posture.

At the time of enrollment, study participants were given the first pre-printed "diary" and asked to record daily the number of hours worked in the office, the number of hours spent keying, and other exposure information. This instrument also was used to collect information about symptoms, but on a weekly basis. The diary was collected weekly and reviewed by study personnel.

The two primary health outcomes of interest were symptoms in the hand or arm and symptoms in the neck or shoulder. For each outcome, 'symptoms' were defined as either reporting pain at a level of six or higher on a visual analog scale of 1 to 10 (10 coded as 'unbearable') or reporting pain in the anatomic area of interest (e.g., the neck-shoulder region or the hand-arm region) for which the participant took medication. Study participants were followed for each outcome

separately until symptoms occurred, the participant withdrew from the study, or the participant completed six months in the study.

Development of a symptom in one anatomic area was not considered a basis for ceasing data collection concerning the other anatomic area. Study participants were followed for a maximum of six months. The data collected allowed for: 1) calculation of the incidence rate of musculoskeletal symptoms for each group of computer users, and 2) analyses of associations between group membership and time to the development of upper extremity musculoskeletal symptoms.

STUDY PARTICIPANT ELIGIBILITY AND RECRUITMENT PROCEDURES

Participants were recruited from among several large employers in the metropolitan Atlanta area. Participating organizations included insurance and financial companies, food product producers, and universities. At each of the participating organizations, a newly hired worker eligible for participation in the study was one who 1) anticipated using a single computer keyboard for 15 hours or more per week and 2) anticipated using a computer keyboard for at least as many hours per week as in his/her previous job. No other criteria were used to determine eligibility for participation (i.e., no criteria were applied to age or any other demographic characteristic to determine eligibility of potential study participants). Those who had upper extremity musculoskeletal symptoms in a given anatomic location at the time of entry were excluded from follow-up to development of symptoms of that anatomic location.

Several of the participating organizations provided Emory investigators with a list of all newly hired employees on a weekly basis. A study staff member contacted each new employee by phone to discuss possible involvement in the study and to determine eligibility. For those participating organizations not providing a list of newly hired employees, a flyer describing the study with contact information was included in employee orientation packets ("Invite Form", Appendix 1) and study staff arranged to participate in new employee orientation sessions to present information about the study and recruit study participants.

DATA COLLECTION INSTRUMENTS AND PROCEDURES

Demographic and personal health history questionnaire

At the time of enrollment, study participants were asked to complete a questionnaire designed to obtain information about past occurrences of musculoskeletal symptoms and disorders, past or current illness potentially associated with musculoskeletal or neurological impairment (e.g., arthritis, diabetes, thyroid illness), medication use, menopausal status (for female participants only), tobacco use, and past computer use. A copy of the questionnaire used to obtain this information ("Personal Health Questionnaire") is included as Appendix 2.

Weekly exposure and symptoms diary

At the time of enrollment, participants were instructed on the use of a data collection instrument designed to obtain information about their workload, symptoms of pain or discomfort, job stress, and non-occupational activities. Information was to be recorded daily about hours worked in the office, hours spent keying, and number of short (10 minutes or less) and long (greater than 10 minutes) breaks from the workstation. On the same instrument, participants recorded information weekly about discomfort or pain in the upper limbs, neck, and shoulder. A study

participant who experienced discomfort also was instructed to indicate the intensity of the discomfort on a 0-10 point visual analog scale, to indicate whether he/she took medication (e.g., Tylenol, Motrin, etc.) for the discomfort, and to provide an answer to the question "What do you think caused the pain?" At the end of the week, study participants were asked to respond to the question "How stressful has your job been?" by checking one of four responses ranging from "Very stressful" to "Not stressful at all". Questions designed to quantify time spent in aerobic activities as well as hand-intensive activities also were included on the weekly exposure and symptom diary. Study participants were asked to enter information on the diary every day that they were enrolled in the study. A copy of the weekly exposure and symptom diary ("Weekly Checklist") is included as Appendix 3.

Occupational Psychosocial Questionnaire

A range of occupational psychosocial information was collected using questions from the Karasek occupational psychosocial questionnaire. The questionnaire was distributed to study subjects at the time of assignment to an intervention group. Domains examined with this instrument include coworker, supervisor and family support, variance, variety, job satisfaction, future job security, cognitive load, work load, and work pressure. A copy of the occupational psychosocial questionnaire ("Psychosocial ") is included as Appendix 4.

Ergonomic assessment procedures

Using a standard checklist, each workstation was examined for physical characteristics such as presence of specific items (e.g., document holder, mouse or other pointing device), and the adjustability of specific equipment. For the purposes of this assessment, an easily adjustable chair was one equipped with a hand operated pneumatic/hydraulic height adjusting mechanism that could be operated from the seated position. Following completion of the checklist, linear measurements (e.g., seated elbow height, table surface height) were recorded. Two additional variables were calculated using the measured data: the height of the "J" key from the floor (= floor to keyboard table surface + keyboard table surface to surface of "J" key) and the height of the vertical midpoint of the monitor screen from the floor (= floor to table surface + table surface to vertical midpoint of monitor screen). A list of all measures obtained and workstation characteristics assessed is included are provided in Tables 1 and 2.

Intervention Procedures

Following evaluation of workplace and ergonomic variables, a study staff person used a table of random numbers to randomly assign the participant to a study group. The use of a random number table assured that each subject entering the study had an equal probability of being assigned to each the three groups [Fleiss, 1981]. Randomization was done in groups of three to assure equal numbers of subjects in each of the study groups.

The Emory/GT intervention was based upon control of risk factors for both neck/shoulder and hand/arm symptoms identified in the prospective study of musculoskeletal disorders. It features a low keyboard set back from work-surface edge, considerable shoulder flexion, placement of the monitor to produce a head tilt angle less than or equal to 3° (usually requires placement of monitor below eye height), minimal head rotation, and a high quality chair (see "high quality chair description", below). The specific requirements of the Emory/GT intervention are:

- Shoulder flexion greater than or equal to 36°

- Head tilt angle* less than or equal to 3°
- Head rotation less than 10° in either direction (L/R)
- Keyboard at least 1 cm below elbow height
- J key at least 12.5 cm from edge of desk or work-surface
- Armrest present
- High quality chair present**

The "conventional" intervention was based on recommendations from a number of sources, including OSHA, NIOSH, and private industry. It is the most common set of recommendations provided to computer users and features a keyboard located at about elbow height and set back from work-surface edge to accommodate a wrist rest, minimal shoulder flexion, placement of the top edge of the monitor at or near eye height to produce a head tilt angle between 10°-19°, minimal head rotation, and a high quality chair (see "high quality chair description", below). The specific requirements of the conventional intervention are:

- Shoulder flexion less than or equal to 14°
- Head tilt angle* between 10°-19°
- Head rotation less than 10° in either direction (L/R)
- Keyboard no less than 1 cm below elbow height and no greater than 4 cm above elbow height (in an effort to maintain 90 degree elbow angle and forearm parallel to floor)
- J key at least 12.5 cm from edge of desk or work surface
- Armrest present
- High quality chair present**

*Head tilt angle is defined as the angle formed between a line defined by the tragion of the ear and the infraorbitale of the eye and the horizon. To clarify the meaning of head tilt angle values, increasing neck extension results in larger values for head tilt angle and increasing neck flexion results in smaller values, including negative values.

** Characteristics of high quality chair: Easily (pneumatically) adjustable for height, adjustable height backrest, full contoured backrest, adjustable seat pan angle, round waterfall seatpan edge, five legged base. [Carter and Banister, 1994]

The "no intervention" group was one in which no changes in workstation dimensions nor in worker postures were recommended. The postures of subjects in this group were expected to be the same as the postures observed among the subjects followed in the NIOSH funded prospective study previously conducted by the investigators [Gerr et al., 2002].

Under the direction of Dan Ortiz, a study staff member reconfigured the subject's workstation if the subject was randomly assigned to the Emory/GT or conventional interventions. First, if the "J" key is located less than 12.5 cm from the edge of the desk, the keyboard was moved so that the "J" key was 12.5 cm from the edge of the desk. Masking tape was applied to the worksurface to give a visual reference for the subject should the keyboard be moved out of the intervention position. Following placement of the keyboard, the participant's chair was replaced if it did not conform to the characteristics of a high quality chair (described above). The chair height then was set to achieve both the correct shoulder flexion angle and the correct difference

between elbow height and "J" key height. The armrests of the chair were adjusted to support the arms in the proper position. Once the chair and upper extremity were properly configured, the monitor will be moved to produce minimal head rotation, and the required head tilt angle. If necessary, monitors were placed on risers to increase the head tilt angle or removed from the top of PC CPUs to produce a decrease in head tilt angle. If these steps did not produce the required posture, other steps (i.e., raising or lowering desks, etc.) were taken to allow all intervention postures to be achieved.

In placing the participant in the desired posture, a six-inch goniometer (North Coast Medical, Inc., San Jose, CA) was used to measure wrist angles and a modified twelve-inch goniometer (North Coast Medical, Inc., San Jose, CA) was used to measure shoulder, elbow, and head and neck angles. The modified goniometer had two carpenter's levels attached to one of the arms, one in a perpendicular orientation and one in a parallel orientation, so that measurements could be made relative to true vertical and horizontal. All postural angles were recorded to the nearest degree. Goniometer pivot and arm placements for each of the postural measurements are described previously [Ortiz et al., 1997, Gerr et al., 2002]. The locations of pivot and arm placements were based on those published in occupational ergonomic [Maeda et al., 1982; Sauter et al., 1991] and physical rehabilitation literature [Lastayo et al., 1994]. The postural measurement methods used were tested by the investigators prior to use in this study and found to have minimal inter-rater variability and good reliability regardless of time-of-day or day-of-week in a test-retest validation study [Ortiz et al., 1997].

Verbal instructions concerning the posture were given and written instructions describing the desired posture were provided to all group A and B subjects. Furthermore, study staff discussed with each participant in these two groups the goal of maintaining the desired posture for the study period (six months), and answered any questions the subject had.

At three days and one week after the intervention, study staff returned to the participant's workplace to check on compliance. As described above, goniometers were used to measure shoulder, elbow, and head and neck angles and a tape measure to measure distance of the 'j' key from the table edge, keyboard height, and elbow height.

Health outcomes assessment

The occurrence of musculoskeletal symptoms was assessed at entry into study with questions on the Demographic and Personal Health History Questionnaire and weekly thereafter during the follow-up period with questions on the weekly exposure and symptoms diary ("Weekly Checklist"). Study participants were asked if they experienced "any discomfort such as pain, aching, burning, numbness or tingling in your neck, shoulders, elbows/forearms, hands/wrists, or fingers." Those who experienced discomfort were asked to indicate the location of the discomfort (neck or shoulders vs. arm or hand) and to rate the severity of the worst discomfort during the previous week on a visual analog scale ranging from 0-10. Separate visual analog scales were used to rate discomfort of the neck or shoulder region and the forearm or hand regions. In addition, the question "Did you take any medication for this discomfort this past week?" was asked separately for the neck or shoulder area and the hand or arm area. Study participants were classified as having experienced musculoskeletal symptoms if they 1) reported musculoskeletal discomfort on any day of the week with a severity of 6 or greater on the visual

analog scale or 2) reported musculoskeletal discomfort on any day of the week which they controlled with medication (over-the-counter or prescription). The occurrence of symptoms was determined separately for the neck/shoulder region and the hand/arm region.

ANALYSIS METHODS

All analyses were undertaken using the statistical package SAS (SAS Institute, Carey, NC). The incidence rates of neck or shoulder symptoms and of arm or hand symptoms were calculated for each of the three intervention arms of the study. The incidence rates are calculated as the number of workers developing symptoms by the total person-time of observation. The incidence rates for neck and shoulder symptoms and for hand or arm symptoms were calculated separately. Analyses were carried out by *intention to treat*. This means that participants randomized to a particular intervention group contribute to that group's incidence rate regardless of whether they remained in the intervention posture. This practice results in a conservative estimate of the effect of the intervention and was used in calculating the sample size necessary to detect a protective effect of the intervention.

Instantaneous risks and relative risks for each of the two interventions compared to the non-intervention group were calculated using survival analysis methodology [Cox and Oakes, 1984; Kalbfleisch and Prentice, 1980]. Survival time was taken as the time to outcome. Those workers who left the study without manifesting the outcome were considered censored at the time they left the study and contributed person-time until they were censored. The three survival curves generated by the product limit method (Kaplan-Meier) were compared using the log rank test (Kleinbaum, 1996). In addition, relative risk were assessed using multivariate Cox's proportional hazards model with time to development of symptoms as the dependent variable and intervention group as the independent variable using the procedure PHREG (SAS Institute).

Confounding variables. Since this was a randomized study we expected each of the three treatment arms to be similar with respect to potentially confounding variables. However, we examined the data to determine if this assumption is correct. The distribution of categorical data across groups was evaluated using a chi-square test, and the distribution of continuous data across groups was evaluated using ANOVA. For example, we determined if each group contained approximately equal numbers of men and women of the same ages. If, by chance, the treatment groups differed in their composition the results were adjusted for these differences.

RESULTS

The flow of study participants is depicted in Figures 1 and 2. A total of 1240 individuals were contacted to determine eligibility for the study. Of these, there was an initial exclusion of 793 individuals. The majority of these individuals were excluded because they either worked too few hours (n=239) or they used multiple computers at work (n=147). The 447 potential participants still remaining were given a screening questionnaire designed to ascertain health related variables including musculoskeletal symptoms during the previous week. Those who had upper extremity musculoskeletal symptoms in a given anatomic location at the time of entry were excluded from follow-up to development of symptoms of that anatomic location. Two separate, overlapping cohorts were defined in order to examine the separate risks for neck and shoulder symptoms and the risks for arm and hand symptoms. Sixty eight individuals were ineligible for inclusion in the study because of symptoms in both anatomic locations. In addition, 3 individuals were excluded from the arm/hand cohort because they reported arm/hand musculoskeletal symptoms during the past week and 23 individuals were excluded from the neck/shoulder cohort because they reported neck/shoulder musculoskeletal symptoms during the past week. A total of 379 individuals were randomized into one of three intervention groups: the Emory/GT intervention (group A), the OSHA/conventional intervention (group B), and a group with no intervention (group C). For those at risk for incident arm/hand symptoms (n=376), 127 were randomized into group A, 130 into group B, and 119 into group C. After randomization, 7 in group A dropped out of the study, 6 in group B, and 4 in group C. As a result, 120 individuals in A were followed prospectively, 124 in B, and 115 in C. For those at risk for incident neck/shoulder symptoms (n= 356), 121 were randomized into group A, 122 into group B, and 113 into group C. After randomization, 7 in group A dropped out of the study, 6 in group B, and 4 in group C. As a result, 114 individuals in A were followed prospectively for neck/shoulder symptoms, 116 in B, and 109 in C.

An analysis of the demographic data revealed that randomization was relatively successful in creating intervention groups with statistically similar compositions for demographic characteristics (Table 3), current and past medical conditions (Table 4), and occupational characteristics (Table 5). The only exceptions were measures of education, chair comfort, and stress. Those in group A and group C were significantly more likely to be college graduates than group B. Those in groups A and B were significantly more likely to judge their chairs as being comfortable than group C. However, this is not unexpected, as chair comfort was assessed after the intervention, at which time participants in group A and B would have had their chairs approved as acceptable or replaced with improved ones. On the first weekly diary, members of group A reported significantly lower stress values than members of group B or C. There were also differences among groups that were not statistically significant, but are nevertheless noteworthy. Specifically, those in group C were more likely to have had a history of hand/arm and neck/shoulder symptoms and were more likely to be of white race. Also, males in group C tended to have lower BMI and males in group A tended to be taller. There were no significant differences between groups with regards to typing speed, job title, the ability to take breaks, or average time spent on the computer per week.

The reliability of the scales for the psychosocial stress variables were assessed by obtaining coefficient alphas (Table 6). All of the scales except for one had a coefficient alpha value greater than 0.70, indicating reasonable reliability. The exception was a measurement of one's

control over equipment, which had a coefficient alpha of 0.45. Excluding one of the components of the scale did not result in a higher alpha. Therefore, in the analyses, control over equipment, was not included as a scale. Instead the individual items were considered as measures of psychosocial stress.

Compliance with the postural interventions was assessed at the time of the intervention, and during two follow-up visits (Tables 7 and 8). Full compliance (i.e., all compliance variables within the established compliance range) with all of the intervention postures was attained for only 25% of individuals in group A and for only 38% of individuals in group B. The primary reason for non-compliance in group A was that the proper elbow difference was impossible to achieve with the participant's workstation. Frequently, the chair had to be raised because the keyboard could not be lowered.

In the arm and hand cohort, 22 (18.3%) group A participants, 25 (20.2%) group B participants, and 25 (21.7%) group C participants developed symptoms (Figure 1). Among those who did not develop symptoms, they stopped contributing person-time to the analysis when they were either lost to follow-up (n=158), completed their time in the study (n=116), or exited the study for another reason (n=13).

In the neck and shoulder cohort, 38 (33.3 %) group A participants, 36 (31.9%) group B participants and 33 (30.3%) group C participants developed symptoms (Figure 2). For those who were censored in the analysis, 125 were lost to follow-up, 97 completed their time in the study, and 12 were censored for other reasons.

The Kaplan-Meier survival curves for the arm/hand cohort indicated that there were no significant differences in survival among the three groups (Figure 3). When limiting the analysis to only those who were judged to be compliant with respect to all of the postural specifications, there was no statistically significant difference in survival between the groups. This was also observed when limiting the analysis to only those judged to be compliant during the first recheck or the second recheck.

The Kaplan-Meier survival curves for the neck/shoulder indicated that there were no significant differences in survival among the three groups for (Figure 4). When limiting the analysis to only those who were judged to be compliant with respect to all of the postural specifications, there was no statistically significant difference in survival between the groups. This was also observed when limiting the analysis to only those judged to be compliant during the first recheck or the second recheck.

Multivariate analyses controlling for gender, age, height, BMI, race, education, handedness, job title and a history of musculoskeletal symptoms, revealed no significant differences in survival between group A or group B compared to group C for either hand/arm (Table 9) or neck/shoulder (Table 10) symptoms.

DISCUSSION

In this randomized clinical controlled trial, no significant differences in survival were observed among the three interventions nor were any trends suggestive of an effect observed. This result was not expected, as a recently completed prospective study of a sample obtained from the same population of computer users suggested moderate effects of posture on symptoms among computer users. While it is possible that the intervention postures have no effect on the rate of musculoskeletal symptoms among computer users, it is also possible that other factors resulted in the failure to observe an effect.

One possible source of bias in the observed results is confounding. For several reasons, we do not believe that the absence of an association is the result of confounding. First, the likelihood of substantial differences in important covariates across intervention groups (necessary for confounding) was minimized by randomly allocating study participants to each of the three intervention groups. Inspection of the results shows that most important covariates were, in fact, distributed similarly across intervention groups, eliminating the possibility of confounding by them. Second, we performed multivariate analyses of associations between survival and intervention group while controlling for gender, age, height, BMI, race, education, handedness, job title and a history of musculoskeletal symptoms. These analyses revealed no significant associations between intervention group and survival for either hand/arm or neck/shoulder symptoms.

Another possible reason for the absence of effects was our inability to fully implement the intervention among the study participants. Fewer than one third of Group A participants were able to meet all of the required compliance variables and fewer than one half of Group B participants were able to comply with all of the required compliance variables. It is possible that greater effects would have been observed had the investigators been more fully able to implement the intervention postures among the study participants. Non-compliance with the intervention postures most likely does not fully account for the absence of findings, however. While complete compliance was uncommon, nearly 70% of both intervention groups were able to comply with ten of eleven compliance categories. Thus, participants were able to achieve a high degree of compliance, if not full compliance. We also performed an analysis restricted to the individuals who achieved full compliance. Again, we observed no meaningful differences between the groups although numbers were small.

Another possible reason for the absence of an observed result was poor ascertainment of health outcome. We consider this unlikely. The method of ascertaining health outcome was similar to that used in previous investigations (Gerr et al., 2002; Marcus et al., 2002) in which associations were observed between postures, demographic characteristics, work organization factors, and symptom outcomes. Indeed, in the current study, two factors that have been observed in the past investigations to associate with symptoms, i.e., female gender and past history of symptoms, have consistently strong associations with the symptom outcomes used in the current study.

Some prior studies of associations between work activities and musculoskeletal outcomes have been criticized for using symptoms alone (as opposed to symptoms and physical examination findings) as the health outcome, as was done in the current study. In a previous study, however, we observed that risk factors for musculoskeletal symptoms and risk factors for musculoskeletal

disorders among a sample obtained from the same study population were sufficiently similar to allow use of symptoms alone as the outcome measure. We believe that had physical examination findings been used to identify health events (in addition to symptoms) the results would not have been meaningfully different.

In summary, the results of this study suggest that ergonomists should exercise caution when making recommendations regarding posture as the sole means of minimizing risk of musculoskeletal symptoms among computer users. Such caution appears warranted as recommendations for postural modification seems to be the mainstay of many ergonomics programs intended for use by computer users. Effects of postural interventions may be more readily observed in future studies if workstations are more readily adjustable to allow for more complete compliance with postural interventions.

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Table 1. Criteria for intervention compliance – Group A

Variable	Criteria for compliance
Chair	Easily (pneumatically) adjustable for height, adjustable height backrest, full contoured backrest, adjustable seat pan angle, round waterfall seatpan edge, five legged base present (if not present, participant was provided with one)
Shoulder rest	No shoulder rest present
Keyboard wrist rest	Keyboard wrist rest present (if not present, participant was provided with a wrist rest)
Edge J	Edge of table to the edge of the "J" key >12.5 cm
Keyboard wrist ulnar deviation	0° to -20°
Keyboard inner elbow angle	>= 120°
Mouse wrist ulnar deviation	-5° to 5°
Mouse wrist extension	20° to 30°
Monitor head tilt angle	< 4°
Monitor head rotation angle	<= 15°
Elbow difference	Elbow height >=2 cm higher than "J" key height
Overall compliance	Participant is compliant for every category

Table 2. Criteria for intervention compliance – Group B

Variable	Criteria for compliance
Chair features	Easily (pneumatically) adjustable for height, adjustable height backrest, full contoured backrest, adjustable seat pan angle, round waterfall seatpan edge, five legged base present (if not present, participant was provided with one)
Keyboard wrist rest	Keyboard wrist rest present (if not present, participant was provided with a wrist rest)
Eye level	Eye level with top of monitor screen
Keyboard wrist ulnar deviation	-10° to 10°
Keyboard inner elbow angle	80° to 100°
Keyboard wrist extension	-10° to 10°
Keyboard shoulder flexion	-10° to 20°
Keyboard shoulder abduction	-10° to 20°
Mouse wrist ulnar deviation	-10° to 10°
Mouse wrist extension	-10° to 10°
Monitor head rotation angle	<15°
Elbow difference	Elbow height is >=3 cm lower than "J" key height
Overall compliance	Participant is compliant for every category

TABLE 3 Demographics by intervention group

	Intervention Group			
	A (N=122)	B (N=125)	C (N=119)	
	N %	N %	N %	p-value
Age				
18-24	19 (15.6)	24 (19.2)	25 (21.7)	0.98
25-34	59 (48.4)	56 (44.8)	52 (45.2)	
35-44	29 (23.8)	30 (24.0)	26 (22.6)	
45-54	13 (10.7)	12 (9.6)	10 (8.7)	
55+	2 1.6)	3 (2.4)	2 (1.7)	
Gender				
Male	30 (24.6)	28 (22.4)	25 (21.7)	0.86
Female	92 (75.4)	97 (77.6)	90 (78.3)	
Ethnicity				
White,not of hispanic origin	68 (56.6)	68 (55.7)	74 (66.1)	0.21
Other	52 (43.3)	54 (44.3)	38 (33.9)	
Missing	2	3	3	
Education - college graduate				
Yes	93 (77.5)	79 (64.8)	86 (76.8)	0.04
No	27 (22.5)	43 (35.3)	26 (23.2)	
Missing	2	3	3	
Current smoker				
No	107 (89.2)	112 (91.8)	105 (93.8)	0.45
Yes	13 (10.8)	10 (8.2)	7 (6.3)	
Missing	2	3	3	
Hand dominance				
Left handed	9 (7.5)	13 10.7)	9 (8.0)	0.65
Right handed	111 (92.5)	109 (89.3)	103 (92.0)	
Missing	2	3	3	
Income				
Less than $35,000	36 (30.8)	49 (40.5)	39 (35.8)	0.61
$35,000-$74,999	53 (45.3)	48 (39.7)	44 (40.4)	
$75,000 and over	28 (23.9)	24 (19.8)	26 (23.9)	
Missing	5	4	6	
BMI- males				
<25	14 (46.7)	14 (50.0)	16 (64.0)	0.14 (FE)
25-29.9	9 (30.0)	13 (46.4)	7 (28.0)	
30+	7 (23.3)	1 (3.6)	2 (8.0)	
BMI- females				
<25	54 (58.7)	58 (59.8)	59 (65.6)	0.33
25-29.9	28 (30.4)	22 (22.7)	23 (25.6)	
30+	10 (10.9)	17 (17.5)	8 (8.9)	

FE: Fisher's Exact Test

Table 4 Current and past medical conditions by intervention group

	Intervention Group						
	A (N=122)		B (N=125)		C (N=119)		
	N	%	N	%	N	%	p-value
History hand/arm disorder past 3 yrs (medication and/or intensity>=6)							
No	99	(82.5)	101	(82.8)	87	(77.7)	0.54
Yes	21	(17.5)	21	(17.2)	25	(22.3)	
Missing	2		3		3		
History neck/shoulder disorder past 3 yrs (medication and/or intensity>=6)							
No	79	(65.8)	81	(66.4)	65	(58.0)	0.34
Yes	41	(34.2)	41	(33.6)	47	(42.0)	
Missing	2		3		3		
Insulin use							
No	118	(98.3)	121	(99.1)	110	(98.2)	0.75 (FE)
Yes	2	(1.7)	1	(0.8)	2	(1.8)	
Missing	2		3		3		
Thyroid disease							
No	120	(100.0)	118	(96.7)	109	(97.3)	0.15 (FE)
Yes	0	(0.0)	4	(3.3)	3	(2.7)	
Missing	2		3		3		
Oral contraceptives use (among females only)							
No	62	(68.1)	68	(72.3)	62	(70.5)	0.80
Yes	29	(31.9)	26	(27.7)	26	(29.6)	
Missing	1		3		2		
Estrogen (among females only)							
No	88	(96.7)	88	(93.6)	83	(94.3)	0.62 (FE)
Yes	3	(3.3)	6	(6.4)	5	(5.7)	
Missing	1		3		2		
Pain medication							
No	101	(84.2)	99	(81.2)	93	(83.0)	0.82
Yes	19	(15.8)	23	(18.9)	19	(17.0)	
Missing	2		3		3		
Other medication							
No	100	(83.3)	101	(82.8)	96	(85.7)	0.81
Yes	20	(16.7)	21	(17.2)	16	(14.3)	
Missing	2		3		3		
Arthritis or Rheumatism							
Yes	3	(2.5)	3	(2.5)	6	(5.4)	0.41 (FE)
No	117	(97.5)	119	(97.6)	106	(94.6)	
Missing	2		3		3		
Slipped or ruptured Discs							
Yes	0	(0.0)	1	(0.8)	0	(0.0)	1.00 (FE)
No	120	(100.0)	121	(99.2)	112	100.0)	
Missing	2		3		3		
Neck/Shoulder Symptomatic: Screener							
no	114	(93.4)	116	(92.8)	109	(94.8)	0.82
Yes	8	(6.6)	9	(7.2)	6	(5.2)	
Hand/Arm Symptomatic: Screener							
no	120	(98.4)	124	(99.2)	115	(100.0)	0.66 (FE)
Yes	2	(1.6)	1	(0.8)	0	(0.0)	
Symptomatic Body Part: Screener							
N/S Only	8	(6.6)	9	(7.2)	6	(5.2)	0.78 (FE)
H/A Only	2	(1.6)	1	(0.8)	0	(0.0)	
Neither	112	(91.8)	115	(92.0)	109	(94.8)	

FE: Fisher's Exact Test

Table 5 Occupational characteristics by intervention group

	Intervention Group						
	A (N=122)		B (N=125)		C (N=119)		
	N	%	N	%	N	%	p-value
Typing Speed							
Less than 50 wpm	45	(38.5)	36	(30.5)	42	(41.2)	0.34
50-60 wpm	55	(47.0)	67	(56.8)	44	(43.1)	
More than 65 wpm	17	(14.5)	15	(12.7)	16	(15.7)	
Missing	5		5		13		
Official Job Title							
Officials and Managers	6	(5.1)	9	(7.6)	9	(8.8)	0.84 (FE)
Professionals	66	(56.4)	54	(45.8)	54	(52.9)	
Technicians	2	(1.7)	3	(2.5)	2	(2.0)	
Sales	1	(0.9)	1	(0.9)	1	(1.0)	
Office and Clerical	42	(35.9)	51	(43.2)	36	(35.3)	
Missing	5		7		13		
Use a Mouse							
Sometimes	5	(4.3)	5	(4.2)	3	(2.9)	0.94 (FE)
Frequently	47	(40.2)	50	(42.4)	39	(38.2)	
Almost all the time	65	(55.6)	63	(53.4)	60	(58.8)	
Missing	5		7		13		
Stepaway from Station							
When you choose	114	(97.4)	117	(99.2)	99	(97.1)	0.52 (FE)
Scheduled times	3	(2.6)	1	(0.9)	3	(2.9)	
Missing	5		7		13		
Chair Comfort							
Very comfortable	56	(47.9)	52	(44.1)	24	(23.5)	0.00 (FE)
Somewhat comfortable	54	(46.2)	59	(50.0)	60	(58.8)	
Somewhat uncomfortable	6	(5.1)	5	(4.2)	16	(15.7)	
Somewhat uncomfortable	1	(0.9)	2	(1.7)	2	(2.0)	
Missing	5		7		13		

FE: Fisher's Exact Test

Table 5 continued: Diary characteristics by intervention group

	Intervention Group			
	A (N=122)	B (N=125)	C (N=119)	
	Mean SD	Mean SD	Mean SD	p-value
Total hrs in office (week 1)	37.17 7.40	37.83 7.83	39.06 7.69	0.16
Total hrs on the computer (week 1)	23.31 11.01	23.33 11.95	25.19 10.77	0.34
Stress (week 1)	2.88 2.04	3.53 2.45	3.47 2.29	0.05
Ln [Total minutes of physical activity (week 1)]	5.08 0.87	5.06 0.75	5.19 0.75	0.58
Ln[Total minutes of aerobic physical activity (week 1)]	4.87 0.85	4.89 0.85	4.72 0.75	0.60
Total minutes of hand intensive physical activity (week 1)	5.25 0.89	5.10 1.04	4.93 0.80	0.33

Table 6. Reliability of psychosocial scales

SCALE	Coefficient alpha	
	Raw	Standardized
Skill discretion	0.74	0.75
Decision authority	0.71	0.71
Decision latitude	0.82	0.82
Psychological job demands	0.70	0.71
Psychological job demands (alt)	0.79	0.80
Control over equipment	0.45	0.46
Supervisor support	0.81	0.82
Coworker support	0.78	0.78
Total work support	0.80	0.79

Table 7 Proportion of Group A participants who met compliance criteria by visit

	Number and percent in compliance by visit					
	Intervention		1st recheck		2nd recheck	
Compliance variable	N	(%)	N	(%)	N	(%)
Chair	122	(100.0)	119	(100.0)	113	(100.0)
Shoulder rest	121	(99.2)	118	(99.2)	112	(99.1)
Keyboard wrist rest	118	(96.7)	115	(96.6)	109	(96.5)
Edge J	102	(83.6)	104	(87.4)	101	(89.4)
Keyboard wrist ulnar deviation	118	(96.7)	106	(89.1)	102	(90.3)
Keyboard inner elbow angle	118	(96.7)	114	(95.8)	100	(88.5)
Mouse wrist ulnar deviation	119	(97.5)	109	(91.6)	108	(95.6)
Mouse wrist extension	107	(87.7)	105	(88.2)	100	(88.5)
Monitor head tilt	106	(86.9)	105	(88.2)	99	(87.6)
Monitor head rotation angle	119	(97.5)	117	(98.3)	112	(99.1)
Elbow difference	63	(51.6)	54	(45.4)	56	(49.6)
OVERALL COMPLIANCE						
Totally compliant	31	(25.4)	34	(28.6)	36	(31.9)
Not compliant in 1 category	64	(52.5)	47	(39.5)	42	(37.2)
Not compliant in 2 categories	17	(13.9)	22	(18.5)	22	(19.5)
Not compliant in 3 categories	9	(7.4)	13	(10.9)	9	(8.0)
Not compliant in 4 categories	1	(0.8)	2	(1.7)	2	(1.8)
Not compliant in >=5 categories	0	(0.0)	1	(0.8)	2	(1.8)

Table 8 Proportion of Group B participants who met compliance criteria by visit

	Number and percent in compliance by visit					
	Intervention		1st recheck		2nd recheck	
Compliance variable	N	(%)	N	(%)	N	(%)
Chair	125	(100.0)	118	(100.0)	118	(100.0)
Keyboard wrist rest	123	(98.4)	116	(98.3)	116	(98.3)
Eye level	104	(83.2)	102	(86.4)	110	(93.2)
Keyboard wrist ulnar deviation	125	(100.0)	116	(98.3)	116	(98.3)
Keyboard inner elbow angle	119	(95.2)	109	(92.4)	110	(93.2)
Keyboard wrist extension	98	(78.4)	97	(82.2)	96	(81.4)
Keyboard shoulder flexion	99	(79.2)	103	(87.3)	95	(80.5)
Keyboard shoulder abduction	118	(94.4)	108	(91.5)	110	(93.2)
Mouse wrist ulnar deviation	125	(100.0)	118	(100.0)	117	(99.2)
Mouse wrist extension	106	(84.8)	101	(85.6)	99	(83.9)
Monitor head rotation angle	122	(97.6)	116	(98.3)	116	(98.3)
Elbow difference	100	(80.0)	85	(72.0)	75	(63.6)
OVERALL COMPLIANCE						
Totally compliant	47	(37.6)	50	(42.4)	50	(42.4)
Not compliant in 1 category	41	(32.8)	29	(24.6)	31	(26.3)
Not compliant in 2 categories	24	(19.2)	25	(21.2)	18	(15.3)
Not compliant in 3 categories	7	(5.6)	8	(6.8)	10	(8.5)
Not compliant in 4 categories	4	(3.2)	6	(5.1)	6	(5.1)
Not compliant in >=5 categories	2	(1.6)	0	(0.0)	3	(2.5)

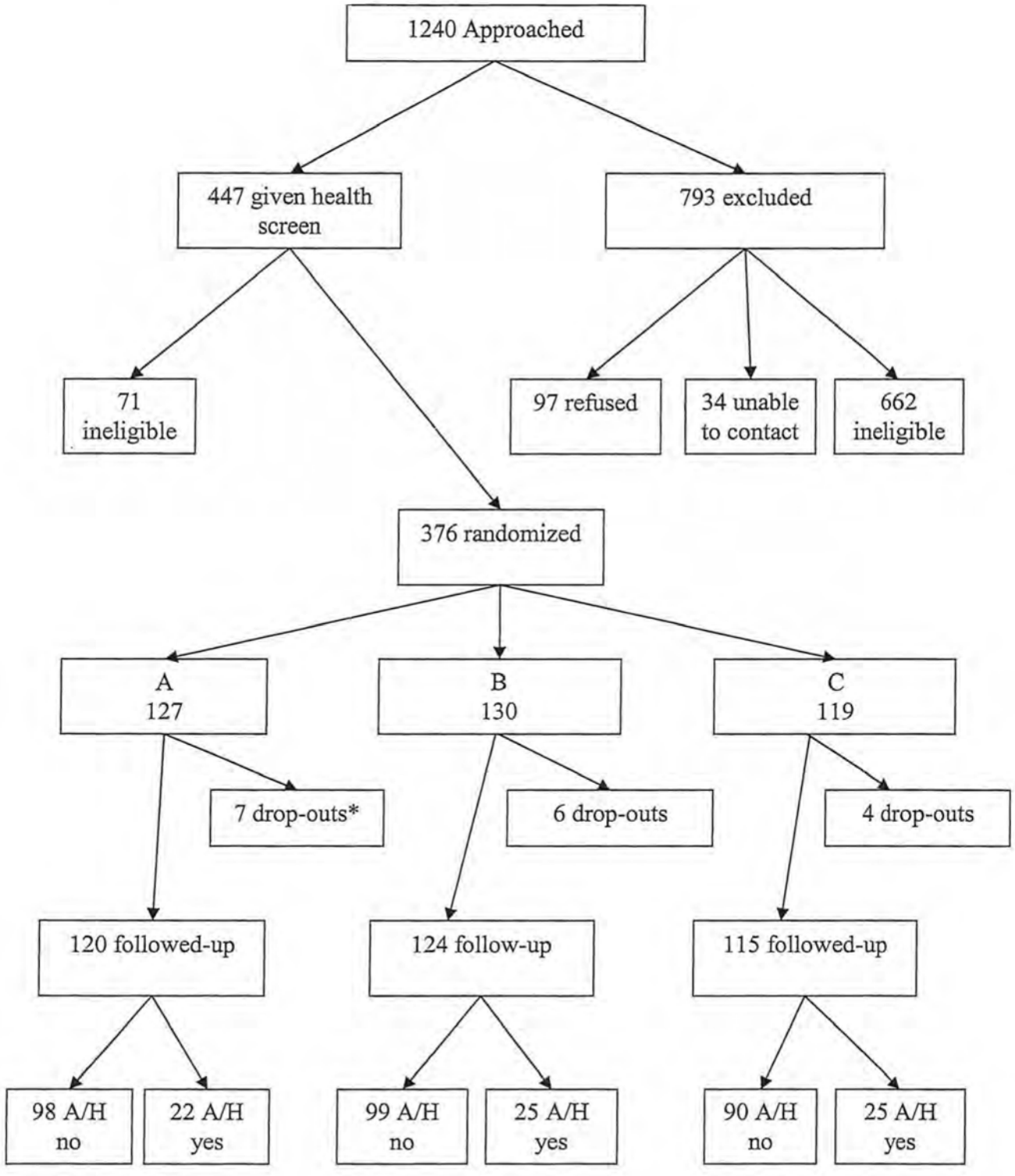
Table 9. Multivariate Survival Model for the Development of Arm or Hand symptoms

Variable	Parameter Estimate	Standard Error	p-value	Hazard Ratio	95% Confidence Interval	
Group A	-0.154	0.297	0.60	0.857	0.478	1.536
Group B	-0.097	0.288	0.73	0.907	0.515	1.597
Female gender	0.915	0.434	0.03	2.498	1.066	5.852
Age	0.001	0.014	0.90	1.002	0.974	1.031
History of symptoms	1.205	0.253	<.01	3.339	2.033	5.483
White race	0.259	0.286	0.36	1.297	0.739	2.275
College graduate	-0.247	0.321	0.44	0.781	0.416	1.465
Left handed	0.018	0.439	0.96	1.018	0.431	2.409
Low BMI	0.125	0.276	0.64	1.134	0.660	1.948
High BMI	-0.307	0.369	0.40	0.735	0.356	1.518
Professional job	0.344	0.263	0.19	1.411	0.842	2.363
Height	1.606	1.753	0.35	4.985	0.160	154.917

Table 10. Multivariate Survival Model for the Development of Neck or Shoulder Symptoms

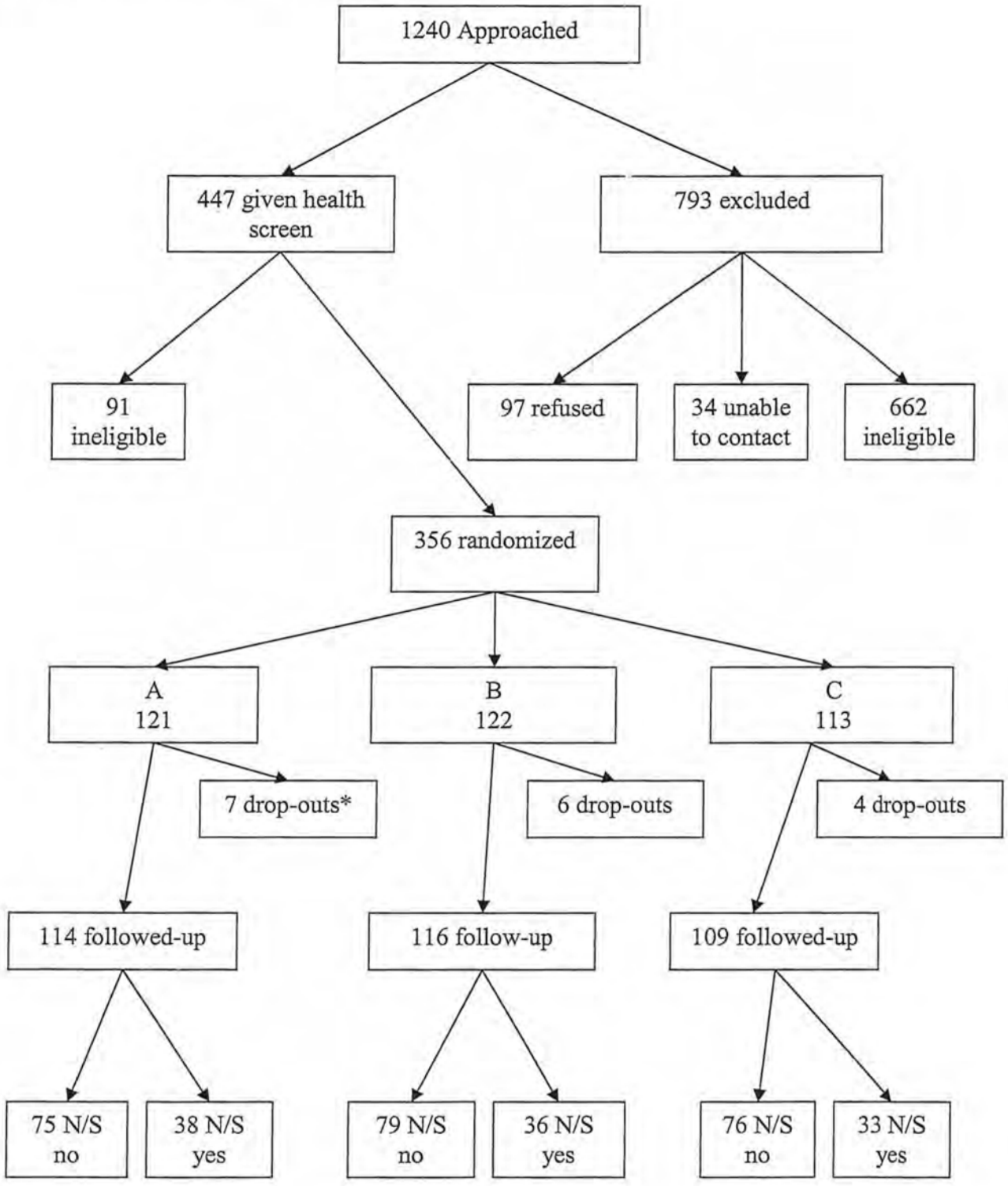
Variable	Parameter Estimate	Standard Error	p-value	Hazard Ratio	95% Confidence Interval	
Group A	0.058	0.243	0.81	1.060	0.658	1.707
Group B	-0.016	0.246	0.94	0.984	0.607	1.590
Female gender	0.502	0.344	0.14	1.653	0.841	3.247
Age	-0.015	0.012	0.21	0.984	0.961	1.009
History of symptoms	0.911	0.199	<.01	2.492	1.687	3.682
White race	-0.004	0.222	0.98	0.995	0.644	1.538
College graduate	-0.253	0.256	0.32	0.776	0.469	1.285
Left handed	-0.099	0.356	0.78	0.905	0.450	1.822
Low BMI	0.316	0.229	0.16	1.372	0.876	2.149
High BMI	-0.197	0.298	0.50	0.821	0.457	1.475
Professional job	0.226	0.215	0.29	1.254	0.822	1.913
Height	1.008	1.500	0.50	2.742	0.145	51.935

Figure 1: ARM AND HAND STUDY PARTICIPANTS



* 1 became ineligible after randomization

Figure 2: NECK AND SHOULDER STUDY PARTICIPANTS



*1 ineligible after randomization

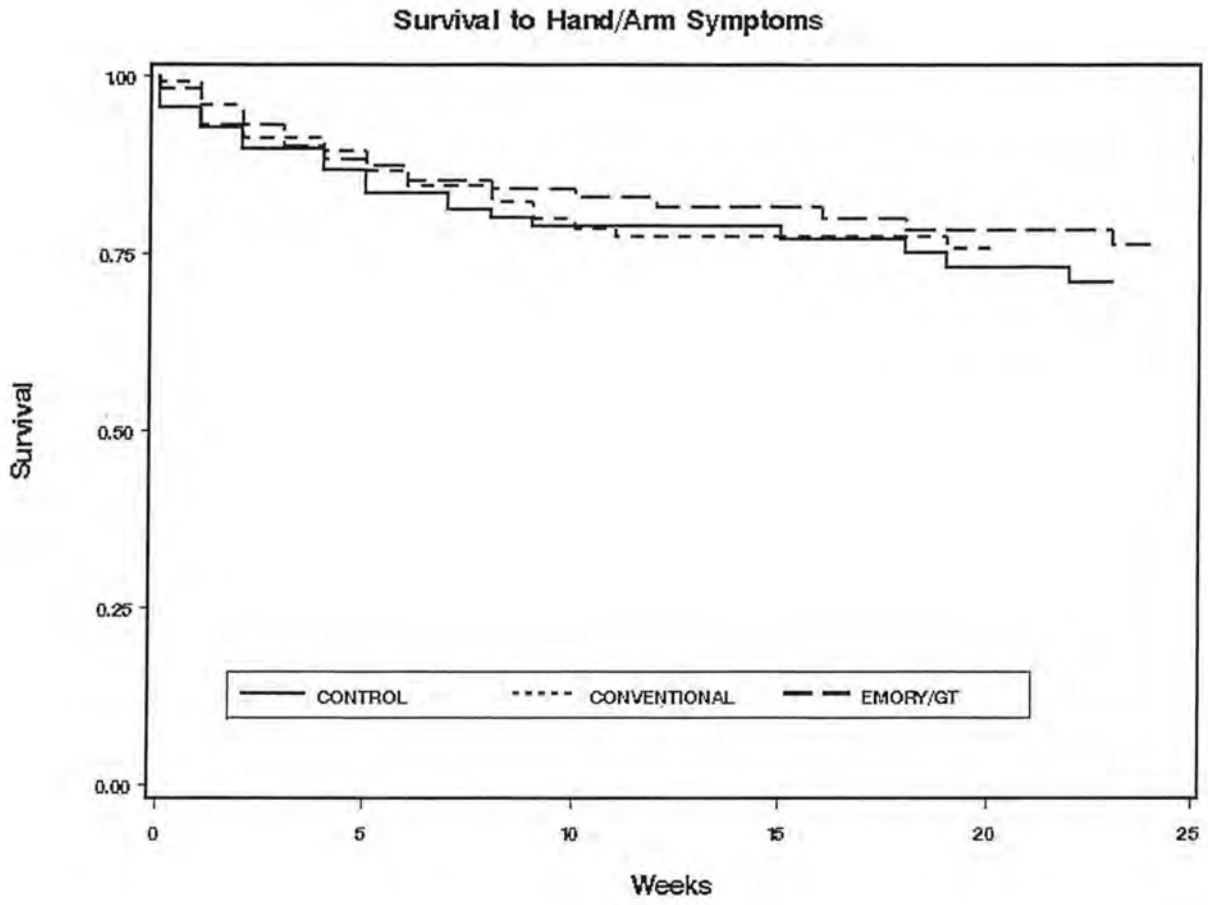

Survival to Hand/Arm Symptoms
Survival
1.00
0.75
0.50
0.25
0.00
0
5
10
15
20
25
Weeks
CONTROL
CONVENTIONAL
EMORY/GT

FIGURE 3

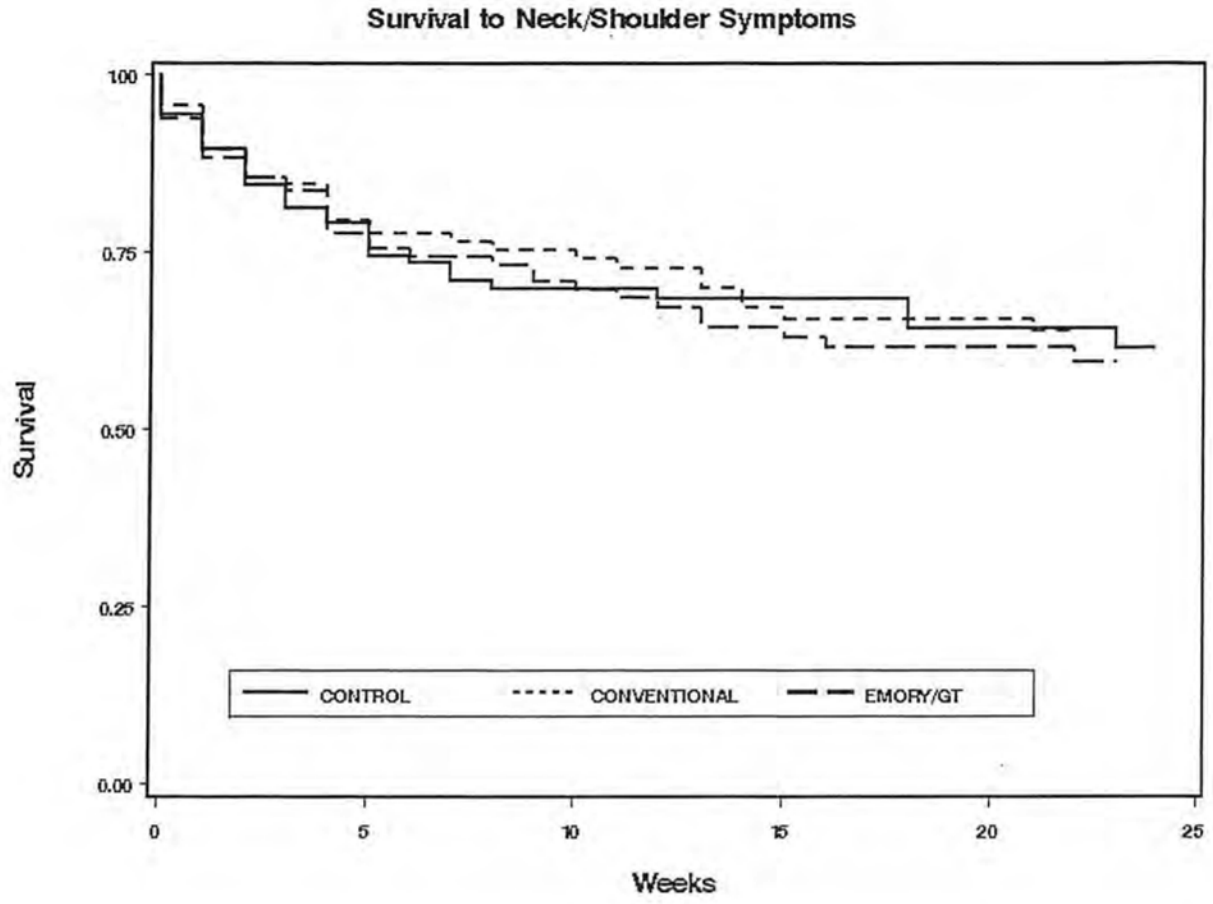

Survival to Neck/Shoulder Symptoms
Survival
1.00
0.75
0.50
0.25
0.00
0
5
10
15
20
25
Weeks
CONTROL
CONVENTIONAL
EMORY/GT

FIGURE 4

Publications

In preparation:

Gerr F, Marcus M, Monteilh C. A randomized controlled trial of an ergonomic intervention among computer users.

Inventions Statement

None.

APPENDICES

APPENDIX 1

INVITE FORM

COMPUTERS, WORK, AND HEALTH
An Emory University Study

NAME _____ DATE ☐☐/☐☐/☐☐

m m d d y y

EMPLOYER _____ ☐☐

DEPARTMENT _____

WORK ADDRESS

_____

TELEPHONE _____ FAX _____ E-mail _____

1. When does (did) your new job begin? ☐☐/☐☐/☐☐ *Continue on other side!*
2. How many hours per week do you expect to use a computer at this job? ☐☐ hrs/week
3. How many computers do you expect to use at this job? One ☐[1] More than one ☐[2]
4. If you expect to use more than one computer on this job, how many hours do you expect to use:
   Your main computer: ☐☐ hrs/week
   All other computers: ☐☐ hrs/week
5. Do you expect to use any other computer (at home, second job, etc.) for more than 20 hrs/wk?
   Yes ☐[1] No ☐[0]
6. Is your work computer a laptop? Yes ☐[1] No ☐[0]
7. Is your new job full-time ☐[1] or part-time? ☐[0]

FOR OFFICE USE ONLY: E1 Yes ☐[1] No ☐[0] R1 Yes ☐[1] No ☐[0] ID ☐☐☐☐☐

_____

_____☐☐

Appendix 2

Personal Health Questionnaire

Participant I.D. ☐☐☐☐☐

DATE: ☐☐/☐☐/0☐
m m d d y

Unless otherwise specified, for each of the following questions please place a check mark (√) in the appropriate box.

1. During the past three years (not including the past seven days) did you experience any discomfort such as pain, aching, burning, numbness, or tingling in your neck, shoulders, elbows, forearms, wrists, hands, or fingers of at least thirty minutes duration?

   ☐[1] Yes *(GO TO QUESTION 2)* ☐[0] No *(GO TO QUESTION 10)*

IF YOU EXPERIENCED <u>NECK OR SHOULDER</u> DISCOMFORT

2. Place an **X** mark on the line below that represents the **<u>worst</u>** neck or shoulder discomfort you experienced during the past three years.

No Discomfort +----+----+----+----+----+----+----+----+----+----+ **Unbearable Discomfort**
0 1 2 3 4 5 6 7 8 9 10

3. On what side of your body was this discomfort? ☐[1] Right side ☐[2] Left side ☐[3] Both sides
4. Did you take any medication for this discomfort? (aspirin, tylenol, bufferin, motrin, etc.) ☐[1] Yes ☐[0] No
5. What do you think caused the discomfort? _____ ☐☐

IF YOU EXPERIENCED <u>ELBOW, FOREARM, WRIST, HAND, OR FINGER</u> DISCOMFORT

6. Place an **X** mark on the line below that represents the **<u>worst</u>** elbow, forearm, wrist, hand, or finger discomfort you experienced during the past three years.

No Discomfort +----+----+----+----+----+----+----+----+----+----+ **Unbearable Discomfort**
0 1 2 3 4 5 6 7 8 9 10

7. On what side of your body was this discomfort? ☐[1] Right side ☐[2] Left side ☐[3] Both sides
8. Did you take any medication for this discomfort? (aspirin, tylenol, bufferin, motrin, etc.) ☐[1] Yes ☐[0] No
9. What do you think caused the discomfort? _____ ☐☐

10. Have you seen a doctor in the **past three years** for either of the following conditions?

YES	NO	HEALTH CONDITION
☐[1]	☐[0]	Arthritis or any kind of rheumatism
☐[1]	☐[0]	Slipped or ruptured disc in the neck or upper back

11. Are you taking any of the following medications regularly? (*Check all medications you are taking).*

YES	NO	MEDICATION
☐[1]	☐[0]	Insulin or other diabetes medicine
☐[1]	☐[0]	Thyroid medications
☐[1]	☐[0]	Oral contraceptives
☐[1]	☐[0]	Estrogen (female hormone) replacement therapy
☐[1]	☐[0]	Pain medication (advil, aspirin, motrin, tylenol, etc.)
☐[1]	☐[0]	Other *(specify)* _____

12. Do you currently smoke at least one cigarette, cigar, or pipeful of tobacco per day? ☐[1] Yes ☐[0] No

13. What is your date of birth? ☐☐ / ☐☐ / ☐☐
m m d d y y

14. What group best represents your ethnic background?
- ☐[1] White, not of Hispanic origin
- ☐[2] African American/Black, not of Hispanic origin
- ☐[3] Hispanic
- ☐[4] Native American
- ☐[5] Asian or Pacific Islander
- ☐[6] Other race *(Specify)* _____

15. What is the highest grade or year of school you completed?
- ☐[1] Elementary to some high school
- ☐[2] High school graduate
- ☐[3] Technical training or trade school
- ☐[4] Associate degree and/or some college
- ☐[5] College graduate with or without graduate school training
- ☐[6] Other *(Specify)* _____

16. How tall are you? *(Without shoes)* ☐ Feet ☐☐ Inches

17. What is your weight to the nearest pound? *(Without shoes)?* ☐☐☐ Pounds

18. Are you left handed or right handed? ☐[1] Left handed ☐[2] Right handed

19. Starting with your last job, please complete the following table for all the previous jobs you held **where you used a computer**.

	Example	Job 1	Job 2	Job 3	Job 4	Job 5	Job 6	Job 7
Job Title	*Accountant*							
Year of Hire	*1990*							
Years in Job	*5 yrs*							
Hours of Computer Use Per	*20*							

20. What income category listed below best matches your total combined HOUSEHOLD income during the past 12 months?

☐[1] Less than $15,000
☐[2] $15,000 - $24,999
☐[3] $25,000 - $34,999
☐[4] $35,000 - $49,999
☐[5] $50,000 - $74,999
☐[6] $75,000 and over

Appendix 3

Weekly Checklist

COMPLETE THESE CHARTS EVERY DAY, INCLUDING DAYS YOU DON'T WORK.

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
Hours worked at job-office and home *(IF VACATION DAY, HOLIDAY, OR SICK DAY ENTER 0).*							
Hours on computer-office & home.							
Number of times you stepped away from your workstation for more than 15 minutes including your lunch break.							
Did you experience any discomfort such as pain, aching, burning, numbness, or tingling in your neck, shoulders, elbows, forearms, wrists, hands, or fingers of at least 30 minutes duration?	Yes ☐[1] No ☐[0]	Yes ☐[1] No ☐[0]	Yes ☐[1] No ☐[0]	Yes ☐[1] No ☐[0]	Yes ☐[1] No ☐[0]	Yes ☐[1] No ☐[0]	Yes ☐[1] No ☐[0]

If you checked <u>YES</u> for discomfort on any day, please answer the questions in the box below.

IF YOU EXPERIENCED <u>NECK or SHOULDER</u> DISCOMFORT:

2. Place an **X** mark on the line below that represents the <u>worst</u> neck or shoulder discomfort you experienced in the past seven days.

No Discomfort +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+ **Unbearable Discomfort**
0 1 2 3 4 5 6 7 8 9 10

3. On what side of your body was this discomfort? ☐[1] Right side ☐[2] Left side ☐[3] Both sides

4. Did you take any medication for this discomfort in the past seven days? (aspirin, motrin, tylenol, etc)

   ☐[1] Yes ☐[0] No

5. What do you think caused the discomfort? _____ ☐☐

IF YOU EXPERIENCED <u>ELBOW, FOREARM,WRIST, HAND, or FINGER</u> DISCOMFORT:

6. Place an **X** mark on the line below that represents the <u>worst</u> elbow, forearm, wrist, hand, or finger discomfort you experienced in the past seven days.

No Discomfort +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+ **Unbearable Discomfort**
0 1 2 3 4 5 6 7 8 9 10

7. On what side of your body was this discomfort? ☐[1] Right side ☐[2] Left side ☐[3] Both sides

8. Did you take any medication for this discomfort in the past seven days? (aspirin, motrin, tylenol, etc)

   ☐[1] Yes ☐[0] No

9. What do you think caused the discomfort? _____ ☐☐

AT THE END OF THIS WEEK PLEASE ANSWER THE FOLLOWING QUESTIONS ABOUT THIS PAST WEEK.

10. Were you out of the office for the entire week (Monday through Friday) for vacation, holiday, illness, etc?

    ☐[1] Yes *(GO TO QUESTION 12 ON OTHER SIDE)* ☐[0] No *(GO TO QUESTION 11 ON OTHER SIDE)*

11. How stressful has your job been during the past week?

Place an **X** mark on the line below that represents the level of job stress you experienced during the past week.

Not stressful at all +-----+-----+-----+-----+-----+-----+-----+-----+-----+-----+ **Very Stressful**
0 1 2 3 4 5 6 7 8 9 10

12. Have there been any changes in your workplace environment?

☐[1] Yes *(GO TO QUESTION 12A)* ☐[0] No *(GO TO QUESTION 13)*

*12*A. Which of the following changes were made?

☐[1] Yes ☐[0] No Replacement of workstation (desk, chair, keyboard, monitor, or mouse)
☐[1] Yes ☐[0] No Adjustment in height of chair or keyboard
☐[1] Yes ☐[0] No Other changes (specify)_____

13. Have there been any changes in your health or medication use besides the discomfort you may have reported?

☐[1] Yes *(GO TO QUESTION 13A)* ☐[0] No *(GO TO QUESTION 14)*

13A. What health and/or medication changes have you experienced?

_____ ☐☐
_____ ☐☐

14. List any **sports, recreation, or other physical activity** you have participated in during the past week. Please include only the time you were physically active (For example: jogging, bicycling, swimming, brisk walking, tennis, aerobics, etc.).

Sport, Recreation or Other Physical Activity	Total Time Past Week Hours : Minutes
_____ ☐☐	☐☐ : ☐☐
_____ ☐☐	☐☐ : ☐☐
_____ ☐☐	☐☐ : ☐☐

15. List any other activities you have participated in during the past week that involved **intensive use of the hands**? (For example: playing a musical instrument, knitting, gardening, carpentry, etc.)

Activity	Total Time Past Week Hours : Minutes
_____ ☐☐	☐☐ : ☐☐
_____ ☐☐	☐☐ : ☐☐
_____ ☐☐	☐☐ : ☐☐

Appendix 4

Occupational Psychosocial Questionnaire

PARTICIPANT ID: ☐☐☐☐☐ **DATE:** ☐☐/☐☐/0☐
m m d d y y

COMPUTERS, WORK, AND HEALTH
Occupational Questionnaire

Instructions: Unless otherwise specified, for each of the following questions please place a check mark (√) in the appropriate box

1. What is your job title?_____ ☐☐

2. What is your typing speed? (Please select the closest answer)
   - ☐[1] Less than 50 words per minute
   - ☐[2] 50 - 65 words per minute
   - ☐[3] More than 65 words per minute

3. How frequently do you use a mouse?
   ☐[1] Never or rarely ☐[2] Sometimes ☐[3] Frequently ☐[4] Almost all the time

4. Can you get up and step away from your workstation when you choose or only at scheduled times?
   ☐[1] When you choose ☐[2] Scheduled times

5. How comfortable is the chair at your workstation?
   - ☐[1] Very comfortable
   - ☐[2] Somewhat comfortable
   - ☐[3] Somewhat un-comfortable
   - ☐[4] Very un-comfortable

6. My job requires that I learn new things.
   ☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

7. My job involves a lot of repetitive work.
   ☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

8. My job requires me to be creative.
   ☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

9. My job allows me to make a lot of decisions on my own.
   ☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

10. My job requires a high level of skill.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

11. On my job, I have very little freedom to decide how I do my work.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

12. I get to do a variety of different things on my job.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

13. I have a lot of say about what happens on my job.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

14. I have an opportunity to develop my own special abilities.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

15. My job requires working very fast.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

16. My job requires working very hard.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

17. I am asked to do an excessive amount of work.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

18. I have enough time to get the job done.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

19. I am free from conflicting demands that others make.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

20. My job requires long periods of intense concentration on the task.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

21. My tasks are often interrupted before they can be completed, requiring attention at a later time.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

22. My job is very hectic.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

23. Waiting on work from other people or departments often slows me down on my job.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

24. I can control the pace of my work when I work with our computer system or automated equipment.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

25. I often have to wait long intervals before the computer system or automated equipment can process my work.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

26. The computer system or automated equipment checks the speed or acuracy of my work for my supervisor.

☐[1] Strongly Disagree ☐[2] Disagree ☐[3] Agree ☐[4] Strongly Agree

27. All in all, how satisfied are you with your job?

☐[1] Very satisfied
☐[2] Somewhat satisfied
☐[3] Not too satisfied
☐[4] Not at all satisfied

We would like you to think about how often certain things happen at your job. For each of the statements below, please check the box that comes closest to your answer.

28. How often do you face hostility or abuse from customers, clients, or coworkers?

☐[1] Rarely ☐[2] Sometimes ☐[3] Fairly Often ☐[4] Very Often

29. How often do each of the following people go out of his/her way to make your work life easier?

A. Your immediate supervisor

☐[1] Rarely ☐[2] Sometimes ☐[3] Fairly Often ☐[4] Very Often

B. Other people at work

☐[1] Rarely ☐[2] Sometimes ☐[3] Fairly Often ☐[4] Very Often

30. How often can each of the following people be relied on when things get tough at work?

A. Your immediate supervisor

☐[1] Rarely ☐[2] Sometimes ☐[3] Fairly Often ☐[4] Very Often

B. Other people at work

☐[1] Rarely ☐[2] Sometimes ☐[3] Fairly Often ☐[4] Very Often

31. How easy is it to talk with each of the following people?

A. Your immediate supervisor

☐[1] Very Easy
☐[2] Somewhat Easy
☐[3] A Little Easy
☐[4] Not at all Easy

B. Other people at work

☐[1] Very Easy
☐[2] Somewhat Easy
☐[3] A Little Easy
☐[4] Not at all Easy

32. Please indicate whether the following statements about the physical environment of your job are true or false.

	TRUE	FALSE
A. The level of noise in the area(s) in which I work is usually high.	☐[1]	☐[0]
B. The level of lighting in the area(s) in which I work is usually poor.	☐[1]	☐[0]
C. The temperature in my work area is usually uncomfortable.	☐[1]	☐[0]
D. My work area(s) is/are awfully crowded.	☐[1]	☐[0]

Appendix 5

Ergonomic Assessment
Group A
Group B
Group C

PARTICIPANT I.D. ☐☐☐☐☐ EXAMINER ☐

GROUP A - Ergonomic Assessment 1 0 DATE: ☐☐ / ☐☐ / 0☐ (M M / D D / Y Y)

TIME: ☐☐ : ☐☐ (H H : M M)

WORKSTATION

Pointing device ☐[1] Yes ☐[0] No

If yes: ☐[1] Mouse ☐[2] Stylus ☐[3] Track Ball ☐[4] Other _____ (Specify)

Side: ☐[1] Right side ☐[2] Left side ☐[3] Crossover ***(If crossover, stop here)***

Document holder ☐[1] Yes ☐[0] No

Wrist rest

Keyboard ☐[1] **Yes** ☐[0] **No**

Pointing device ☐[1] Yes ☐[0] No

Telecommunications

Headphones ☐[1] Yes ☐[0] No

Shoulder rest ☐[1] **Yes** ☐[0] **No**

Chair features

Height easily adjustable ☐[1] **Yes** ☐[0] **No**

Backrest: low back support ☐[1] **Yes** ☐[0] **No**

Backrest: mid back support ☐[1] **Yes** ☐[0] **No (backrest reaches bottom of shoulder blade)**

Five legged base ☐[1] **Yes** ☐[0] **No**

Arm rest ☐[1] **Yes** ☐[0] **No**

Sharp leading edge ☐[1] Yes ☐[0] No

Keyboard: Standard QWERTY ☐[1] Yes ☐[0] No

Other ☐[1] Yes ☐[0] No (Specify, e.g. split, non-detachable)

_____

LINEAR MEASUREMENTS (in centimeters using leading zeros)

FROM:	TO:	(-)
Edge of table/KP	**Edge of "J" key**	☐☐.☐
Floor	Table surface/KP (A)	☐☐.☐
Table surface/KP	Surface of "J" key (B)	☐☐☐.☐ ("J" key below table surface = "-")
Floor to "J" key = (A + B)		☐☐.☐
Floor	Table/Mouse platform	☐☐.☐
Width: Edge of "J" key	Center of mouse	☐☐.☐
Depth: Edge of "J" key	Center of mouse	☐☐☐.☐ (Mouse below "J" key = "-")

(over)

COMMENTS

Comments ☐[1] Yes ☐[0] No

END TIME: ☐☐:☐☐
H H M M

PARTICIPANT I.D. ☐☐☐☐☐ EXAMINER ☐

GROUP B - Ergonomic Assessment 2 0

DATE: ☐☐ / ☐☐ / 0☐
M M D D Y Y

TIME: ☐☐ : ☐☐
H H M M

WORKSTATION

Pointing device ☐[1] Yes ☐[0] No
If yes: ☐[1] Mouse ☐[2] Stylus ☐[3] Track Ball ☐[4] Other _____ (Specify)

Side: ☐[1] Right side ☐[2] Left side ☐[3] Crossover ***(If crossover, stop here)***

Document holder ☐[1] Yes ☐[0] No

Wrist rest
Keyboard ☐[1] **Yes** ☐[0] **No**
Pointing device ☐[1] Yes ☐[0] No

Telecommunications
Headphones ☐[1] Yes ☐[0] No
Shoulder rest ☐[1] Yes ☐[0] No

Chair features
Height easily adjustable ☐[1] **Yes** ☐[0] **No**
Backrest: low back support ☐[1] **Yes** ☐[0] **No**
Backrest: mid back support ☐[1] **Yes** ☐[0] **No (backrest reaches bottom of shoulder blade)**
Five legged base ☐[1] **Yes** ☐[0] **No**
Arm rest ☐[1] **Yes** ☐[0] **No**

Sharp leading edge ☐[1] Yes ☐[0] No

Keyboard: Standard QWERTY ☐[1] Yes ☐[0] No
Other ☐[1] Yes ☐[0] No (Specify, e.g. split, non-detachable)

_____

LINEAR MEASUREMENTS (in centimeters using leading zeros)

FROM:	TO:	(-)
Edge of table/KP	Edge of "J" key	☐☐.☐
Floor	Table surface/KP (A)	☐☐.☐
Table surface/KP	Surface of "J" key (B)	☐☐☐.☐ ("J" key below table surface = "-")
Floor to "J" key = (A + B)		☐☐.☐
Floor	Table/Mouse platform	☐☐.☐
Width: Edge of "J" key	Center of mouse	☐☐.☐
Depth: Edge of "J" key *(over)*	Center of mouse	☐☐☐.☐ (Mouse below "J" key = "-")

COMMENTS

Comments ☐[1] Yes ☐[0] No

END TIME: ☐☐ : ☐☐
H H M M

NORAERGB 1/27/04

PARTICIPANT I.D. ☐☐☐☐☐ EXAMINER ☐

GROUP C - Ergonomic Assessment 3 0 DATE: ☐☐ / ☐☐ / 0☐ (M M / D D / Y Y)

TIME: ☐☐ : ☐☐ (H H : M M)

WORKSTATION

Pointing device ☐[1] Yes ☐[0] No

If yes: ☐[1] Mouse ☐[2] Stylus ☐[3] Track Ball ☐[4] Other _____ (Specify)

Side: ☐[1] Right side ☐[2] Left side ☐[3] Crossover ***(If crossover, stop here)***

Document holder ☐[1] Yes ☐[0] No

Wrist rest
- Keyboard ☐[1] Yes ☐[0] No
- Pointing device ☐[1] Yes ☐[0] No

Telecommunications
- Headphones ☐[1] Yes ☐[0] No
- Shoulder rest ☐[1] Yes ☐[0] No

Chair features
- Height easily adjustable ☐[1] Yes ☐[0] No
- Backrest: low back support ☐[1] Yes ☐[0] No
- Backrest: mid back support ☐[1] Yes ☐[0] No (backrest reaches bottom of shoulder blade)
- Five legged base ☐[1] Yes ☐[0] No
- Arm rest ☐[1] Yes ☐[0] No

Sharp leading edge ☐[1] Yes ☐[0] No

Keyboard: Standard QWERTY ☐[1] Yes ☐[0] No

Other ☐[1] Yes ☐[0] No (Specify, e.g. split, non-detachable)

_____

ANTHROPOMETRIC MEASUREMENTS (cm)

Elbow to fingertip length ☐☐☐.☐

Shoulder to elbow length ☐☐☐.☐

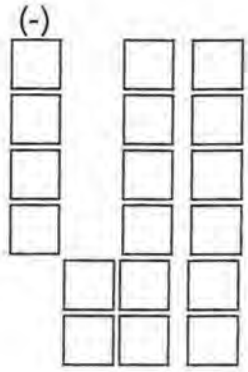
POSTURAL MEASUREMENTS (in degrees)

Pointing Device

	(-)		
Wrist ulnar deviation	☐	☐☐	(deviation to thumb = "-")
Wrist extension	☐	☐☐	(knuckles below wrist = "-")
Shoulder flexion	☐	☐☐	(elbow behind body = "-")
Shoulder abduction	☐	☐☐	(elbow across body = "-")
Inner elbow angle		☐☐☐	

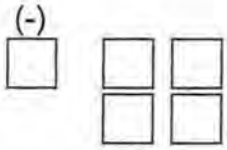
POSTURAL MEASUREMENTS (in degrees) continued

Keyboard



Wrist ulnar deviation	(-) ☐☐☐	(deviation to thumb = "-")
Wrist extension	☐☐☐	(knuckles below wrist = "-")
Shoulder flexion	☐☐☐	(elbow behind body = "-")
Shoulder abduction	☐☐☐	(elbow across body = "-")
Inner elbow angle	☐☐☐	
Trunk angle	☐☐☐	

Monitor



Head tilt angle	(-) ☐☐☐	(below horizontal = "-")
Head rotation angle	☐☐	

LINEAR MEASUREMENTS (in centimeters using leading zeros)

FROM:	TO:	(-)
Floor	Elbow typing height (C)	☐☐.☐
Edge of table/KP	Edge of "J" key	☐☐.☐
Floor	Table surface/KP (A)	☐☐.☐
Table surface/KP	Surface of "J" key (B)	☐☐☐.☐ ("J" key below table surface = "-")
Floor to "J" key = (A + B)		☐☐.☐
Floor	Table/Mouse platform	☐☐.☐
Width: Edge of "J" key	Center of mouse	☐☐.☐
Depth: Edge of "J" key	Center of mouse	☐☐☐.☐ (Mouse below "J" key = "-")

COMMENTS

Comments ☐[1] Yes ☐[0] No

END TIME: ☐☐ : ☐☐ (H H : M M)

GROUP C RECHECK (2-3 days): ☐☐ / ☐☐ / 0☐ (M M / D D / Y Y) TIME: ☐☐ : ☐☐ (H H : M M)

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service
Centers for Disease Control
and Prevention (CDC)

Memorandum

Date: February 19, 2004

From: Michael J. Galvin, Ph.D., Program Official
Office of Extramural Programs, NIOSH, E-74

Subject: Final Report Submitted for Entry into NTIS for Grant 5R01OH003858-03.

To: William D. Bennett
Data Systems Team, Information Resources Branch, EID, NIOSH, P03/C18

The attached final report has been received from the principal investigator on the subject NIOSH grant. If this document is forwarded to the National Technical Information Service, please let us know when a document number is known so that we can inform anyone who inquires about this final report.

Any publications that are included with this report are highlighted on the list below.

Attachment
cc: Sherri Diana, EID, P03/C13

List of Publications

Title: Preventing Musculoskeletal Disorders Among Vdt Operators
Investigator: Fredric E. Gerr
Affiliation: Emory University
City & State: Atlanta, GA
Telephone: (404) 727-5884
Award Number: R01OH3858
Start & End Date: 9/30/1999-9/29/2002
Total Project Cost: 894316
Program Area:
Key Words:

Final Report Abstract:

We performed the first randomized trial of specific ergonomic and postural interventions among persons using computer keyboards for more than 15 hours per week. Two specific sets of postural interventions were studied: 1) postural interventions based on the results of a major prospective study of musculoskeletal disorders among VDT users (ROl OH 03160) and 2) postural interventions based on recommendations of OSHA, NIOSH, and several computer manufacturers. The incidence of neck/shoulder symptoms and hand/arm symptoms during six months of follow-up among individuals in these two intervention groups was compared to the incidence in a third group of computer users who did not receive any intervention.

Approximately 440 individuals agreed to participate in the study, signed informed consent forms and completed a screening questionnaire designed to determine eligibility for randomization. Approximately 90 individuals were ineligible due to existing musculoskeletal symptoms at entry into the study. A total of376 individuals were randomized into one of three intervention groups: the Emory/GT intervention (group A), the OSHN conventional intervention (group B), and a group with no intervention (group C). For individuals in the intervention groups, study staff adjusted workstations, where possible, and trained individuals to assume the intervention postures. Individuals reported musculoskeletal symptoms on a weekly diary. Participants who reported discomfort intensity of 6 or greater on a 0-10 visual analog scale or who reported musculoskeletal symptoms requiring use of analgesic medication were considered symptomatic. Compliance with all components of the intervention was attained for only 25% of individuals in group A and for only 38% of individuals in group B. Difficulty in attaining compliance was largely due to the inflexibility of workstation configurations.

There were no significant differences in the incidence of musculoskeletal symptoms among the three groups. The number of individuals who developed arm or hand symptoms was 22 (18.3%) in group A, 25 (20.2%) in group Band 25 (21.7%) in group C. The number of individuals who developed neck or shoulder symptoms was 38 (33.3%) in group A, 36 (31.9%) in group Band 33 (30.3%) in group C.

Postural interventions are difficult to implement because of the inflexibility of workstations commonly in use. This study provides evidence that workplace postural in-

terventions are unlikely to reduce the risk of upper extremity musculoskeletal symptoms among computer users.

Publications: