BRENDA LEE GREENE  
Effectiveness of an Active Ergonomics Training Program for Computer Users  
(Under the direction of DAVID M. DEJOY)

Work-related musculoskeletal disorders (WMSDs) are recognized as an occupational epidemic with substantial impact on individual health and corporate well-being. Primary and secondary prevention of WMSDs is an essential task for many occupational safety and health professionals. Identification of strategies to effectively prevent and manage WMSDs are in the preliminary stages and no intervention or combination of interventions has emerged as optimal. The purpose of this research was to investigate the effectiveness of an active ergonomics training (AET) intervention.

A prospective two-group randomized design was used. Eighty-seven symptomatic and asymptomatic University of Georgia employees (70 female, 17 male) who worked at a computer for a minimum of 10 hours per week participated in the study. Subjects participated in a six-hour group training intervention at their workplace. Key elements of the AET intervention were skill development in workstation analysis, active participation, and integration of multiple prevention strategies. Workstation observations to measure the risk for cumulative trauma disorders (CTDs) were done pre- and post-intervention using the Rapid Upper Limb Assessment (RULA). All other outcomes were measured by survey: symptoms, knowledge, self-efficacy, outcome expectations, work pressure, perceived organizational support, and workstation control and autonomy. The ANCOVA procedure, using the baseline measures as the covariate, was used to determine the post-intervention differences between the groups for all outcomes except symptoms. Symptoms were analyzed with the Mann-Whitney U test statistic.

After receiving AET, risk factor exposure was significantly reduced for participants at higher risk (RULA score of 4.62 and above) \[ F(1,82)= 6.42, p<.01 \]. Significant increases in knowledge \[ F(1,74)=8.39, p<.01 \], self-efficacy \[ F(1,73)=6.95, p<.01 \], and outcome expectations \[ F(1,75)=8.75, p<.01 \] were also found after AET.
Additionally, the AET intervention had a positive impact on the way participants organized their work and on the initiation of exercise. There were no significant differences between the intervention and control groups for musculoskeletal symptoms, workstation control and autonomy, organizational support, and work pressure following the training. The primary conclusion from this study is that active ergonomics training was effective in decreasing exposure to risk factors for CTDs in computer users.

INDEX WORDS: Ergonomics, Training, Musculoskeletal symptoms
EFFECTIVENESS OF AN ACTIVE ERGONOMICS TRAINING PROGRAM FOR
COMPUTER USERS

by

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DEDICATION

I dedicate this study to the many people who have sustained work-related musculoskeletal injuries. My hope is that the scientific inquiry process and discovery of new knowledge will be applied so that fewer people experience work-related musculoskeletal disorders. Through improved knowledge, and the application of that knowledge, we can all live more healthful and productive lives.
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CHAPTER 1
INTRODUCTION

Work-related musculoskeletal disorders (WMSDs) have been recognized as an occupational epidemic with substantial impact on individual health and corporate well-being (Herrington & Morse, 1995; Warren, Dillon, Morse, Hall, & Warren, 2000). Financial costs of WMSDS include lost-worktime, workers’ compensation claims, and medical costs. In addition to the financial implications, the emotional toll on the individual, family members, and co-workers is considerable and perhaps, immeasurable. A recognized need exists to develop, implement, and evaluate intervention strategies for the prevention of WMSD (Haartz & Sweeney, 1995; Lincoln et al., 2000). The overall purpose of this study was to evaluate the effectiveness of an active ergonomics training intervention to reduce ergonomic stressors and ultimately prevent upper extremity WMSDs in computer users.

Scope and Magnitude of the Problem

Work-related musculoskeletal disorders are defined as “diseases and injuries affecting the musculoskeletal, peripheral nervous, and neurovascular systems that are caused or aggravated by occupational exposure to ergonomic hazards” (National Institute for Occupational Safety and Health [NIOSH], 1995). Some of the specific diagnoses that comprise WMSDs include tendonitis, tenosynovitis, peripheral nerve entrapments, and muscle strain. Work-related musculoskeletal disorders can be the result of an acute trauma, such as a fall, or they can be the result of cumulative trauma, such as repetitive gripping. In computer users, the nature of the musculoskeletal
injury is cumulative trauma due to chronic exposure to ergonomic stressors. According to the Bureau of Labor Statistics, 65 percent of the 392,000 new cases of occupational illness reported in 1998 were attributable to disorders associated with repeated trauma (Bureau of Labor Statistics, 1999b). While the number of new cases of disorders associated with repeated trauma has decreased from 332,000 cases in 1994 to 253,000 cases in 1998, the percentage of occupational illness cases attributable to disorders associated with repeated trauma during that time remained relatively constant at 65 percent. Musculoskeletal disorders of the upper extremity and neck comprise the majority of cases in the repeated trauma category. In addition to the known cases of repeated trauma to the upper extremity, evidence exists that at least 85% of WMSDs are undetected by current surveillance systems (Warren et al., 2000). Therefore, the actual problem of repeated trauma to the upper extremity may be greater than reported by the Bureau of Labor Statistics.

Work-related musculoskeletal disorders also have a substantial impact on corporate well-being. According to the Bureau of Labor Statistics, repetitive motion injuries, primarily of the upper extremity, resulted in a median of 15 days off work in 1998, the longest lost-worktime among highly prevalent events and exposures (Bureau of Labor Statistics, 1999a). The median days off work for the specific upper extremity disorder of carpal tunnel syndrome alone was 24 days in 1998. Carpal tunnel syndrome resulted in more time away from work than for any other injury or illness, including fractures and amputations. The average costs per claim for both medical and indemnity payments for cumulative trauma disorders in the most recent year available, 1996-1997, was $9,856 (National Safety Council, 1999). These costs were nearly equivalent to the average total costs per claim for all injuries, $10,488 (National Safety Council, 1999). In 1994, the 21,338 claims for work-related musculoskeletal disorders of the upper extremity accounted for 3.6% of all workers’ compensation claims and 6.4% of all claims costs (Hashemi, Webster, Clancy, &
Prevention of work-related musculoskeletal disorders of the upper extremity could save companies millions of dollars in lost productivity, healthcare costs, and workers’ compensations claims.

Prevention of work-related musculoskeletal disorders in general, and among computer users in particular, is a challenge that many workplaces face today. The information age has lead to more people using computers and longer periods of usage. It is estimated that approximately 50% of the 120 million U.S. workers use computers and keyboards in the workplace (Amick, Swanson, & Chang, 1999). The Occupational Safety and Health Administration (OSHA) has proposed a federal standard for ergonomics programs in the workplace (Federal Register, 2000). Training is a critical component of the proposed ergonomics standard. Research conducted by the National Institute of Occupational Safety and Health (NIOSH) and independent researchers indicates upper extremity musculoskeletal disorders are a significant problem in computer users (Hales et al., 1994; Sauter & Swanson, 1996). Therefore, a clear need exists to develop, implement, and evaluate the effectiveness of intervention strategies for the prevention of WMSD (Haartz & Sweeney, 1995).

**Purpose of the Study**

The purpose of this study was to evaluate the effectiveness of an active ergonomics training intervention in relation to organizational and psychosocial factors in computer users. This research contributes new knowledge due to the uniqueness of the active intervention. Many ergonomics training programs are didactic, but by teaching the participant to actively evaluate his or her computer workstation, the active ergonomics training program maximizes participant involvement and transferability of ergonomic knowledge and skills. Another way in which unique knowledge was added to the literature on intervention effectiveness is through the measurement and analysis of individual, physical environmental, and psychosocial variables.
In 1996, the National Institute of Occupational Safety and Health (NIOSH) identified 21 research priorities for occupational safety and health as part of the National Occupational Research Agenda (NORA) (NIOSH, 1996). The 21 priorities were organized into three major categories: disease and injury, work environment and workforce, and research tools and approaches. This research addressed priorities within each of the three NORA categories: musculoskeletal disorders of the upper extremity (disease and injury), intervention effectiveness (research tools and approaches), and work organization (work environment and workforce).

**Research Questions and Hypotheses**

Two questions addressed by this research were: 1) What are the effects of an active ergonomics training (AET) intervention on changes in musculoskeletal symptoms related to work, risk factor exposure, self-efficacy, and knowledge level? 2) What are the effects of an AET intervention on psychosocial and work organization factors? The first research question addressed the need to systematically investigate, in a methodologically sound manner, the effectiveness of theory-informed interventions. The following hypotheses were associated with the first research question. **H1:** There will be a difference between the control condition and the AET condition in musculoskeletal symptoms related to work. **H2:** Risk factor exposure will decrease more in the AET condition compared to the control condition. **H3:** Ergonomics knowledge will increase in the AET condition compared to the control condition. **H4:** Ergonomics related self-efficacy will increase in the AET condition compared to the control condition. **H5:** Ergonomics related outcome expectations will increase in the AET condition compared to the control condition. The second question addressed the need to determine how AET affects non-ergonomic workplace factors. The following hypotheses were associated with the second question. **H6:** Perceived organizational support will increase more in the AET
condition compared to the control condition. **H7:** Workstation control and autonomy will increase more in the AET condition compared to the control condition. **H8:** Perceived work pressure will decrease in the AET condition compared to the control condition.
CHAPTER 2
REVIEW OF THE LITERATURE

The review of the literature is organized around Sauter and Swanson’s (1996) ecological model of musculoskeletal disorders in computer users. A description of the model is presented and then the model constructs relevant to the proposed research project are discussed. The ecological model is necessarily complex in order to describe the dynamic interplay between individual and environmental factors, but only the constructs of physical demands, individual factors, and work organization directly relate to the AET intervention. The review of the literature concludes with the theoretical rationale for the AET program.

An Ecological Model of WMSD Causation

The physical nature of the work-related musculoskeletal injury in computer users is chronic exposure to ergonomic stressors, but physical factors alone do not explain the etiology of WMSDs in computer users. Evidence from many disciplines supports the complexity and interrelatedness of multiple risk factors in the causation of WMSDs (Amick et al., 1999; Bernard, 1997; Faucett & Rempel, 1994). Sauter and Swanson (1996) describe an ecological model of musculoskeletal disorders in VDT users consistent with other WMSD explanatory models (Armstrong et al., 1993; Kilbom, 1988), and in accord with other injury and prevention models in the broader context of occupational safety and health (DeJoy & Southern, 1993; Hagberg et al., 1997). Sauter and Swanson’s ecological model identifies office technology as the origin of musculoskeletal disorders and identifies risk factors at the individual level, physical environmental level, and organizational level (see Figure 2.1). According to
Sauter and Swanson, individual factors, such as knowledge and beliefs, moderate the relationship between physical demands and biomechanical strain, and between work organization and psychological strain. Theoretically, interventions aimed at decreasing physical demands and enhancing individual knowledge, beliefs, and abilities should decrease the prevalence of musculoskeletal symptoms and disorders.

Work organization refers to the way work processes are structured and managed, and it encompasses participation, temporal aspects of the job, workload demands, interpersonal aspects of work, and organizational characteristics (Amick et al., 1999; NIOSH, 1996). According to Sauter and Swanson, the effect of work organization on musculoskeletal outcomes is mediated through both psychological strain and physical demands, although, a direct effect of work organization on musculoskeletal outcomes has not been ruled out (Amick et al., 1999). Interventions that improve work organization should have a positive impact on musculoskeletal outcomes, in that improved work organization may reduce physical workload and/or psychological strain (see Figure 2.1).

Figure 2.1 Ecological Model of Musculoskeletal Disorders (Sauter & Swanson, 1996)
Physical Demands and WMSD

This section begins with a description of the proposed mechanisms by which physical demands cause WMSDs. The evidence supporting the causal relationship between physical demands and WMSDs in computer users is then reviewed. Finally, this section concludes with a review of engineering interventions directed toward decreasing physical demands in computer users. The general mechanism of effect at a systems level is that physical demands cause an exposure to ergonomic risk factors that results in a mechanical, physiological, or psychological internal disturbance and an internal response to that disturbance occurs (Armstrong et al., 1993). The internal response that occurs may or may not be an injury depending on one’s capacity. Capacity refers to the individual’s ability to maintain homeostasis in response to exposures (Armstrong et al., 1993). When exposure to physical risk factors is high, the risk of WMSD is high (Andersson, Fine, & Silverstein, 2000; Bernard, 1997). The physical risk factors for the development of WMSD in computer users are force, repetition, duration, and awkward postures (Bernard, 1997; Stobbe, 1996). The specific pathophysiologic mechanism of each diagnosis classified as a WMSD has also been described at the tissue level (Andersson, Fine, & Silverstein, 2000; Szabo & Gelberman, 1987; Thorson & Szabo, 1992).

Evidence for the causal pathway from physical demands to musculoskeletal outcomes has been studied as a function of exposure to ergonomic risk factors and VDT use. The association between ergonomic risk factors and the development of neck and upper extremity WMSD in VDT users has fairly strong support (Armstrong, Fine, Goldstein, Lifshitz, & Silverstein, 1987; Bernard, 1997; Sauter, Schleifer, & Knutson, 1991; Stock, 1991). Moreover, working in the presence of multiple risk factors increases the likelihood of developing WMSD, and decreased exposure to
physical risk factors decreases the risk of injury (Andersson et al., 2000; Bernard, 1997). Some progress has been made in establishing the relationship between the amount of VDT use and musculoskeletal outcomes. A number of epidemiologic studies indicate increased musculoskeletal symptoms among current or past VDT users as a function of increased exposure (Hales et al., 1994; Marcus & Gerr, 1996; Matias, Salvendy, & Kuczek, 1998; Sauter et al., 1991). This literature, however, is not entirely consistent (Amick et al., 1999; Bergqvist, Wolgast, Nilsson, & Voss, 1995a). The seemingly contradictory findings may be attributable to different operational definitions of VDT users (current non-users versus those who have never used) and the use of different musculoskeletal outcomes. In summary, fairly strong evidence supports the causal pathway between physical demands and the development of musculoskeletal disorders. Evidence exists that decreased exposure to physical demands decreases the risk for injury, but the precise dose-response relationships have not been developed.

Interventions

Engineering approaches have been used to decrease physical demands in computer users in an attempt to prevent musculoskeletal disorders. Engineering interventions generally employ a mechanical or biomechanical perspective to physically manipulate the environment (job/equipment design) to reduce or eliminate occupational hazards. Seven studies that use an engineering or biomechanical approach to investigate the effects of workstation redesign for computer users were found in the literature. Aaras (1994) studied the relationship between the trapezius muscle load and the incidence of musculoskeletal injury in the neck and shoulder region by implementing a redesign of the computer workstation for three groups of data entry and data dialogue workers. The outcomes assessed were muscle load around the neck measured by electromyography (EMG) and pain intensity measured with a visual analog scale. After the intervention, a trend toward a reduction in muscle
load was found in all three groups, and a statistically significant reduction in muscle load was found in the group of female data dialogue workers. A statistically significant decrease in pain was found in the group of female data entry workers and male data dialogue workers. The third group, female data dialogue workers, showed a trend toward decreased pain after the intervention. These results indicate computer workstation redesign did reduce the muscle load around the neck and musculoskeletal pain in some groups of computer users.

Two studies have examined the engineering of keyboards in relation to muscle forces in the forearm and hand (Fernstrom, Ericson, & Malker, 1994; Gerard, Jones, Smith, Thomas, & Wang, 1994). Both studies had sample sizes of less than ten participants and were conducted in a work simulation setting. One study (Fernstrom et al., 1994) evaluated mechanical versus different electronic keyboards, and the other study (Gerard et al., 1994) evaluated a split, angled keyboard versus a standard flat computer keyboard. The results demonstrated the electronic keyboards required less muscle activity, measured by EMG, than the mechanical keyboards, but the electronic keyboards were not significantly different from each other. When the split, angled keyboard was compared to the standard keyboard, the muscle activity was statistically significantly less in the flexor muscles, but not in the extensor muscles.

The effect of a split angled keyboard design was also compared to the standard keyboard in relation to wrist posture, musculoskeletal comfort, and typing performance in several studies (Smith et al., 1998; Swanson, Galinsky, Cole, Pan, & Sauter, 1997; Tittiranonda, Rempel, Armstrong, & Burastero, 1999). Data were obtained from between 18 and 50 participants performing typing tasks for three to fourteen consecutive days. No group consisted of more than 10 participants. The findings from Smith and colleagues (1998) indicate that compared to the use of the standard keyboard, use of the split angled keyboard resulted in significantly less forearm pronation and wrist ulnar deviation, but also resulted in significantly greater
wrist extension. Lesser amounts of all wrist and forearm joint angle parameters are recommended for optimal keyboard function. The findings from Tittiranonda and colleagues (1999) indicate that use of a split angled keyboard significantly decreased the amount of time spent in extreme wrist extension and ulnar deviation. Two studies reported no statistical difference in musculoskeletal discomfort between using the standard keyboard versus the split angled keyboard (Smith et al., 1998; Swanson et al., 1997) and one study (Tittiranonda et al., 1999) did not report musculoskeletal discomfort, but did report users preferred the split angled keyboard. Performance results revealed a decline in typing performance as the hours of typing increased during the day (Smith et al., 1998) and across the days (Swanson et al., 1997), but no significant difference between the types of keyboard was found (Smith et al., 1998; Swanson et al., 1997).

The effect of three different models of split angled keyboards and a standard keyboard in relation to pain, functional status, and clinical findings was studied in computer users diagnosed with musculoskeletal disorders (Tittiranonda, Rempel, Armstrong, & Burastero, 2000). One unique aspect of this study was that the outcomes were measured at multiple time points up to six months post-baseline. Twenty participants were randomly assigned to one of the four keyboard groups. Each participant used that type of keyboard for the entire six months of the study. At six months in the group using the Microsoft Natural Keyboard™ model of split angled keyboard compared to the standard keyboard group. At six months no significant differences in clinical diagnostic findings between the four groups were found. Keyboards are engineered in a variety of shapes with a variety of features, and currently, strong evidence does not exist that one type of keyboard is superior.

Engineering interventions provide valuable information on muscle load, posture, and musculoskeletal discomfort under different workstation conditions. The
traditional hierarchy of controls approach to workplace hazards recognizes engineering interventions as the preferred solution for workplace hazards (NIOSH, 1997). However, the extent to which engineering interventions alone can prevent WMSD of the upper extremities in computer users is questionable based on research to date. All of the reviewed studies had small sample sizes (less than 20 participants total or per group) and most of the studies used simulated conditions over a short time period. In fact, these engineering interventions suggest that other factors, such as workload and task content, may have at least as great a role as ergonomic factors on performance and fatigue in computer users (Smith et al., 1998). Clearly, there is a need to evaluate the effectiveness of interventions that incorporate sound ergonomic principles, but that also address individual, psychosocial, and work organization factors contributing to the incidence of WMSD.

**Individual Factors and WMSD**

This section identifies those genetic, acquired, or dispositional characteristics linked to WMSD and describes a general mechanism of effect. Interventions targeted at the individual level, such as training and exercise, are also reviewed. According to Sauter and Swanson (1996), individual factors, such as age, knowledge, and beliefs modify the effects of physical demands and work organization on musculoskeletal outcomes. Although the exact mechanism of effect of individual factors on musculoskeletal disorders is not clearly understood, psychosocial stress-strain models are often used in an attempt to explain the relationship (Sauter & Swanson, 1996; Smith, 1997). The underlying theory is that psychological stress involves the interaction of environmental demands with individual attributes (needs, expectations, resources, etc.), which leads to acute psychological, behavioral, and physiological reactions that can ultimately affects physical health (Sauter & Swanson, 1996). Individual factors with a demonstrated positive association with upper extremity or
cervical musculoskeletal disorders are being female, being female with children at home, and being over the age of 40 (Bergqvist, Wolgast, Nilsson, & Voss, 1995b).

**Training Interventions**

Awareness, knowledge, and skill are considered essential elements for the prevention and management of injuries, and training is a key method used to improve these elements (Cohen & Colligan, 1998; NIOSH, 1997; Kukkonen, Luopajarvi, & Riihimaki, 1983). In the recently enacted ergonomics program standard (Federal Register, 2000), training is identified as a required component of ergonomics programs in the workplace. In spite of the recognized importance of ergonomics training in computer users, only a few published studies of ergonomics training effectiveness exist.

Rizzo, Pelletier, Serxner, and Chikamoto (1997) compared the effects of instructor-directed and self-directed ergonomics training on knowledge and self-reported computer work behaviors in computer users. The instructor-directed training consisted of one 60-minute session with 30 minutes of videotape presentation on workstation adjustments and an instructor-led presentation on WMSD risk factors with a discussion period at the end of the session. Pamphlets reviewing the content of the videotape were distributed for follow-up reference. The self-directed training consisted of the same videotape and pamphlets, but no instructor-led presentation or discussion period. Both educational strategies resulted in a statistically significant increase in knowledge and self-reported computer work behaviors compared to the control group. Shortcomings of this research were the lack of measurement of musculoskeletal outcomes and self-reported work behaviors.

Kamwendo and Linton (1991) compared the effect of neck care education alone to the effect of neck care education combined with consultation for compliance strategies. The educational program consisted of four hours of training by a physical therapist on the topics of anatomy, etiology of WMSD, ergonomics, and exercise. The
group receiving education and compliance strategies received an additional two-hours of individual consultation with a physical therapist regarding ergonomic changes and with a psychologist regarding work organization changes. The group receiving education and compliance strategies implemented more ergonomic changes and the improvements lasted longer compared to the group receiving training only. Within-group comparison revealed significantly reduced pain and fatigue at two different times of day in both treatment groups, but not the control group. Between-group comparisons post-intervention showed a significant reduction in fatigue for the training only group, but when workload was controlled, the difference disappeared.

An experimental study by Brisson, Montreuil, and Punnett (1999) evaluated the effect of a six-hour ergonomic training program on ergonomic stressors and prevalence of WMSD. The training program consisted of two three-hours sessions scheduled two weeks apart. The training content included workstation self-assessment and the topic of organizational support was addressed by having the supervisor attend the session with their employees. Within-group improvements in postural stressors and decreased musculoskeletal symptoms occurred more frequently in the group receiving ergonomic training, compared to the control group, but between-group statistical comparisons were not reported. Age was found to be a modifying variable, workers less than 40 years old had greater improvements than workers older than 40 years of age.

Based on the research to date, it is difficult to draw any conclusions about the effectiveness of ergonomics training for computer users. Only two studies reported the effect of training on musculoskeletal outcomes (Brisson et al., 1999; Kamwendo & Linton, 1991). Only one of these studies (Brisson et al., 1999) used a measure other than self-report to evaluate behavior change resulting from ergonomics training. The added benefits of individualized or augmented training interventions remains unclear.
Clearly, further research on the effectiveness of ergonomics training programs for computer users is indicated.

**Exercise Interventions**

Few studies were found in the literature regarding the effectiveness of workplace exercise interventions on musculoskeletal outcomes (Silverstein, Armstrong, Longmate, & Woody, 1988; Takala, Viikari-Juntura, & Tynkkynen, 1994). The proposed mechanisms by which exercise in the workplace prevents upper extremity WMSD are: 1) increased circulation to an active area for nutrition to the tissues; 2) increased strength of the active muscles thereby reducing the neuromuscular fatigue of work; and 3) increased flexibility of the musculotendinous structures to counteract the repeatedly contracted position assumed throughout the day. Of the two studies found, neither study reported significant reductions in musculoskeletal symptoms after months of exercise, but both studies had serious methodological flaws. The research by Silverstein and associates (1988) pooled symptoms across body regions, so an improvement in one region, such as the hand, might not have shown up because of a worsening of symptoms in a different region, such as the neck. The exercise and non-exercise groups were non-equivalent with regard to the type of manufacturing job held and the shift worked; therefore, the lack of a difference between the groups may have been due to factors other than exercise. During data collection the production rate stayed the same, so 15 minutes of exercise might have been compensated by working faster throughout the day. In the study by Takala and colleagues (1994), group exercises to the whole body were done for 45 minutes, once a week for 10 weeks. It is highly questionable whether a single weekly dose of exercise for 45 minutes is adequate to produce beneficial musculoskeletal effects. A strong physiological rationale exists for the use of exercise in workers to prevent musculoskeletal disorders, but clearly more research is needed on the effectiveness of exercise interventions.
Work Organization and WMSD

Work organization refers to the way work processes are structured and managed, and it encompasses participation, temporal aspects of the job, workload demands, interpersonal aspects of work, and organization characteristics (Amick et al., 1999; NIOSH, 1996). According to Sauter and Swanson (1996), the relationship between work organization and musculoskeletal outcomes is mediated through physical demands and psychological strain. Several mechanisms for the effect of work organization on musculoskeletal outcomes have been proposed (Bernard, 1997; Sauter & Swanson, 1996). One explanation is that psychological strain produces muscle tension that compounds the biomechanical strain from physical demands. A second explanation is that work organization changes may be associated with a change in physical demands. A third explanation is that work organization demands may affect the awareness, reporting, and causal attribution of musculoskeletal symptoms.

The indirect pathway from work organization to musculoskeletal outcomes has been studied with many diverse constructs including employee involvement, work pressure, social support, and various other job/task characteristics. Involvement is defined as employee opportunities for participation in decision-making (Lawler, 1988). High levels of participation are associated with low levels of many different physical symptoms, including musculoskeletal pain (Spector, 1986). Another work organization factor is work pressure (Carayon, Yang, & Lim, 1995). Through use of factor analysis, Carayon (1994) demonstrated that the dimension of work pressure explained 11% of the variance of job stressors in office workers, second only to supervisor support (13%). Other studies have found work pressure to be associated with, or predictive of, workers with musculoskeletal pain (Hales et al., 1994; Stephens & Smith, 1996). A review of the literature by NIOSH reveals other psychosocial factors associated with WMSDs of the upper extremity and neck (Bernard, 1997).
Monotonous work is associated with increased musculoskeletal symptoms. Low job control and low role clarity also have a positive relationship to the outcome of WMSDs. Surprisingly, job satisfaction has not been consistently associated with the development of WMSDs.

**Participatory Ergonomics Interventions**

Interventions aimed at altering work organization typically fall under the category of administrative interventions, in that they attempt to reduce occupational hazards by modifying work practice and policies (Zwerling et al., 1997). One administrative intervention is referred to as participatory ergonomics. Participatory ergonomics programs have been defined in a variety of ways (Lanoie & Tavenas, 1996; Noro & Imada, 1991), but in a generic sense, participatory ergonomics refers to any approach that incorporates the principles of ergonomics and worker participation for the purpose of achieving a safe and effective work environment. Most participatory ergonomics programs that have been studied have been implemented in either meatpacking plants or manufacturing and assembly plants. One descriptive study reported on the outcomes of a participatory ergonomics program implemented in an office environment (Vink, Peeters, Grundemann, Smulders, & Kompier, 1995). The intervention consisted of formation of a steering team with top management members and the formation of a smaller team consisting of office workers. After approximately one year, the teams were found effective in facilitating worker change. No change in sick-leave was found, but there was a decrease in neck and shoulder pain reported by office workers. The participatory ergonomics effectiveness research from workplace settings other than the office, indicate some benefit in decreased risk factor exposure (Keyserling, Brouwer, & Silverstein, 1993; Moore, 1994; Moore & Garg, 1997b; Vink, Urlings, & van der Molen, 1997). The effectiveness in those non-office settings with regard to musculoskeletal injury and injury-related absences is less clear.
and more contradictory (Evanoff, Bohr, & Wolf, 1999; Moore, 1994; Moore & Garg, 1997a; Riley, Cochran, Stentz, May, Schwoerer, 1994; Vink et al., 1997).

**Microbreak Interventions**

Another intervention aimed at altering work organization is microbreaks. Microbreaks have been defined as a work break that lasts less than two minutes (Genaidy, Delgado, & Bustos, 1995). The purpose of microbreaks is to allow the body an opportunity to recover from exposure to the risk factors of highly repetitive work. Two studies have reported the effects of microbreaks on performance or musculoskeletal symptoms in computer users (Henning, Sauter, Salvendy, & Krieg, 1989; Sundelin & Hagberg, 1989). In one study, microbreaks were scheduled after 20 minutes of every 40-minute work period (Henning et al., 1989). The length of the microbreak was self-determined. Keyboard performance worsened after microbreaks, but heart rate decreased after longer microbreaks. In the other study, participants engaged in a word processing task were scheduled to take 15 microbreaks of 15 to 20 second duration within a 90-minute work period (Sundelin & Hagberg, 1989). The subjects were asked to perform one of three different activities on break: 1) sit quietly with arms resting in lap and eyes closed, 2) actively move wrist and hands, or 3) walk and leave the workstation. Perceived discomfort was compared after each of the three different activities during the microbreak. The lowest discomfort was reported following the microbreak that involved walking away from the workstation.

**Active Ergonomics Training Program**

The review of the literature establishes the linkage between physical demands, individual factors, and work organization factors and WMSDs in computer users. The traditional hierarchy of controls approach to workplace hazards recognizes engineering interventions as the preferred solution to workplace hazards, but research indicates that the interaction of individuals with their environment is also important.
Training is recognized as a key element in all programs addressing ergonomics hazards (NIOSH, 1997; Kukkonen et al., 1983). By training individuals how to evaluate their workstation environments for ergonomics hazards, the individual worker is empowered to begin to take steps to reduce ergonomics hazards. The Occupational Safety and Health Administration recognizes the importance of training and has included training as a critical component of a proposed ergonomics standard (Federal Register, 2000).

The active ergonomics training (AET) program is based primarily on Sauter and Swanson’s (1996) ecological model. The AET program addresses three components of the ecological model, individual factors, physical demands, and work organization. The AET intervention is designed to increase individual knowledge and skills, and decrease physical demands by using those skills to complete an ergonomic workstation assessment and implement ergonomic and behavioral changes.

Within the ecological framework, the constructs of self-efficacy and outcome expectations from the social cognitive theory (Bandura, 1977) also inform the AET intervention. Self-efficacy refers to an individual’s belief in his or her capabilities for the attainment of specific goals or task outcomes (Bandura, 1977). These beliefs develop from a variety of sources, including performance feedback, vicarious experiences, and social influences. Self-efficacy is defined at the behavior-situation level (Maibach & Murphy, 1995), and is, therefore, discussed in relation to the situation of ergonomics training and the behavior of workstation analysis. Self-efficacy has been identified as an important factor in the adoption and maintenance of health-promoting or safety behaviors (Bandura, 1977; DeJoy, 1996; King et al., 1992; Rogers & Prentice-Dunn, 1997). An outcome expectation is one’s belief about the likely outcomes for a given behavior (Bandura, 1977). Research evidence supports the hypothesis that individuals with higher confidence in their ability to perform a variety of health and safety behaviors, and a stronger belief that performance of those
behaviors will lead to positive outcomes, are more likely to perform those health and safety behaviors (King et al., 1992; Lorig & Gonzalez, 1992; Resnicow et al., 1997). It is proposed that ergonomics training will increase self-efficacy through feedback and skill-building and also increase positive outcome expectations. May, Schwoerer, Reed et al. (1997) have studied the relationship between self-efficacy related to job performance and ergonomic job design in computer users. The results indicate that ergonomic job design improvements were most likely to influence employees with low job performance self-efficacy. No studies have examined self-efficacy related to workstation analysis or ergonomics training; however, changes in self-efficacy have been linked to other types of training (McCormick, Masse, Cummings, & Burke, 1999).

Key elements of the AET program are: 1) skill development in problem-solving for ergonomics workstation issues and solutions; 2) active participation, and 3) integration of multiple prevention strategies. The problem-solving component is consistent with NIOSH recommendations for workplace training initiatives (NIOSH, 1997). Problem-solving has been recognized by educators as a type of learning for decades (Kingsley & Garry, 1957). Recently, the problem-solving process has been successfully applied to the workplace for the purpose of decreasing musculoskeletal injuries in employees in meatpacking and electronics manufacturing settings (Moore & Garg, 1996; Pasmore & Friedlander, 1982). With the exception of the study by Brisson, Montreuil, and Punnett (1999), the problem-solving process has not been incorporated in ergonomics training for computer users.

Traditional ergonomics training is often accomplished with a pamphlet or videotape, and if classroom training occurs, the format is typically didactic (Key, 1997). This approach to training does not facilitate active participation. From an education perspective, active participation refers to the principle that learning must be performed by the student, rather than transmitted by the teacher (Kemp, 1977). From
a workplace health and safety perspective, active participation refers to worker involvement in workplace health and safety issues (Gjessing, Schoenborn, & Cohen, 1994). This concept originated from the business literature (Lawler, 1988). Both the education and health and safety perspectives are incorporated in the AET program. Participants will be actively learning ergonomics principles and actively participating in the process of workstation analysis.

The development of WMSDs is a complex process and no one prevention strategy will address all of the different facets of the problem. The AET program emphasizes workstation design, but also addresses exercise, work organization, and microbreaks. The recommendations for workstation design are based on standard guidelines for computer workstations (American National Standards Institute, 1988, Putz-Anderson, 1988). The recommended exercises are based on principles of therapeutic exercise and posture (Kisner & Colby, 1990), and are consistent with exercises identified as safe and usable in an office environment (Lee, et al., 1992).

The AET program incorporates the training requirements and guidelines from NIOSH (Cohen & Colligan, 1998) and uniquely addresses worker problem-solving of computer workstation ergonomic stressors via assisted self-assessment. The computer workstation user is taught not only proper workstation design, but also how to assess the extent to which his or her workstation is consistent with proper workstation design. The best workstation design depends on worker needs, resources, and individual preferences. The active ergonomics training program offers a new and unique approach to ergonomics training.
CHAPTER 3
METHODS

The purpose of this chapter is to describe the methods that were used to conduct this research study. Chapter three contains five topic areas: study design, research context, instruments, intervention description, and data collection procedures.

Study Design

A prospective two-group experimental pretest and posttest design was used. Refer to Figure 3.1 for a graphic representation of the design. Both the intervention and control groups received the active ergonomics training (represented as X in Figure 3.1), but the training was delayed for the participants serving in the control group.

Participants were randomly assigned to one of four training sessions. Of the four training sessions, two were combined to form the intervention group and the other two formed the control group. After participants were randomly assigned to groups, the physical proximity of participant work locations in the intervention and control groups was assessed. In an attempt to minimize the spill-over of treatment effects to the control group, participants from the same work location were assigned to the same study group. When this did not occur randomly, the group to which the majority of physical work group members were assigned was the group to which all members of that physical work group were assigned. The data collection instruments included questions designed to detect spill-over effects.
<table>
<thead>
<tr>
<th>Intervention</th>
<th>Random assignment</th>
<th>O₁ X O₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group n=43</td>
<td>Random assignment</td>
<td>O₁ X O₂</td>
</tr>
<tr>
<td>Control</td>
<td>Random assignment</td>
<td>O₁ O₂ X O₃</td>
</tr>
<tr>
<td>Group n=44</td>
<td>Random assignment</td>
<td>O₁ O₂ X O₃</td>
</tr>
</tbody>
</table>

Figure 3.1 Study Design

Research Context

Site

The University of Georgia is a large land-grant university with the main campus located in Athens, Georgia. Approximately 30,000 graduate and undergraduate students attend the university. Based on UGA Fact Book figures (University of Georgia, 1999) from the most recent semester available, Fall 1999, the university employs 8,860 fulltime workers and 729 part-time workers. According to the Training and Development Department, no formal or systematic ergonomics training is currently offered to university employees.

Sample

Participant recruitment was carried out with the assistance of the Training and Development Department. The Training and Development Department contacted units across campus with a known or suspected interest in ergonomics training. Once units demonstrated a confirmed interest in the training, the AET intervention was offered to all employees in these units who worked at a computer at least 10 hours per week. Certain exclusion criteria were necessary to avoid confounding due to coexisting medical conditions. Employees diagnosed by a physician as having an acute musculoskeletal injury or trauma to the trunk or upper extremities within the previous six months were excluded from participation. Examples of acute
musculoskeletal injuries included fractures, dislocations, sprains, and strains. Employees being treated by a health care professional for cervical or upper extremity disorders also were excluded from participation in the study.

Forty-three participants were recruited into the intervention group and forty-four participants were recruited into the control group. Three participants per group dropped out of the study due to scheduling or workload conflicts. Forty participants completed the training and follow-up measures in the intervention group and forty-one participants completed the measures in the control group. The sampling method was non-randomized due to the nature of the research. With non-randomized sampling threats to external validity are not well controlled; thus, generalizability of the results will be limited to the sample. Participation in the study was voluntary and all participants signed the informed consent form (Appendix A). Approval for human subjects research was received from the Institutional Review Board (IRB) at the University of Georgia.

The University Assistant Librarian expressed serious interest in participating in this project (Appendix B), and most of the study participants were recruited from the libraries. Library employees perform a variety of tasks. For example, a reference librarian spends a high percentage of computer time manipulating a mouse; a front desk librarian spends more time using a keyboard; employees in cataloging use a scanner, keyboard, and mouse to code and input data. A common element of all library employees is working at a computer during much of the workday. Another common element is that the work is very repetitive. The nature of the work requires static postures and offers little opportunity to vary tasks. An observation of the workplace revealed a wide variation in workstation equipment and design. All library employees had their own individual workstations. The majority of the workstations were equipped with an adjustable chair; however, a few workstations had the older non-adjustable chairs. Nearly all workstations were equipped with wrist pads, but the
presence of other accessories, such as keyboard trays and monitor platforms, was inconsistent. Some of the work surfaces were adjustable, and many were not. The workstations were located on different floors in three different buildings. Some workstations were found in individual offices and others in a cubicle spaces with two to four computer workstations per cubicle area. When multiple computer workstations were located together, no standard pattern existed. The workstations were facing each other, back to back, or at an angle to each other.

Current ergonomics training for library employees consisted of independently watching a 20-minute videotape on office ergonomics. No other ergonomics training was offered by the library or through the university. There was clear management support for ergonomics training and other interventions. Evidence of management support consisted of the existence of an ergonomics committee that meets regularly and the availability of funds for ergonomics-related equipment. The library has an ergonomics committee consisting of nine library employees. The Assistant University Librarian and Library Training Coordinator are members of the committee along with seven other library employees from all job levels. The purposes of the committee are to: 1) educate library employees about ergonomics issues; 2) act as a sounding board regarding ergonomics issues; and 3) make recommendations regarding equipment to minimize ergonomic hazards. The committee maintains a website for ergonomics information: http://www.libs.uga.edu/ergo/info.html. In the past, the committee has brought in a Yoga instructor to teach relaxation and flexibility techniques. In the future, the committee is planning to bring in instructors to teach the Alexander Technique of body awareness and movement and stress management techniques.

Sample Size

A power analysis was conducted to estimate the number of subjects needed. The outcome relating to the change in risk factor exposure is the most meaningful because it involves behavior change. Brisson, Montreuil, and Punnett (1999) reported
a 25% decrease in two out of three postural risk factors in subjects less than 40 years old that received ergonomics training. The adjusted effect size is .35, using the pretest as a covariate and assuming a .75 correlation between the pretest and posttest. Using charts from Cohen (1977), based on a two-group comparison, with an alpha level of .05 and a power of .80, 30 individuals per group were needed. To ensure the necessary sample size, at least 40 participants per group were recruited.

Instruments

Sauter and Swanson’s ecological model (1996) provided the theoretical framework for this research. Four components of the ecological model were studied: physical demands, individual factors, work organization, and musculoskeletal outcomes. The review of the literature demonstrated an association between ergonomics training and the dependent variables or outcome measures of risk factor exposure, musculoskeletal symptoms, and knowledge. Self-efficacy in ergonomics has not been studied, but changes in self-efficacy have been linked to other types of training (McCormick et al., 1999).

A brief definition of each variable and the instrument used to measure that variable follows.

Outcome Measures

Risk factor exposure. Risk factor exposure was defined as the presence of conditions that increase the probability of occurrence of a musculoskeletal disorder. The Rapid Upper Limb Assessment (RULA) is a standard tool used to assess risk factor exposure at the computer workstation (McAltamney & Corlett, 1993). The RULA provides a composite risk score based on the postural angles held at the neck, back, and joints of the upper extremity. An experimental study to assess the validity of composite scores was conducted in computer users (McAltamney & Corlett, 1993). The findings demonstrated a significant association between RULA scores greater
than 1 and reported pain. McAltamney and Corlett (1993) also report “a high consistency of scoring” among physical therapists and engineers when using RULA to assess workers performing several different work tasks, but no correlation coefficient or specific percentage of agreement was given. Prior to data collection, the researcher and two research assistants met to establish inter-rater reliability for RULA. The procedures for scoring were demonstrated by the primary researcher and discussed with the research assistants. The scoring form that was used is found in Appendix C. After the raters were comfortable with scoring, each person independently assessed the same worker and workstation using RULA. Nine subjects were used to establish reliability. The overall RULA scores were analyzed with an analysis of variance technique to compute an intraclass correlation coefficient (ICC). The ICC on RULA scores for three different workstation analyses constituted the interrater reliability during the study.

Musculoskeletal Symptoms. Musculoskeletal symptoms were an intermediate proxy for upper extremity WMSD injury. Due to the relative statistical rarity of upper extremity WMSD and the long latency between exposure and onset of the disorder, incidence of injury is not always a practical outcome and intermediate outcomes appropriate to the intervention must be selected (Zwerling et al., 1997). Pain and other symptoms are often indicators of musculoskeletal disorders and are predictive of the presence of musculoskeletal disorders (Baron, Hales, & Hurrell, 1996; Ohlsson, Attewell, Johnsson, Ahlm, & Skerfving, 1994). The use of symptom surveys to detect workers at risk of developing WMSD and to detect a change following an intervention is common (Hales & Bertsche, 1992; Orgel, Milliron, & Frederick, 1992; Silverstein et al., 1988). Two of the most commonly used symptom surveys, the Nordic Musculoskeletal Questionnaire (NMQ) and the NIOSH symptom survey, were found to be both reliable and valid as a workplace screening tool, although no specific reliability estimates were provided (Baron et al., 1996). Evidence for validity of the
NIOSH symptom survey was found through a trend analysis of the relationship between the magnitude of reported pain and the presence of abnormal physical examination findings. The Chi Square for trend was statistically significant, indicating that increased pain was associated with the presence of positive physical findings.

The presence of musculoskeletal symptoms was assessed by a symptom survey modified from NIOSH (Baron et al., 1996) (Appendix D). The participants were first asked if they had musculoskeletal symptoms in the past year. For symptomatic participants, three aspects of symptoms, intensity, frequency, and duration, were evaluated for each of the following body areas: head, neck, shoulder and upper arm, elbow/forearm, wrist, hands/fingers, upper back, and lower back. For each symptomatic body region, the intensity of pain was rated on an ordinal scale from one (mild pain) to four (worst ever). If the body region was asymptomatic, a score of 0 was assigned. For each symptom, the frequency was determined by asking how often the symptoms occurred in the past two weeks. Frequency was rated on an ordinal scale from one (once in the past week) to four (daily in the past week). If no discomfort was present in a body region, a score of 0 was assigned. Duration was defined as how long the symptom had been continuously present. Duration was determined by asking how long the symptoms usually lasted during the past week. Duration was rated on an ordinal scale from one (less than 1 hour) to four (> 3 days to 1 week). If no discomfort was present in a body region, a score of 0 was assigned.

**Ergonomic knowledge.** A 15-item multiple choice and true/false instrument was used to assess ergonomic knowledge and beliefs (Appendix E). The pre-test and post-test were the same. The knowledge questions were at the recall, comprehension, and application levels (Bloom, 1983) and were based on the learning objectives for the training sessions. Prior to use with participants, the instrument underwent revision through the content analysis process by four physical therapists with experience in assessing office workstations. According to the content experts, the ergonomics quiz
was accurate and sampled the content specified in the learning objectives for the training.

Self-efficacy and outcome expectations. Self-efficacy refers to the perceived capabilities for the attainment of specific goals or task outcomes (Bandura, 1977). These perceptions develop from a variety of sources, including performance feedback, vicarious experiences, and social influences. Outcome expectations are the anticipated results of behaviors (Rogers & Prentice-Dunn, 1997), in this research it refers to the extent to which one believes changes in the workstation will result in beneficial effects. There are no known instruments to measure self-efficacy or outcome expectations for making workstation adjustments. Three questions on the Ergonomics quiz (Appendix E) were used to assess self-efficacy (items 2, 4, & 6) and three were used for outcome expectations (items 1, 3, & 5).

Workstation control/autonomy. The work organization questionnaire (Appendix F) contained three questions to measure control/autonomy related to work organization and workstation design, and these were adapted from Hackman and Oldham (1975). The three questions were: 1) My job permits me to decide on my own how to go about doing the work; 2) My job gives me considerable opportunity for independence and freedom in how my workstation is set-up; 3) My job denies me any chance to use my personal initiative or discretion in setting up my workstation. The three control and autonomy items were scored on a scale from 1 to 6, a higher score indicating greater perceived control and autonomy. The three items were averaged for a single control and autonomy score.

Work pressure. Work pressure was defined as perceived pressure from work tasks. Work pressure was measured with a six-question scale scored from 1 to 4, a higher score indicating greater perceived work pressure (Smith, Cohen, Stammerjohn, & Happ, 1981). The six items (Appendix F) were averaged for a single work pressure score. In an attempt to cluster stressful and non-stressful office jobs, Carayon, Yang,
and Lim (1994) investigated different psychosocial factors. A portion of their analysis on 262 office workers included assessing the reliability of this scale measuring work pressure. The estimate for reliability of internal consistency was .82. Additionally, evidence for concurrent validity of the scale was obtained through use of the known group technique, using job categories as the groups. The scale demonstrated good validity by yielding a statistically significant difference in work pressure across the groups known to vary in work pressure.

*Organizational support.* Organizational support refers to the organization’s concern for employee well-being. The original scale from Eisenberger and Huntington (1986) consisted of 16 items with an internal consistency reliability estimate of .93. A shortened version of the scale, consisting of nine items scored on a scale from 1 to 6 was used. The nine items were averaged for a single organizational support score, a higher score indicating greater perceived organizational support. The scales for participation, work pressure, and organizational support were combined into one work organization questionnaire for ease of administration. The work organization questionnaire is found in Appendix F.

**Other Measures**

*Computer exposure.* The pre-intervention symptom survey (Appendix D) included questions regarding the number of hours per week and per day the participant spent working at the computer while on the job. The categories to determine computer exposure per week were based on categories used by Sauter et al. (1991). Category 1 = 10-19 hours of computer use per week, category 2 = 20-29 hours of computer use per week, category 3 = 30-39 hours of computer use per week, category 4 = 40 or more hours of computer use per week. Number of hours spent using a computer at home or at any location away from their UGA workplace also was measured. The categories are 0 hours per week, 1-10 hours per week, 11-20 hours per week, 21 or more hours per week. To estimate the lifetime exposure to computers, a question on
the symptom survey asked about the total number of years the participant had used a computer.

*Demographic variables.* The following demographic information was collected: age, sex, race, number of years working on a computer, and number of years at current job. Questions relating to demographic variables were included as part of the pre-intervention symptom survey (Appendix D).

*Workstation changes.* On the post-intervention symptom survey (Appendix G) participants were asked if they made changes to their computer workstation and if so, what changes were made. Participants were also asked about the request and receipt of equipment or accessories for the computer workstation.

*Work organization changes.* On the post-intervention symptom survey (Appendix G) participants were asked if they made changes to the way they organized or paced their work tasks.

*Exercise changes.* On the post-intervention symptom survey (Appendix G) participants were asked if they made any changes to their exercise activity.

*Spill-over intervention effects.* On the post-intervention symptom survey (Appendix G) participants were asked if they had observed coworkers making changes to the workstation.

A summary of the primary study variables, corresponding theoretical model components, measures, and psychometric properties of the measures are summarized in Table 3.1.
<table>
<thead>
<tr>
<th>Model Component</th>
<th>Study Variables</th>
<th>Measures</th>
<th>Psychometric Properties</th>
<th>Level of Measurement</th>
<th>Scoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical Demands</td>
<td>Risk Factor Exposure</td>
<td>RULA</td>
<td>$\chi^2$ significant at .01 for association between high score and pain</td>
<td>Interval</td>
<td>1-7, higher score indicates greater risk</td>
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<tr>
<td>Computer Exposure</td>
<td></td>
<td>Symptom Survey</td>
<td>None</td>
<td>Categorical</td>
<td>1-4</td>
</tr>
<tr>
<td>Equipment Change</td>
<td></td>
<td>Symptom Survey</td>
<td>None</td>
<td>Categorical</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Individual Factors</td>
<td>Ergonomic Knowledge</td>
<td>Ergonomics Quiz</td>
<td>None</td>
<td>Ratio</td>
<td>0-100, percentage correct</td>
</tr>
<tr>
<td></td>
<td>Self-efficacy (SE)/Outcome Expectations</td>
<td>Ergonomics Quiz, questions 1-6</td>
<td>None</td>
<td>Interval</td>
<td>1-6, higher score indicates greater SE</td>
</tr>
<tr>
<td>Demographic Information</td>
<td></td>
<td>Symptom Survey</td>
<td>None</td>
<td>Categorical</td>
<td>Depends on question</td>
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<tr>
<td>Work Organization</td>
<td>Control/Autonomy for workstation design &amp; work organization</td>
<td>Adapted from Hackman and Oldham (1975)</td>
<td>None</td>
<td>Interval</td>
<td>1-6, higher score indicates greater control/autonomy</td>
</tr>
<tr>
<td></td>
<td>Work Pressure</td>
<td>Smith, Cohen, Stammerjohn &amp; Happ, (1981)</td>
<td>Alpha coefficient = .82</td>
<td>Interval</td>
<td>1-4, higher score indicates greater work pressure</td>
</tr>
<tr>
<td></td>
<td>Organizational Support</td>
<td>Adapted from Eisenberger &amp; Huntington (1986)</td>
<td>Alpha coefficient = .92</td>
<td>Interval</td>
<td>1-6, higher score indicates greater organizational support</td>
</tr>
<tr>
<td>Musculoskeletal Outcomes</td>
<td>Musculoskeletal Symptoms</td>
<td>Symptom Survey</td>
<td>$\chi^2$ significant at .05 for association between pain and physical findings</td>
<td>Ordinal</td>
<td>Increased values associated with increased frequency, duration, &amp; intensity.</td>
</tr>
</tbody>
</table>
**Intervention Description**

The theoretical framework for the AET program was Sauter and Swanson’s ecological model (1996). The AET program addressed three components of the model: individual factors, physical demands, and work organization. The AET intervention was designed to increase individual knowledge and skills, and to facilitate the active use of this knowledge and skill in completing an ergonomic workstation assessment and implementing ergonomic and behavioral changes to reduce risk factors for injury. Within the ecological framework, the protection motivation theory (Rogers & Prentice-Dunn, 1997; Rogers, 1983) was also used to guide this intervention. The AET program uniquely addressed worker problem-solving of computer workstation ergonomic stressors via assisted self-assessment and small group case analyses. The computer workstation user was taught not only proper workstation design, but also how to assess the extent to which his or her workstation was consistent with proper workstation design. Additionally, workplace exercises and principles of work organization were presented. A summary of the theoretical constructs, objectives, and program topics are presented in Table 3.2. The course handout is found in Appendix H.

The active ergonomics training intervention consisted of a total of six hours of didactic interactions, discussion, and simulation activities. The AET group met two days in the same week for three hours per session. The AET program occurred during working hours and employees participated on paid time. The first session began with a 30-minute power point presentation on the impact and causes of upper extremity and neck injuries at computer workstations. Signs and symptoms indicating the onset of WRMSD were next identified. Participants were given the opportunity to discuss their experience with neck and upper extremity injuries and their attitude toward personal responsibility for health and workstation design. Next, a 30-minute overview of anatomy and biomechanics of the spine and principles of proper body mechanics and
postural alignment were presented. A presentation on proper workstation design was
given followed by a demonstration on how to use the ergonomic checklist (Appendix I). Following the demonstration, the participants split into groups of four members
and each group was given a photograph of a person at a workstation. The group
members worked together to identify risk factors at the workstation. Each group
presented their findings to the entire group. The active participation away from the
classroom for the next two days consisted of the participants evaluating their own
workstation using the checklist.

The second session started with questions and findings from their workstation
checklist evaluation. Next, solutions for common problems, such as poor wrist angle,
improper screen position, and poor sitting posture were presented. The participants
again split into small groups and had an opportunity to problem-solve through
workstation solutions of a case presented photographically. Each group presented
their solutions to the entire group. The next 45 minutes were spent on office exercise.
The instructor demonstrated the spine and extremity exercises and the participants had
an opportunity to practice each exercise. The training portion of the session concluded
with a discussion on work practice strategies to decrease risk factors for WMSD.
<table>
<thead>
<tr>
<th>Session 1</th>
<th>Model Construct</th>
<th>Learning Objectives</th>
<th>Program Content/Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity &amp; vulnerability</td>
<td>State the risk factors for WMSD</td>
<td>Causes and impact of upper extremity and neck injuries at computer workstations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perceive the seriousness &amp; potential severity of WMSD</td>
<td>Spinal anatomy and biomechanics</td>
<td></td>
</tr>
<tr>
<td></td>
<td>State the warning signs of WMSD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome expectations</td>
<td>State the principles of body mechanics and workstation design</td>
<td>Principles of body mechanics and workstation design</td>
<td></td>
</tr>
<tr>
<td></td>
<td>State why good design prevents WMSD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy, maladaptive response rewards, &amp; adaptive response costs</td>
<td>Use ergonomic checklist to evaluate workstation</td>
<td>Discussion of participant’s experience</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perceive little reward for not evaluating workstation</td>
<td>Demonstration of use of an ergonomic checklist to identify the presence of risk factors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Perceive relatively little cost for evaluating workstation</td>
<td>Assignment to evaluate workstation with the checklist</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 2</th>
<th>Model Construct</th>
<th>Learning Objectives</th>
<th>Program Content/Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-efficacy, outcome expectations, maladaptive response rewards, &amp; adaptive response costs</td>
<td>Identify ergonomics risk factors at own computer station</td>
<td>Discuss results of workstation evaluation assignment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>State solutions to workstation risk factors</td>
<td>Demonstration of workstation solutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Feel confident in ability to identify and solve workstation risk factors</td>
<td>Group problem-solving of workstation solutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Describe changes in work practices, stretch breaks, and exercises to minimize risk factors</td>
<td>Identify traditional solutions and alternative solutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Complementary preventive strategies-work practices, stretch breaks, exercise</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2 Theoretical Constructs, Learning Objectives, and Activities
Data Collection Procedures

The participants completed the consent form (Appendix A) either during the orientation to the training or when the researcher performed the first workstation assessment. The participants completed the pre-intervention symptom survey (Appendix D), knowledge quiz (Appendix E), and the work organization questionnaire (Appendix F) during the first half hour of the training in the intervention group, or on their own prior to the first workstation assessment in the control group. Post-intervention measures were completed in the same manner.

Two Master of Physical Therapy students from Emory University served as research assistants for the workstation analyses. The students were in their eighth and final semester of the Master of Physical Therapy program. The students had successfully completed their didactic and clinical coursework to date and they possessed the necessary background in observational skills. The students had completed 16 weeks of clinical experience and were eligible to apply for licensure to practice physical therapy in May 2001. The researcher and research assistants completed an ergonomics workstation analysis at each participant’s workstation one to two weeks prior to the training sessions and three days to two weeks after the training sessions. A summary of the administration of the instruments is found in Table 3.3.
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Administered By</th>
<th>Completed By</th>
<th>Completed When</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Factor Exposure Checklist</td>
<td>Trainer</td>
<td>Trainer</td>
<td>Before and after training</td>
</tr>
<tr>
<td>Symptom Survey</td>
<td>Training &amp; Development Department</td>
<td>Participant</td>
<td>Before and after training</td>
</tr>
<tr>
<td>Ergonomic Knowledge Quiz</td>
<td>Training &amp; Development Department</td>
<td>Participant</td>
<td>Before and after training</td>
</tr>
<tr>
<td>Work organization questionnaire</td>
<td>Training &amp; Development Department</td>
<td>Participant</td>
<td>Before and after training</td>
</tr>
<tr>
<td>Process evaluation</td>
<td>Training &amp; Development Department</td>
<td>Participant</td>
<td>After training</td>
</tr>
</tbody>
</table>
CHAPTER 4
ANALYSIS OF THE DATA

Presentation of the data is organized with the descriptive data presented first, followed by the obtained psychometric properties of the measures used in this sample. Finally, the statistical analyses of the hypotheses and the results of additional tests are presented. There were eight primary outcome variables, musculoskeletal symptoms, risk for injury, ergonomics knowledge, self-efficacy, outcome expectations, control and autonomy for workstation alignment, organizational support, and work pressure. All of the variables except musculoskeletal symptoms are interval level variables and are presented together. Musculoskeletal symptoms are an ordinal level variable with three distinct qualities: intensity, duration, and frequency; therefore, symptoms are presented separately from the other seven primary outcomes.

Data Cleaning Procedures

Eighty-seven University of Georgia employees participated in the study. Prior to performing any statistical analyses, the data were visually screened for outliers, missing data, and data entry errors. One outlier was found on the second ergonomics quiz, the score was unusually low (33% correct responses). All scores on all of the other variables were checked for this participant and no other outlying scores were found, therefore, the outlying score was retained. Twenty-five percent of the participants (22 cases) were randomly selected and checked across all variables for data entry errors. Out of 4,730 cells of data only four data entry errors were detected. The data entry error rate was .08 %, indicating great confidence that the data being analyzed in the database are accurate. For those measures requiring hand calculation
of scores (Rapid Upper Limb Assessment and the ergonomics quiz), 25% of the data were checked for calculation errors. All of the ergonomic quiz scores were correct and all but two of the Rapid Upper Limb Assessment (RULA) scores were correct, again indicating great confidence that the scores being analyzed were calculated accurately. All detected errors were corrected.

Participant Characteristics

The sample consisted of 87 University of Georgia employees who work at computer stations more than 10 hours per week. The majority of participants worked for the University libraries; however, participants also came from other locations on campus. Sixty-nine participants (79%) worked at the Main library, six participants (7%) worked at the Science library, two participants (2%) worked at the Law library, five participants (6%) worked at the Georgia Center for Continuing Education, three participants (4%) worked at the University Computing and Networking Services (UCNS), one participant (1%) worked at the Family and Consumer Science Department, and one participant (1%) worked at University Housing. The data were collected from February 26 through April 20, 2001. The primary researcher collected all data with the exception that trained research assistants performed some of the participant workstation observations to obtain the RULA scores. Fifty-eight of the participants were observed by the primary researcher, 13 participants were observed by one research assistant (KH), and 16 participants were observed by another research assistant (TS). Observers rated the same participants on both the pre-test and post-test to the extent possible. All but three participants were rated by the same observer on both the pre-test and post-test. Interrater reliability of the RULA scores was calculated prior to the start of data collection and throughout data collection, the reliability estimates are reported in the section on psychometric properties.
Seventy women and 17 men participated in the study. The age of the participants was equally distributed among the age categories of 18-29 (23%), 30-39 (29%), 40-49 (22%), and 50 and over (26%). The participants were generally well-educated: all participants graduated from high school and had some degree of education beyond high school. Twelve participants (13%) had some college coursework or an Associate’s degree, 39 participants (45%) had a Bachelor’s degree or postgraduate courses, 33 participants (38%) had a Master’s degree, and 3 participants (4%) had a doctoral degree. In general, the participants represented employees with a fair amount of experience at their present job. Forty-eight participants (55%) had been at their present job for more than 3 years, 22 participants (25.5%) had been at their present job between one and three years, and 17 participants (19.5%) had been at their job one year or less.

The level of computer exposure for participants in the intervention and control groups is presented in Table 4.1. The average participant worked at the computer between 20 and 39 hours per week. The daily computer exposure at work for the average participant was 4.1 or more hours. The weekly computer exposure at home for the average participant was between 0 and 10 hours. The lifetime computer exposure for the average participant was greater than three years.
### Table 4.1 Participant Computer Exposure at Work and Home

<table>
<thead>
<tr>
<th>Hours Per Day At Work</th>
<th>Percentage of Sample n = 87</th>
<th>Computer Exposure at Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 2 hours</td>
<td>2 %</td>
<td></td>
</tr>
<tr>
<td>2.1 - 4 hours</td>
<td>20 %</td>
<td></td>
</tr>
<tr>
<td>4.1 – 6 hours</td>
<td>29 %</td>
<td></td>
</tr>
<tr>
<td>6.1 or more</td>
<td>49 %</td>
<td></td>
</tr>
</tbody>
</table>

### Between Group Comparisons at Baseline

Each participant was randomly assigned to one of four training groups. Training groups 1 and 2 received the intervention first while training groups 3 and 4 initially received no training and served as the comparison group.
statistics for the primary interval level outcome measures at baseline for each of the four training groups are presented in Appendix J. The differences between the groups were minimal, ANOVAs were conducted to assess differences between the groups on the primary outcome measures. The assumption of homogeneous variances between the groups was met for all of the primary outcome measures at baseline except three: RULA (3, 83) Levene’s statistic = 2.95, p < .05; ergonomics quiz (3, 79) Levene’s statistic = 4.18, p < .01; and outcome expectations (3, 79) Levene’s statistic = 4.33, p < .01. Due to the essentially equal and adequate sample sizes, the differences in variances between the groups on these three measures were not a concern. The results of the ANOVAs (Table 4.2) show no significant differences between the four training groups on the primary outcomes measured at baseline; therefore, groups 1 and 2 were combined to form the intervention group for subsequent analyses, and groups 3 and 4 were combined to constitute the comparison group.

The Chi-square test for independent samples was used to assess differences between the intervention and control groups on the demographic and computer exposure variables at baseline. No statistically significant differences (p < .05) were found between the intervention and control groups at baseline for age $\chi^2 (3) = .89$, educational level $\chi^2 (5) = 3.56$, tenure at present job $\chi^2 (5) = 4.7$, computer exposure at work in hours per day $\chi^2 (3) = 2.30$, computer exposure at work in hours per week $\chi^2 (3) = 4.15$, computer exposure at home in hours per week, and lifetime computer exposure $\chi^2 (4) = 1.39$. The two groups were significantly different in terms of gender, with more men present in the control group, $\chi^2 (1) = 5.67$, p < .05.
Table 4.2 Analysis of Variance Summary Comparing the Four Training Groups at Baseline

<table>
<thead>
<tr>
<th>Measure</th>
<th>Source</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RULA</td>
<td>Between Groups</td>
<td>3</td>
<td>2.46</td>
<td>1.47</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>83</td>
<td>1.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ergo Quiz</td>
<td>Between Groups</td>
<td>3</td>
<td>.02</td>
<td>2.53</td>
<td>.06</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>79</td>
<td>.008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>Between Groups</td>
<td>3</td>
<td>.86</td>
<td>1.55</td>
<td>.21</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>79</td>
<td>.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome Expectations</td>
<td>Between Groups</td>
<td>3</td>
<td>.59</td>
<td>1.40</td>
<td>.25</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>79</td>
<td>.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control/Autonomy</td>
<td>Between Groups</td>
<td>3</td>
<td>1.66</td>
<td>2.14</td>
<td>.10</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>73</td>
<td>.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Org. Support</td>
<td>Between Groups</td>
<td>3</td>
<td>1.23</td>
<td>.98</td>
<td>.98</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>72</td>
<td>1.25</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work Pressure</td>
<td>Between Groups</td>
<td>3</td>
<td>.14</td>
<td>.37</td>
<td>.78</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>74</td>
<td>.37</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Descriptive statistics for the primary interval level outcome measures recorded at baseline are presented in Table 4.3. The RULA was scored on a 1 - 7 point scale, a higher score indicates greater risk factor exposure. Ergonomic knowledge was measured with a 15-item ergonomics quiz, the score reported is the number of correct responses divided by 15. Self-efficacy was measured with three items scored on a scale from 1 to 6, a higher score indicates greater self-efficacy. Outcome expectations
were measured with three items scored on a scale from 1 to 6, a higher score indicates more confidence in a positive effect of the training. Control and autonomy for workstation design and work organization were measured with three items scored on a scale from 1 to 6, a higher score indicates greater perceived control and autonomy. Organizational support was measured with nine items scored on a scale from 1 to 6, a higher score indicates greater perceived organizational support. Work pressure was measured with six items scored on a scale from 1 to 4, a higher score indicates greater perceived work pressure. With the exception of RULA and the ergonomics quiz, scores were computed by taking the mean of responses to the included items.

Table 4.3 Descriptive Statistics for Interval Level Outcomes at Baseline

<table>
<thead>
<tr>
<th></th>
<th>Intervention Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Min</td>
</tr>
<tr>
<td>RULA</td>
<td>43</td>
<td>3.00</td>
</tr>
<tr>
<td>Ergo Quiz</td>
<td>41</td>
<td>.60</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>41</td>
<td>3.33</td>
</tr>
<tr>
<td>Outcome Expectation</td>
<td>41</td>
<td>4.33</td>
</tr>
<tr>
<td>Control/Autonomy</td>
<td>38</td>
<td>3.67</td>
</tr>
<tr>
<td>Org. Support</td>
<td>37</td>
<td>1.33</td>
</tr>
<tr>
<td>Work Pressure</td>
<td>38</td>
<td>1.33</td>
</tr>
</tbody>
</table>

A t-test for independent samples was used to assess differences between the intervention and control groups on the interval level outcome measures at baseline. The assumption of homogeneous variances between the groups was met for all primary outcome measures except outcome expectations, Levene’s statistic 3.95,
p < .05 and workstation control and autonomy, Levene’s statistic 6.05, p < .05. Due to the essentially equal and adequate sample sizes for the two groups, the differences in variances between the groups were of little concern. The t-tests revealed no statistically significant differences between the intervention and control groups at baseline.

Descriptive statistics for the outcome of musculoskeletal symptoms measured at baseline are presented in Table 4.4. Three distinct qualities of symptoms were measured: intensity, duration, and frequency. Each quality was measured on a 0 – 4 scale with the higher numbers indicative of more severe symptoms. Data were initially collected on eight body areas: head, neck, shoulder/upper arm, elbow/forearm, wrist, hand, upper back, and low back. Regional composite scores were computed to provide an impression of symptoms in a functional region. Scores from the head, neck, and upper back were combined to describe symptoms in the upper spine. Scores from the shoulder/upper arm, elbow/forearm, wrist, and hand were combined to describe symptoms in the upper extremity. Scores from the low back remained a separate region. A review of the means and frequencies for all qualities of symptoms revealed that the region of the head, neck, and upper back was the most commonly and severely involved site. Although fewer participants reported symptoms in the low back (resulting in lower average scores), those who did report low back symptoms, reported more intense and frequent symptoms of longer duration for that region compared to the other two regions. The Mann-Whitney U test was used to assess differences between the intervention and control groups at baseline. No significant differences were found (p < .05) between the groups for intensity of symptoms in the upper extremity (U = 874.5), upper spine (U = 906), or lower spine (U = 879.5); frequency of symptoms in the upper extremity (U = 877), upper spine (U = 882.5), or
lower spine (U = 904.5); or duration of symptoms in the upper extremity (U = 814.5), upper spine (U = 924.5), and lower spine (U = 922).

### Table 4.4 Descriptive Statistics for Musculoskeletal Symptoms at Baseline

<table>
<thead>
<tr>
<th></th>
<th>Intervention Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n  Min  Max  Mean  SD</td>
<td>n  Min  Max  Mean  SD</td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Extremity</td>
<td>43  0.00  1.75 .57 .53</td>
<td>43  0.00  2.50 .70 .74</td>
</tr>
<tr>
<td>Upper Spine</td>
<td>43  0.00  2.33 .77 .72</td>
<td>43  0.00  3.00 .83 .88</td>
</tr>
<tr>
<td>Lower Spine</td>
<td>43  0.00  2.00 .63 .82</td>
<td>43  0.00  3.00 .77 1.0</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Extremity</td>
<td>43  0.00  3.00 .80 .83</td>
<td>43  0.00  3.50 .96 1.06</td>
</tr>
<tr>
<td>Upper Spine</td>
<td>43  0.00  4.00 1.08 1.02</td>
<td>43  0.00  4.00 1.06 1.17</td>
</tr>
<tr>
<td>Lower Spine</td>
<td>43  0.00  4.00 .98 1.32</td>
<td>43  0.00  4.00 .91 1.21</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Extremity</td>
<td>43  0.00  2.75 .60 .62</td>
<td>43  0.00  3.75 .87 .95</td>
</tr>
<tr>
<td>Upper Spine</td>
<td>43  0.00  2.65 .94 .88</td>
<td>43  0.00  4.00 1.08 1.18</td>
</tr>
<tr>
<td>Lower Spine</td>
<td>43  0.00  4.00 .95 1.31</td>
<td>43  0.00  4.00 .93 1.24</td>
</tr>
</tbody>
</table>

**Psychometric Properties of the Measures**

This section describes the estimates of reliability that were obtained from the study sample for the primary outcome measures. The measures are discussed in the order in which they were presented in Chapter 3. A summary of the measures and the reliability coefficients are found in Table 4.5.

The Rapid Upper Limb Assessment (RULA) (McAltamney & Corlett, 1993) was used to measure risk factor exposure at the participant’s computer workstation. A single measure Intraclass Correlation Coefficient (ICC) was calculated as an estimate of interrater reliability. Based on 9 subjects observed before the start of data
collection, the ICC was .74. Based on 3 subjects assessed at the first and last data collection sessions, the ICC during the study was .80.
The ergonomics quiz was created for this study to test knowledge about computer workstation ergonomics. Based on the assessment and input from four content experts as described in Chapter 3, the quiz had content validity. The reliability analysis of the observed test scores revealed an alpha coefficient equal to $0.20$. Although this value is considered an estimate of low internal consistency, no individual items performed poorly from an item analysis perspective. The low alpha coefficient is more likely attributable to low score variance due to relatively easy questions (Crocker & Algina, 1986). The score variance was $0.009$.

The efficacy scale for workstation adjustments was also created for this study. The efficacy scale was intended to measure two factors, self-efficacy and outcome expectations. Exploratory factor analysis using principal axis factoring with varimax rotation was done on the baseline data of all 83 participants responding to the efficacy questions. Two factors were identified based on the criterion of a minimum eigenvalue of one. The two factors accounted for $66.22\%$ of the total variance. Four of the

### Table 4.5 Reliability Estimates of the Interval Level Outcome Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Number of Items</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>RULA</td>
<td>Single overall score</td>
<td>$0.80$</td>
</tr>
<tr>
<td>Ergo Quiz</td>
<td>15</td>
<td>$0.20$</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>3</td>
<td>$0.73$</td>
</tr>
<tr>
<td>Outcome Expectations</td>
<td>3</td>
<td>$0.71$</td>
</tr>
<tr>
<td>Control/Autonomy</td>
<td>3</td>
<td>$0.83$</td>
</tr>
<tr>
<td>Org. Support</td>
<td>9</td>
<td>$0.97$</td>
</tr>
<tr>
<td>Work Pressure</td>
<td>6</td>
<td>$0.78$</td>
</tr>
</tbody>
</table>

Note: All reliability estimates are Cronbach’s alpha coefficients except the RULA score reflects interrater reliability and is an Intraclass Correlation Coefficient.
six items loaded very strongly (.75 or greater) on the intended dimension. Two of the
six items loaded in a complex manner, with factor loadings greater than .30 on both
the self-efficacy and outcome expectations dimensions, but each item had higher
loadings on the expected dimension. The complete factor loadings are found in
Appendix K. Retaining all items yielded alpha coefficients of .73 for self-efficacy and
.71 for outcome expectations.

The work organization questionnaire was intended to measure the three distinct
constructs of control and autonomy for workstation design, work pressure, and
organizational support. Exploratory factor analysis using principal axis factoring with
varimax rotation was done on the baseline data. Three factors were identified based
on the criteria of a minimum eigen value of one. The three factors accounted for
71.21 % of the total variance. All items clearly loaded on one of the primary factors.
The three control and autonomy items loaded on one factor (n=77), the nine
organizational support items loaded on a second factor (n=76), and the six work
pressure items loaded on a third factor (n=78). The complete factor loadings are
found in Appendix L. Based on the reliability analysis of baseline data, the alpha
coefficients for the subscales were .83 for workstation control and autonomy, .78 for
work pressure, and .97 for organizational support.

Hypothesis Testing

ANCOVA procedures were used to test the hypotheses regarding the
effectiveness of the training intervention on the primary interval level outcome
measures. The primary benefit of using analysis of covariance is to statistically
decrease the error variance by using the linear relationship between the covariate and
the dependent variable (Keppel, 1991). Because the decreased error variance may
result in increased power to detect between group differences, the ANCOVA was
chosen to analyze the data. Prior to conducting the ANCOVA, a scatter plot of the
residual and predicted values for each of the primary outcome variables was assessed visually for shape and distribution. The assumptions of linearity, normality, and homoscedasticity appear to have been met given the limitations of the sample size. The assumption of equal group regression slopes was tested with an F test and the results will be discussed later with hypotheses two through seven. The presence of outliers was scanned on the scatter plot and followed up by assessing Cook’s distance. Cook’s distance was less than 1.0 for all data points, all of the data were analyzed in subsequent statistical tests. The pre- and post-intervention means for the primary outcome measures along with the adjusted mean scores are presented in Table 4.6. The adjusted and unadjusted post-test means were very similar because the groups were essentially equal on the pre-test measures.
The first hypothesis stated in the alternative form was: H1: *There will be a difference between the control condition and the AET condition in musculoskeletal symptoms related to work.* Due to the ordinal-level data, the Mann-Whitney U statistic was used to test the first hypothesis. No significant differences were found.
(p < .05) between the groups for intensity of symptoms, frequency of symptoms, or
duration of symptoms in any body region. Refer to Table 4.7 for the Mann-Whitney U
value and the pre- intervention and post-intervention symptoms means. The null
hypothesis that there was no difference in musculoskeletal symptoms between the
control group and the AET intervention group was not rejected.

The remaining seven hypotheses stated in the alternative form were: H2: Risk
factor exposure will decrease more in the AET condition compared to the control
condition. H3: Ergonomics knowledge will increase in the AET condition compared
to the control condition. H4: Ergonomics related self-efficacy will increase in the
AET condition compared to the control condition. H5: Ergonomics related outcome
expectations will increase in the AET condition compared to the control condition.
H6: Perceived organizational support will increase more in the AET condition
compared to the control condition. H7: Workstation control and autonomy will
increase more in the AET condition compared to the control condition. H8: Perceived
work pressure will decrease in the AET condition compared to the control condition.
The data were analyzed to test the assumption of homogeneity of the within-group
regression slopes. ANCOVAs were conducted with an interaction term between the
covariate (pre-test) and the group levels at the .10 alpha level. Three of the seven
primary interval level outcome variables, RULA, ergonomics quiz, and self-efficacy,
showed a statistically significant covariate by group interaction (see Table 4.8).
Table 4.7  Descriptive Statistics and Mann-Whitney Results for Musculoskeletal Symptoms (Hypothesis 1)

<table>
<thead>
<tr>
<th></th>
<th>Intervention Group</th>
<th>Control Group</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>Pre-test Mean (SD)</td>
<td>Post-test Mean (SD)</td>
<td>n</td>
<td>Pre-test Mean (SD)</td>
<td>Post-test Mean (SD)</td>
<td>U</td>
</tr>
<tr>
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</tr>
<tr>
<td>Upper Extremity</td>
<td>43</td>
<td>.57 (.53)</td>
<td>.67 (.74)</td>
<td>43</td>
<td>.70 (.74)</td>
<td>.59 (.63)</td>
<td>787</td>
</tr>
<tr>
<td>Upper Spine</td>
<td>43</td>
<td>.77 (.72)</td>
<td>.69 (.59)</td>
<td>43</td>
<td>.83 (.88)</td>
<td>.79 (.75)</td>
<td>815</td>
</tr>
<tr>
<td>Lower Spine</td>
<td>43</td>
<td>.63 (.82)</td>
<td>.63 (.90)</td>
<td>43</td>
<td>.77 (1.0)</td>
<td>.74 (.99)</td>
<td>798.5</td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper Extremity</td>
<td>43</td>
<td>.80 (.83)</td>
<td>.87 (.96)</td>
<td>43</td>
<td>.96 (1.06)</td>
<td>.90 (.98)</td>
<td>827.5</td>
</tr>
<tr>
<td>Upper Spine</td>
<td>43</td>
<td>1.08 (1.02)</td>
<td>.83 (.77)</td>
<td>43</td>
<td>1.06 (1.17)</td>
<td>1.08 (1.04)</td>
<td>758.5</td>
</tr>
<tr>
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<td>43</td>
<td>.98 (1.32)</td>
<td>.88 (1.26)</td>
<td>43</td>
<td>.91 (1.21)</td>
<td>1.00 (1.47)</td>
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<tr>
<td>Upper Extremity</td>
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<td>.60 (.62)</td>
<td>.86 (.98)</td>
<td>43</td>
<td>.87 (.95)</td>
<td>.73 (.75)</td>
<td>800.5</td>
</tr>
<tr>
<td>Upper Spine</td>
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<td>.94 (.88)</td>
<td>.79 (.67)</td>
<td>43</td>
<td>1.08 (1.18)</td>
<td>1.11 (1.02)</td>
<td>721.5</td>
</tr>
<tr>
<td>Lower Spine</td>
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<td>.95 (1.31)</td>
<td>.75 (1.06)</td>
<td>43</td>
<td>.93 (1.24)</td>
<td>1.07 (1.44)</td>
<td>762.5</td>
</tr>
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</table>
Table 4.8  ANCOVA Results for the Assumption of Equal Group Regression Slopes

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<th>F value</th>
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<td>19.86 **</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>2.83</td>
<td>1.80</td>
</tr>
<tr>
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<td>1</td>
<td>10.07</td>
<td>6.42 **</td>
</tr>
<tr>
<td>Error</td>
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<td>1.57</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ergo Quiz 1</td>
<td>1</td>
<td>.03</td>
<td>4.29 *</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>.09</td>
<td>12.59 **</td>
</tr>
<tr>
<td>Ergo Quiz 1 x Group</td>
<td>1</td>
<td>.06</td>
<td>8.39 **</td>
</tr>
<tr>
<td>Error</td>
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<td>.00</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy 1</td>
<td>1</td>
<td>9.82</td>
<td>35.55 **</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>3.05</td>
<td>11.05 **</td>
</tr>
<tr>
<td>Self-efficacy 1 x Group</td>
<td>1</td>
<td>1.92</td>
<td>6.95 **</td>
</tr>
<tr>
<td>Error</td>
<td>73</td>
<td>.28</td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Outcome Expectation 1</td>
<td>1</td>
<td>2.90</td>
<td>12.60 **</td>
</tr>
<tr>
<td>Group</td>
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<td>.09</td>
<td>.41</td>
</tr>
<tr>
<td>Outcome Expectation 1 x Group</td>
<td>1</td>
<td>.02</td>
<td>.10</td>
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<tr>
<td>Error</td>
<td>74</td>
<td>.23</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control/autonomy 1</td>
<td>1</td>
<td>23.95</td>
<td>82.29 **</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>.00</td>
<td>.00</td>
</tr>
<tr>
<td>Control/autonomy 1 x Group</td>
<td>1</td>
<td>.00</td>
<td>.01</td>
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<tr>
<td>Error</td>
<td>69</td>
<td>.29</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organizational Support 1</td>
<td>1</td>
<td>62.62</td>
<td>177.41 **</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>.57</td>
<td>1.62</td>
</tr>
<tr>
<td>Org. Support 1 x Group</td>
<td>1</td>
<td>.34</td>
<td>.95</td>
</tr>
<tr>
<td>Error</td>
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<td>.35</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work Pressure 1</td>
<td>1</td>
<td>17.36</td>
<td>163.78 **</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>.05</td>
<td>.48</td>
</tr>
<tr>
<td>Work Pressure 1 x Group</td>
<td>1</td>
<td>.03</td>
<td>.25</td>
</tr>
<tr>
<td>Error</td>
<td>69</td>
<td>.11</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The designation “1” refers to measurements taken at baseline.
* p < .05, ** p < .01

For RULA, a graph of the relationship between the pre-test (RULA 1) and the post-test (RULA 2) for each group clearly shows that the relationship between RULA 1 and RULA 2 was not the same for each group, that is, the slopes were not
homogeneous (Figure 4.1). The regression lines for the two groups intersected at a RULA score of 3.26. Participants in the intervention group with high RULA scores (greater risk) before the intervention had a greater decrease in scores post-intervention than participants with low RULA scores (lower risk). The Johnson-Neyman procedure was used to determine the point at which the difference between the two groups was statistically significant. Participants in the intervention group scoring 4.62 or higher on RULA 1 demonstrated a statistically significant decrease in their risk for musculoskeletal injury after the intervention compared to the control group. Thus, null hypothesis 2, that there was no difference in risk factor exposure between the AET condition compared to the control condition, was rejected for participants with baseline RULA scores of 4.62 or higher.

A similar graph for the ergonomics quiz pre-test (ergonomics quiz 1) and post-test (ergonomics quiz 2) for each group clearly shows that the relationship between ergonomics quiz 1 and ergonomics quiz 2 was not the same for each group (Figure 4.2). The regression lines for the two groups intersected at a score of 1.03, indicating a score of over 100% correct responses. The Johnson-Neyman procedure was used to determine the point at which the difference between the two groups was statistically
significant. Participants in the intervention group with a score of 96% or less on the ergonomics quiz demonstrated a significant increase in knowledge after the training compared to the control group. In practice, this means that participants scoring less than 100% showed a statistically significant increase in knowledge because the quiz had a total of only 15 points and each question was valued at 1 point. Null hypothesis 3, that there was no difference in ergonomics knowledge between the AET condition compared to the control condition, was rejected for participants scoring less that 100% on the baseline ergonomics quiz.

![Figure 4.2 Group by Ergonomics Quiz Interaction (Hypothesis 3)](image)

As shown in Figure 4.3, the relationship between pre-intervention self-efficacy (self-efficacy 1) and post-intervention self-efficacy (self-efficacy 2) was not the same for each group. The regression lines for the two groups intersected at a self-efficacy score of 5.98. The Johnson-Neyman procedure was used to determine the point at which the difference between the two groups was statistically significant. Participants in the intervention group with baseline scores of 5.38 or lower on the six-point self-efficacy scale demonstrated a statistically significant increase in self-efficacy following the intervention. Null hypothesis 4, that there was no difference in ergonomics related self-efficacy between the AET condition compared to the control
condition, was rejected for participants scoring 5.38 or less on the baseline self-efficacy survey.

![Graph showing self-efficacy](image)

Figure 4.3 Group by Self-Efficacy Interaction (Hypothesis 4)

The measures that met all of the ANCOVA assumptions were further tested: outcome expectations, workstation control and autonomy, organizational support, and work pressure. These measures were associated with hypotheses five through eight. The results of these analyses are summarized in Table 4.9. The results indicate that all of the baseline measures (covariates) were significant predictors of the dependent variables, the post-intervention measures. Post-intervention outcome expectations were significantly higher in the intervention group compared to the control group, $F(1,75) = 15.57$, $p < .001$. The effect size was moderate, $\eta^2 = .10$. Ten percent of the adjusted variability in outcome expectations can be attributed to the AET intervention. Thus, null hypothesis 5, that there was no difference in ergonomics related outcome expectations between the AET condition compared to the control condition, was rejected. There were no statistically significant differences in the post-intervention organizational measures between the groups. Thus null hypothesis 6, that there was no difference in perceived organizational support between the AET
condition compared to the control condition; null hypothesis 7, that there was no
difference in participation between the AET condition compared to the control
condition; and alternative hypothesis 8, that there was no difference in perceived work
pressure between the AET condition compared to the control condition, were all
accepted.
Table 4.9 ANCOVA Summary Table for Interval Level Outcome Measures (Hypotheses 5, 6, 7, & 8)

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>df</th>
<th>Mean Square</th>
<th>F value</th>
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<td>15.57 **</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>1.99</td>
<td>8.75 **</td>
</tr>
<tr>
<td>Error</td>
<td>75</td>
<td>.23</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control/Autonomy 1</td>
<td>1</td>
<td>30.67</td>
<td>106.91 **</td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>.14</td>
<td>.48</td>
</tr>
<tr>
<td>Error</td>
<td>70</td>
<td>.29</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organizational Support 1</td>
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<td>62.31</td>
<td>176.64 **</td>
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<td>.60</td>
<td>1.71</td>
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<tr>
<td>Error</td>
<td>69</td>
<td>.35</td>
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</tr>
<tr>
<td>Total</td>
<td>72</td>
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<td></td>
</tr>
<tr>
<td>Work Pressure 1</td>
<td>1</td>
<td>18.03</td>
<td>171.98 **</td>
</tr>
<tr>
<td>Group</td>
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<td>.09</td>
<td>.90</td>
</tr>
<tr>
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<td>.10</td>
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<tr>
<td>Total</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The designation “1” refers to measurements taken at baseline.
* p < .05, ** p < .01

Additional Analyses

In addition to the primary outcome measures, other data were collected to provide further insight into the findings. At the time that participants in both groups completed the second comfort survey, they were asked about any changes in their workstation, work organization, or exercise practices since the first workstation analysis. A significantly greater proportion of participants in the intervention group
had made changes to their workstation, work organization, and their general exercise practice. Interestingly, a significantly greater proportion of participants in the intervention group had requested workstation equipment, but there was no significant difference between the groups in the proportion of participants who received workstation equipment. There was also no significant difference between the groups in the proportion of participants who had observed coworkers making workstation changes. These findings are summarized in Table 4.10.

The process evaluation was based on the standard forms used by the UGA Training and Development Department. Participants rated the instructor on the extent to which each of the five primary course objectives were covered. The ratings ranged from 1 to 5, 1 was defined as poor, 3 as moderate, and 5 as very well. The following overall course objectives were evaluated by the participants: 1) State the risk factors for musculoskeletal disorders; 2) State the warning signs of musculoskeletal disorders; 3) Use an ergonomic checklist to identify physical stressors at the workstation; 4) Identify and implement solutions to correct physical stressors at the workstation; 5) Describe work organization strategies and exercises to prevent musculoskeletal disorders. Descriptive statistics of the ratings by group for each objective are presented in Table 4.11. The average ratings per objective are high (> than 4.0), indicating that the course material was adequately covered. A t-test was conducted to assess the differences between the group means, there were no statistically significant differences (p < .05) between the two training groups for the objectives. The t-test results are also presented in Table 4.11.
<table>
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<th>Control Group</th>
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<th>df</th>
<th>n</th>
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<td>No</td>
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<td>73 %</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>33.17**</td>
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<tr>
<td>Work Organization Change</td>
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<td>8 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>35 %</td>
<td>92 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td>1</td>
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</tr>
<tr>
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<td>8 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>30 %</td>
<td>92 %</td>
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<td></td>
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<tr>
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<td></td>
<td></td>
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<td>1</td>
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<tr>
<td>Equipment Requested</td>
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<td>15 %</td>
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</tr>
<tr>
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<td></td>
<td></td>
<td>9.83**</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
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<td>17 %</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>No</td>
<td>70 %</td>
<td>83 %</td>
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<td>81</td>
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<td>30 %</td>
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</tr>
<tr>
<td></td>
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<td>65 %</td>
<td>70 %</td>
<td></td>
<td></td>
</tr>
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<td>.23</td>
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** ** p < .01
Table 4.11 Descriptive Statistics and t-test Results for the Process Evaluation

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<td>Max</td>
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</tr>
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<td>3.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Ergonomic Checklist</td>
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<td>4.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Workstation Solutions</td>
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<td>3.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Exercise &amp; Work Org.</td>
<td>18</td>
<td>3.00</td>
<td>5.00</td>
</tr>
</tbody>
</table>

Summary of Results

Eighty-seven University of Georgia employees participated in the active ergonomics training study. All of the participants worked at a computer for a minimum of 10 hours per week, but the typical exposure was much higher. On average, the participants worked at the computer 4.1 or more hours per day and between 20 and 39 hours per week. The intervention and control groups were not significantly different at baseline with respect to the demographic variables and the scores on the outcome measures, with one exception. The control group included more men compared to the intervention group.

The reliability of all of the outcome measures used in the study was calculated for this study sample, with the exception of the comfort survey. Psychometric properties of the comfort survey were not assessed because pain ratings were expected to vary across the three weeks of the study so measures of reliability were inappropriate. All of the outcome measures, except the ergonomics quiz, performed
well, with Cronbach’s alpha coefficients of .70 or higher. The interrater reliability for RULA scores was .80. Most participants scored well on the ergonomics quiz (sample mean = 84 %) and the variance of scores was very small (.009). These factors may explain the .20 estimate of internal consistency for the ergonomics quiz.

The two research questions addressed by this research were: 1) What are the effects of an active ergonomics training (AET) intervention on changes in musculoskeletal symptoms related to work, risk factor exposure, self-efficacy, outcome expectations, and knowledge level? 2) What are the effects of an AET intervention on psychosocial and work organization factors? Statistical testing of the hypotheses associated with the first research question found no significant effect of the AET intervention on frequency, duration, or intensity of musculoskeletal symptoms across the short timeframe of the study. However, AET did have significant and positive effects on ergonomics knowledge, self-efficacy, outcome expectations, and risk factor exposure. Ergonomics knowledge increased significantly for all participants in the intervention group scoring less than 100 % on the pre-test. Self-efficacy increased significantly for all participants in the intervention group scoring 5.38 or less on the pre-test. Outcome expectations were increased significantly for all participants in the intervention group following the training. Risk factor exposure was reduced significantly for all participants in the intervention group with higher levels of risk (RULA score of 4.62 and above). The finding of decreased risk post-intervention is consistent with the Chi-square finding indicating that significantly more people in the intervention group made physical changes to their workstation. Additionally, participants in the intervention group were successful at decreasing their risk for injury in the absence of receiving more equipment or workstation accessories than participants in the control group.

There were no significant differences between the intervention and control groups for workstation control and autonomy, organizational support, and work
pressure following the training. The beneficial effects of the AET intervention appear to be related to individual factors. In addition to the benefits of increased knowledge, increased ergonomics-related efficacy, and decreased risk for injury, the AET intervention had a positive impact on the way employees organized their work and on the initiation of exercise.
CHAPTER 5
DISCUSSION AND RECOMMENDATIONS

This final chapter is organized in four sections. In the first two sections the findings and conclusions of the study are discussed. Next, limitations of the research are presented. The final section consists of recommendations for future research based on the knowledge and experience gained from this study.

Discussion

The principal purpose of this research was to assess the effectiveness of the AET intervention. The AET intervention was somewhat unique in that the participants were taught to analyze their own workstations and identify potential solutions for any ergonomic stressors. Key elements of the AET intervention were skill development in workstation analysis, active participation, and integration of multiple prevention strategies.

AET Training Effectiveness

The effects of AET were dependent on the obtained baseline scores for three of the outcome measures: ergonomics knowledge, self-efficacy, and risk factor exposure. These findings may reflect ceiling effects for the measures used or simply that participants who started with high levels of ergonomic knowledge and self-efficacy, and low levels of injury risk did not benefit appreciably from the AET intervention. However, these findings also suggest that the majority of participants benefited from the AET intervention. For ergonomic knowledge, the results show that participants
who scored less than 100% on the baseline quiz (94% of the participants) benefited from the AET training. For self-efficacy, participants with baseline scores of 5.38 or less on a 6-point scale (82% of the participants) benefited from the AET training. The risk of musculoskeletal injury was assessed with the 7-point RULA scale. Participants with baseline RULA scores or 4.62 or above (85% of the participants) benefited from the AET intervention.

The finding of increased knowledge after training was expected and is consistent with other studies of ergonomics training in the literature (King, Fisher, & Garg, 1997; Rizzo, Pelletier, Serxner, & Chikamoto, 1997; Robertson & Robinson, 2000). The importance of this finding is that knowledge of proper workstation design and work practices is believed to be a prerequisite to safe work behaviors necessary to prevent injury. In addition to prerequisite knowledge, self-efficacy and outcome expectations are strong antecedents for behavior (Bandura, 1986; Rogers & Prentice-Dunn, 1997). The finding of increased self-efficacy after AET training adds new knowledge about the effects of ergonomics training. The finding that outcome expectations for workstation changes significantly increased after AET training also provides new knowledge about the effects of ergonomics training. The increase in outcome expectations post-intervention was not dependent on baseline expectations scores. Neither the data nor the literature provides much explanation for why the effect of training was more homogeneous for outcome expectations than self-efficacy. Baseline self-efficacy was slightly lower and more variable than baseline outcome expectations, perhaps characteristics of the sample or the sample size account for the differences.

Measurement of musculoskeletal injury risk with the use of RULA reflects the physical workstation, the employee’s behavior, and the job itself. It is not enough for employees to simply have “ergonomically” designed workstations, but employees must also be in good physical alignment at their workstation and use safe work
practices in order to have low risk for injury. In fact, a fundamental tenet of the science of ergonomics is that the person and the workplace conditions comprise an interactive and interdependent system (NIOSH, 1997). Based on the knowledge that the job itself did not change from pre- to post-intervention and that there was no significant change in workstation equipment, the decreased risk for injury can be attributed to a change in employee behavior. Participant-reported changes were primarily adjustments to the chair, or altered placement of the monitor, keyboard, and mouse, or increased frequency of microbreaks. Employees in the intervention group altered their workstations, work postures, and work practices in a positive way following the AET intervention. This positive change in behavior is consistent with the increase in self-efficacy and the more positive outcome expectations for making workstation changes seen post-intervention. The finding that this behavioral change resulted in decreased risk in only participants initially at higher risk for musculoskeletal injury is understandable. If an employee is already at low risk for injury, there is little room for improvement. The practical application of this finding is that workstation assessments can detect employees at high risk for musculoskeletal injury and then intensive, problem-solving training can be effectively targeted at those high-risk employees.

There have been few published studies on ergonomics training in this population of workers. Robertson and Robinson (2000) reported on the systematic evaluation of office ergonomics training programs in two companies. They found significant improvements in self-reported and observed workstation changes consistent with the findings in the current research study. Brisson, Montreuil, and Punnett (1999) in their study of a similar six-hour ergonomics training program also reported improvements in postural stressors measured by observation following ergonomic training for computer users.
The results indicate that the AET intervention did not significantly alter the frequency, duration, or intensity of musculoskeletal symptoms. The perception and measurement of pain is a complex issue (McDowell & Newell, 1996). Two mechanisms are thought to be responsible for pain production, mechanical forces and chemical irritation (Wyke, 1976). Pain produced by the application of mechanical forces occurs when the stress or deformation of musculoskeletal tissue is sufficient to irritate nociceptive receptors, as in prolonged sitting or typing. When the tissue deformation is terminated, the pain readily disappears (McKenzie, 1981). Pain can also be produced by the release of irritating chemical substances from traumatized or inflamed tissue. If the tissues are allowed to heal, the tissues will progress beyond the inflammatory state and the pain will diminish within 5 to 20 days (McKenzie, 1981).

One possible explanation for why an improvement in symptoms did not occur is that the follow-up period was short and somewhat variable. The post-intervention comfort survey was administered to the participants at the end of the last training session with instructions that the completed survey would be picked up during the final workstation analysis that occurred one to two weeks later. Participants could have completed the comfort survey at any time from the day of the training up to two weeks following the training. This variation in survey completion may have attenuated any changes in symptoms, in that, working at a properly adjusted workstation for one to 14 days may not be enough time for the symptoms to subside. Another possible explanation for the finding is that the mean scores for intensity, frequency, and duration of symptoms were low (1.08 or less on a 0-4 scale), indicating mild pain, and the dispersion around the mean was relatively large (approximately equal to the mean). The combination of mild symptoms and a large variability in level of symptoms within the groups may help to explain why the groups did not differ from each other on symptoms after the AET intervention. A third explanation for the finding is that the intervention or administration of the survey increased awareness and reporting of symptoms due to
the novelty of being asked about symptoms in the workplace. As one participant in this study wrote on the survey, “In the original survey I think I said I did not have as many of these symptoms. The ergonomics training made me aware of them and what may be causing them.” This explanation has been invoked by other researchers when faced with similar results (Schoenmarklin, 1994). Perhaps follow-up surveys over six months to one year are necessary to detect beneficial effects of the training. Other researchers have reported a reduction in symptoms for employees less than 40 years old measured at six-months post-ergonomics training (Brisson et al., 1999). A fourth explanation for the obtained results is that the musculoskeletal symptoms may have been related to non-work related activities, such as gardening and recreational activities. Perhaps changes in these activities overshadowed changes in work activities. A longer follow-up would allow the investigation of the stability of symptoms over time.

A second purpose of this research was to assess the effects of an AET intervention on psychosocial and work organization factors. The data revealed no significant differences between the intervention and control groups for workstation control and autonomy, organizational support, and work pressure after the AET intervention. These findings may indicate that the benefits from the AET training related to attitudes toward the job and the organization are more long-term benefits and were not detected in the short timeframe of the study. Another possible explanation for the findings is that one training program alone is an inadequate amount of training to produce beneficial effects on attitudes toward the job and the organization.

**AET Effectiveness and the Ecological Model**

Interpretation of the findings within the context of Sauter and Swanson’s theoretical model for the development of musculoskeletal disorders further advances the understanding of the management of WMSDs. The model predicts that physical
demands indirectly affect musculoskeletal outcomes and that individual factors moderate the effect of physical demands on musculoskeletal outcomes. The AET intervention was aimed at increasing individual knowledge, beliefs, and skills regarding workstation ergonomics. The AET intervention was generally effective in increasing those individual factors. The gain in knowledge, beliefs, and skills were translated into behavior that resulted in workstation changes. The workstation changes lead to decreased physical demand as measured by RULA, but did not result in a decrease in musculoskeletal symptoms. Sauter and Swanson’s model also predicts that work organization factors indirectly affect musculoskeletal outcomes and that individual factors moderate the effect of work organization factors on musculoskeletal outcomes. The individual gain in knowledge, beliefs, and skills following the AET intervention did not result in a change in the work organization outcomes of organizational support, work pressure, and workstation control and autonomy as predicted by the model. These results suggest that individual factors can moderate physical demands, but not work organization factors. Work organization outcomes may be beyond individual control and may be influenced more by management practices.

Essential Elements of Ergonomics Training

The present study provides some insight into the elements of successful ergonomics training. The AET intervention focused on increasing individual knowledge, beliefs, and skills within an environment that supported ergonomics programs. One of the essential elements of the AET intervention was skill development in workstation analysis through problem-solving. Problem-solving has been recommended by NIOSH as a method for building employee expertise in ergonomics (NIOSH, 1997). The AET study is one of the few training interventions for computer users to incorporate employee problem-solving with respect to ergonomic analysis and workstation design. A second essential element of the AET
intervention was active participation. The active participation element of the AET intervention is subsumed under the general heading of participatory ergonomics in that worker participation in analyzing and changing the workstation was encouraged. The finding in this study of employee changes at their workstations following the intervention is consistent with the findings of a participatory ergonomics intervention implemented in an office environment (Vink et al., 1995). One difference between participatory ergonomics intervention and the AET intervention is that participatory ergonomics interventions are often aimed at the development of employee teams and the interaction between the teams and management (Lanoie & Tavenas, 1996; Noro & Imada, 1991), the AET intervention was aimed at the individual. This difference may partially explain why the AET intervention was not effective in changing culturally shared beliefs of organizational support, workstation control and autonomy, and work pressure.

**The Rapid Upper Limb Assessment Instrument**

Experience with RULA, based on over 200 observations during this study, provided insights into the use of RULA as a risk assessment tool. The advantage of RULA is that it is relatively simple to use for people trained in observation. A criticism of RULA is that the scoring is subjective based on the rater’s judgments about the position of joints and body regions. A fair amount of effort is required to attain good reliability. The raters in this study achieved good reliability with RULA by identifying and addressing the following decision points. One of the first decisions to be made by the rater is which participant activities will be included in the observation. Some library employees had very repetitive jobs that required the employee to do nearly the same motions all day, but other employees, for example reference librarians, had a variety of tasks at the computer. When the five-minute observation for RULA was done, the employee was asked if the tasks they were doing at the time of the observation were representative of the majority of their tasks at the
computer. All observations were based on tasks that the participants did routinely at their workstations. The raters agreed that any activity that occurred regularly during the observation were included in the observation. The decisions related to rating specific joints and body positions with RULA are often guided by specific range of motion recommendations by McAltamney and Corlett (1993). However, there are some regions that have no specific range of motion guidelines, requiring the raters to further operationally define criteria for rating in order to achieve an acceptable level of interrater reliability. For example, in the upper arm composite score, how much shoulder elevation or abduction is necessary to be considered as present and be scored 1? For this study, shoulder elevation was defined as being present if it was judged to be extreme or severe, as in cradling the phone between the ear and shoulder. The rationale for this definition is that some people have a mild amount of asymmetry in shoulder elevation whether they are sitting at the workstation or standing. The severe amount of shoulder elevation was chosen as the criterion to exclude any common postural aberrancy and to be able to attribute the score to work activities. For shoulder abduction, an angle greater than 30 degrees was judged as abducted and given a score of 1. The rationale was based on the “loose packed position” of the joint being 20-30 degrees of abduction (in the plane of the scapula) and beyond that range, joint compression and muscle tension increase. Identifying and clarifying these decisions helped the research team to achieve an acceptable level of interrater reliability.

Conclusions

An AET intervention for computer users was developed based on recommendations for training and ergonomics programs from the literature. Key elements of the training leading to successful outcomes were a work environment supportive of ergonomics programs, skill development in workstation analysis through problem-solving, active participation, and integration of multiple prevention strategies.
The AET intervention was effective in improving individual attitudes, knowledge, and behavior related to workstation ergonomics. By changing employees’ workstation alignment, work postures, and work practices, the AET intervention was effective in decreasing risk factor exposure for musculoskeletal injury in computer users as measured by RULA. Workstation assessments with RULA detected employees who were at high risk for injury. Results from this study provide evidence that high risk employees benefit from problem-solving, participative training. A practical recommendation resulting from this study is that resources should be allocated to identify employees at high risk for musculoskeletal injury and then provide additional training. There was no significant effect of the AET intervention on frequency, duration, or intensity of musculoskeletal symptoms, workstation control and autonomy, organizational support, and work pressure. Comfort surveys administered over six months to a year may be needed to detect potential changes in symptoms. The addition of a team-building component with management may be beneficial to address shared beliefs, such as organizational support.

RULA was a valuable tool for assessing risk for musculoskeletal injury. With additional criteria for rating and extensive practice, RULA was a reliable instrument. While RULA is relatively simple to use and can be completed in 5 to 10 minutes per workstation, workstation assessment of all employees is time-consuming and therefore, costly.

**Limitations**

The length of time for data collection affects the outcomes that can be measured and potentially the study findings. The short time frame of this study necessitated the use of surrogate measures for musculoskeletal injury. Musculoskeletal symptoms and risk factor exposure are useful and widely used surrogate measures, but if the data collection period could be extended to two to five
years, the effect of AET on injury rates and organizational outcomes could be investigated. The short time frame of the study may have influenced the outcomes attained. It is possible that the short-term effects of the AET intervention, those measured in this study, will be different than the long-term effects. For instance, with a longer follow-up period, a change in symptoms or shared organizational beliefs may appear and the decreased risk factor exposure may attenuate.

Field research affords the opportunity to investigate intervention outcomes with employees in a real work environment, not just subjects in a laboratory setting. However, an inherent limitation of field research is that features of an environment are uncontrolled and unmeasured. It is possible that characteristics of the environment or the participants, other than those measured, interacted with the intervention to produce positive training effects. The computer work tasks of the participants were representative of the spectrum of tasks across computer users, some participants had highly repetitive tasks and other participants had more variety in their job tasks, but the majority of participants were from one workplace, the University of Georgia Libraries. The strong experimental design of this study allows one to draw conclusions of intervention effectiveness for this sample, but further research of the AET intervention in other work settings is necessary.

A final limitation of the study was that the raters for the workstation observation with RULA were not blinded to the participant’s group assignment. Due to the financial and resultant personnel limitations, the researcher who conducted the training was also responsible for conducting workstation observations. However, the high interrater reliability throughout the study provides strong evidence that all participants were assessed consistently and no rater bias was present.
Recommendations for Future Research

This research begins to fill an identified gap in the occupational safety and health literature regarding effective interventions to prevent WMSD. However, in order to fully answer the question regarding AET intervention effectiveness it is necessary to include the study of distal outcomes, such as incidence of musculoskeletal injury and cost effectiveness. The ability to determine musculoskeletal injury would be enhanced with a physical examination conducted by additional personnel. Study of distal outcomes would require a three to five year time frame. The longer time frame would also allow investigation into the duration of the behavior change resulting in decrease risk. That is, will the drop in RULA scores be maintained over time or is a booster session required to sustain the benefit gained from the initial training?

The replication of this study with other populations in need of ergonomics training for computer workstations, such as insurance claim representatives and data entry operators is necessary. Employees who are currently receiving medical care for WMSDs are particularly in need of training. Will the AET intervention work equally well with a group of injured workers? The AET intervention should be beneficial for any employee who uses a computer extensively and who does not share their workstation, but this study only addressed one sample that was not receiving medical care. Using a recruitment strategy that involved random selection of participants and inclusion of injured workers would help to increase the generalizability of the results.

An interesting question resulting from this study is, what is the effect of diffusion of ergonomics information within the organization on risk for musculoskeletal injury? After baseline measures were taken, approximately one third of the participants in both groups reported observing coworkers making workstation changes. Can the diffusion process be used to enhance the training effect? Perhaps
developing formal and informal mechanisms for diffusion within the organization can improve overall benefits.
1. REFERENCES


APPENDIX A
INFORMED CONSENT FORM

I agree to participate in the research titled "Effectiveness of an Active Ergonomics Training Program for Computer Users". This research is being conducted by Brenda Greene, Department of Health Promotion and Behavior, (706) 583-0692 under the direction of Dr. Dave DeJoy, Department of Health Promotion and Behavior, (706) 542-4368. I understand that my participation is entirely voluntary; I can withdraw my consent at any time without penalty and have the results of the participation, to the extent that it can be identified as mine, returned to me, removed from the research records, or destroyed.

The purpose of the research is to study the effectiveness of an ergonomics training program to prevent musculoskeletal disorders in computer users. A unique ergonomics training program is being studied to determine the effect of the training on risk factor exposure, musculoskeletal symptoms, confidence in the ability to change the workstation, and knowledge level. Ergonomics training may affect other factors, such as, organizational support and work pressure. By participating in this research study I may benefit by increased awareness of ergonomic risk factors and increased skill in strategies to minimize those risks.

My participation will involve attending a six-hour ergonomics training program and completing questionnaires two or three times during the course of the study. The questionnaires can be completed in thirty minutes or less. Additionally, two workstation ergonomic analyses will be conducted at my workstation. The workstation analysis will take approximately ten minutes each time.

No serious discomforts or stresses are anticipated. Participants may experience minor discomfort from being observed at their workstation or they may feel some minor, temporary discomfort in the back or extremities from adjusting computer equipment. Participants will be instructed in proper body mechanics to minimize the likelihood of muscular discomfort. No risks are foreseen.
My responses are confidential and will only be presented with other participant responses in a grouped format. The results of this participation will be confidential, and will not be released in any individually identifiable form without my prior consent, unless otherwise required by law.

The researcher will answer any further questions about the research, now or during the course of the project, and can be reached by telephone at (706) 583-0692.

________________________________________
Signature of Researcher  Date

________________________________________
Signature of Participant  Date

Research at the University of Georgia that involves human participants is overseen by the Institutional Review Board. Questions or problems regarding your rights as a participant should be addressed to Julia D. Alexander, M.A., Institutional Review Board, Office of the Vice President for Research, University of Georgia, 606A Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-6514; e-Mail Address JDA@ovpr.uga.edu.
November 7, 2000

Dr. David DeJoy
Asst. to the Dean
School of Health and Human Performance
Aderhold

Dear Dr. DeJoy:

This letter is to notify you that yesterday, November 6, 2000, I met with Brenda Greene to discuss the University Libraries participation in her dissertation project.

For the past several years, the Libraries has begun to explore ways to deal with ergonomic issues especially in the area of workstation health. We have over 300 employees, the bulk of whom spend a large portion of their day sitting at a computer terminal. When Ms. Greene’s research was presented to me, I knew that the Libraries would be an excellent laboratory for her study. We enthusiastically agree to participate in the project.

As I understand it through my discussion with Ms. Greene, this will involve the identification of at least 30 individuals (perhaps more depending on interest from our employees). These individuals will undergo six (6) hours of ergonomics training plus pre and post training workstation observations and questionnaires.

I look forward to working with Ms. Greene on this project and am happy to facilitate and coordinate her work in the Libraries in any way that I can.

Sincerely,

Florence E. King
Assistant University Librarian for Human Resources

Athens, Georgia 30602-1641 • (706) 542-0626 • FAX: (706) 542-4144
An Equal Opportunity/Affirmative Action Institution
# APPENDIX C

## RAPID UPPER LIMB ASSESSMENT SCORING FORM

<table>
<thead>
<tr>
<th>Upper Arm</th>
<th>UA (1-6)</th>
<th>Table A Posture Score (1-9)</th>
<th>Static</th>
<th>Load</th>
<th>Score C</th>
</tr>
</thead>
<tbody>
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<td></td>
<td>20/20 21-45 46-90 &gt;90</td>
<td></td>
<td>&lt;2hr</td>
<td>&gt;2hr</td>
<td>&lt;4hr</td>
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<td>(0)</td>
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<td>(0)</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>4-6hr</td>
<td>&gt;6hr</td>
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<tr>
<td>Elevtn</td>
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<tr>
<th>Lower Arm</th>
<th>LA (1-3)</th>
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<td>60-100 &lt;60 &gt;100</td>
</tr>
<tr>
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<td>(1) (2) (2)</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>Across Mid</td>
<td>(0) (1)</td>
</tr>
<tr>
<td>Out to side</td>
<td>(0) (1)</td>
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<table>
<thead>
<tr>
<th>Wrist</th>
<th>W (1-4)</th>
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<td>0 0-15 &gt;/</td>
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<tr>
<td>&gt;15&gt;/</td>
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<tr>
<td>(1) (2) (3)</td>
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<tr>
<th>RD/UD</th>
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<tr>
<td>(0) (1)</td>
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<th>Wrist Twist</th>
<th>Mid End</th>
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<tbody>
<tr>
<td>(1) (2)</td>
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</tbody>
</table>

| Pro/Sup    | |
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RAPID UPPER LIMB ASSESSMENT SCORING FORM

<table>
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<tr>
<th>Neck</th>
<th>Neck (1-6)</th>
<th>Static</th>
<th>Load</th>
<th>Score D</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>11-20</td>
<td>&gt;20</td>
<td>In /</td>
<td>&lt;2h</td>
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<tr>
<td>√ /</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>No</td>
<td>Y</td>
<td></td>
<td></td>
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<tr>
<td>Rotat’n</td>
<td>(0)</td>
<td>(1)</td>
<td></td>
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<tr>
<td>SBend</td>
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<tr>
<th>Trunk</th>
<th>Supp0</th>
<th>0-20</th>
<th>21-60</th>
<th>&gt;60</th>
<th>Trunk (1-6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>√ /</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
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<tr>
<td>No</td>
<td>Y</td>
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<tr>
<td>Rotat’n</td>
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<td>SBend</td>
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<tr>
<th>Legs</th>
<th>Supp &amp; bal</th>
<th>No t S &amp; bal</th>
<th>Legs (1-2)</th>
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</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
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</tbody>
</table>

Total RULA Score _______________ Side Observed _______________
Evaluator ___________ Date_______ Activity Observed _______________
APPENDIX D
PRE-INTERVENTION SYMPTOM SURVEY

1. In the past year (or since you started this job, if you have been working here less than a year) have you had fatigue, pain, aching, stiffness, burning, numbness, or tingling in your head, neck, back, shoulder/upper arm, elbow/forearm, wrist, or hand?

[   ] Yes      [   ] No

If you answered “No” to question 1, skip to question 5.

2. For only those area(s) in which you have had symptoms, please check how often you have experienced the fatigue, pain, aching, stiffness, burning, numbness, or tingling in the past week.

<table>
<thead>
<tr>
<th></th>
<th>Once</th>
<th>Twice</th>
<th>3 to 6 days</th>
<th>Everyday</th>
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</thead>
<tbody>
<tr>
<td>Head</td>
<td></td>
<td></td>
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<tr>
<td>Neck</td>
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</tr>
<tr>
<td>Shoulder/Upper Arm</td>
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<tr>
<td>Elbow/Forearm</td>
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<tr>
<td>Wrist</td>
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<tr>
<td>Hand</td>
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<td>Upper Back</td>
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<tr>
<td>Lower Back</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. For **only** those area(s) in which you have symptoms, how long have these symptoms typically lasted **in the past week**?

<table>
<thead>
<tr>
<th></th>
<th>Less than 1 hour</th>
<th>One hour up to 1 day</th>
<th>More than 1 day up to 3 days</th>
<th>More than 3 days up to 1 week</th>
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</thead>
<tbody>
<tr>
<td>Head</td>
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<td>Neck</td>
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<tr>
<td>Shoulder/Upper Arm</td>
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<td>Elbow/Forearm</td>
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<tr>
<td>Wrist</td>
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<td>Lower Back</td>
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</tbody>
</table>
4. For **only** those area(s) in which you have symptoms, describe the typical intensity of the fatigue, pain, aching, stiffness, burning, numbness, or tingling **during the past week**.

<table>
<thead>
<tr>
<th>Area</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Worst ever</th>
</tr>
</thead>
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5. How many hours per day do you usually spend working on the computer at work?

- [ ] 0 - 2 hours
- [ ] 2.1 - 4 hours
- [ ] 4.1 - 6 hours
- [ ] 6.1 or more hours

6. How many hours per week do you usually spend working on the computer at work?

- [ ] 10 - 19 hours
- [ ] 20 - 29 hours
- [ ] 30 - 39 hours
- [ ] 40 or more hours
7. How many hours per week do you usually spend working on the computer at home?

[ ] 0 hours per week
[ ] 1 - 10 hours per week
[ ] 11 - 20 hours per week
[ ] 21 hours or more hours per week.

8. What is your age?  
[ ] 18 - 29  
[ ] 30 - 39  
[ ] 40 - 49  
[ ] over 50

9. What is your sex?  
[ ] Female  
[ ] Male

10. What is your highest educational level?

[ ] High school graduate/GED  
[ ] Some college or technical/vocational training  
[ ] Associate degree (2 years)  
[ ] Bachelor degree (4 years)  
[ ] Postgraduate classes  
[ ] Master’s degree  
[ ] Doctoral degree

11. How many years in your lifetime have you been working at a computer?

[ ] less than 1 year  
[ ] more than 1 year to 2 years  
[ ] more than 2 years to 3 years  
[ ] more than 3 years to 5 years  
[ ] more than 5 years

12. How long have you been working at your present job?

[ ] less than 6 months  
[ ] 6 months to 1 year  
[ ] more than 1 year to 2 years  
[ ] more than 2 years to 3 years  
[ ] more than 3 years to 5 years  
[ ] more than 5 years
13. How long have you worked at the UGA libraries?

[ ] less than 6 months
[ ] 6 months to 1 year
[ ] more than 1 year to 2 years
[ ] more than 2 years to 3 years
[ ] more than 3 years to 5 years
[ ] more than 5 years

Code number (last 4 digits of social security number):_________
APPENDIX E
ERGONOMICS QUIZ

Instructions: Please circle the number that best represents your agreement with the following statements.

1=strongly disagree  2= disagree  3= slightly disagree
4=slightly agree  5= agree  6= strongly agree

1. Adjusting the workstation for good postural alignment is an important aspect of preventing musculoskeletal discomfort.  
   Disagree     Agree
   1 2 3 4 5 6

2. I have confidence in my ability to use an ergonomic checklist to identify ergonomic stressors at my workstation.  
   1 2 3 4 5 6

3. Once musculoskeletal discomfort begins, workstation changes or changes in work habits will help.  
   1 2 3 4 5 6

4. I have confidence in my ability to identify solutions to improve ergonomic stressors at my workstation.  
   1 2 3 4 5 6

5. I feel confident that making workstation changes will help prevent musculoskeletal discomfort.  
   1 2 3 4 5 6

6. I have confidence in my ability to correctly adjust my workstation.  
   1 2 3 4 5 6

For the next section, please answer all questions even if you are not certain of the answer.

7. Ergonomics refers to the fit between workstation design, job demands, equipment, and the worker’s capabilities.  
   True     False

8. All of the following are risk factors for repetitive arm or neck injuries except:

   a. awkward arm or hand positions
   b. using your non-dominant hand
   c. doing the same arm/hand activity for long time periods
   d. forceful hand activity

9. Repetitive arm and neck injuries can result in inflammation or compression of the tendons and nerves.  
   True     False
10. Warning signs that a repetitive arm or neck injury is beginning are all of the following except:

a. decreased motion in the neck or arm joints
b. pain in the arm or upper spine that lasts longer than two days
c. a feeling of swelling in the arm that lasts longer than two days
d. a feeling of general physical fatigue

11. To prevent repetitive injuries, when working at your desk, you should use your chair backrest:

a. 0-25% of the time
b. 26-50% of the time
c. 51-75% of the time
d. 76-100% of the time

12. To prevent repetitive injuries, while working at the computer your head and neck should be in which position?

a. tilted up
b. tilted down
c. not tilted up or down
d. turned toward the side

13. To prevent repetitive injuries, while working at the computer your hands should be in which position?

a. in line with the forearm
b. lower than the forearm
c. “cocked up” higher than the forearm
d. turned toward the little finger

14. The more force you use for typing or mousing, the less likely you are to sustain a musculoskeletal injury. True False

15. When the chair is adjusted properly all of the following are true except:

a. the thighs are parallel with the floor
b. the feet are flat on the floor or stool
c. the low back is supported
d. the back of your knees touch the chair
16. When not wearing bifocals, the correct position of the monitor is:
   a. six inches from your face
   b. ten inches from your face
   c. with the top of the computer screen at eye level
   d. with the top of the computer screen above eye level

17. The mouse or input device you use should be located:
   a. between the computer screen and the keyboard
   b. at a height different from the keyboard
   c. as close to you as the keyboard
   d. anywhere you can fit it

18. The documents that you are typing from or looking at should be:
   a. flat on the desk
   b. elevated on an angled surface or holder
   c. as far away from the computer screen as possible
   d. placed above the computer screen

19. To prevent repetitive injuries, you should rest or stretch your hands and fingers for a minute every:
   a. 30 minutes
   b. two hours
   c. four hours
   d. six hours

20. The farther out the arm is in front or to the side of the body, the more relaxed the shoulders will be.  
    True     False

21. You can improve the physical demands of the job by making proper workstation adjustments.  
    True     False

Your code number: ________
APPENDIX F

WORK ORGANIZATION QUESTIONNAIRE

Instructions: Please circle the number that best represents your agreement with the following statements about your workplace.

1=strongly disagree   2= disagree   3= slightly disagree
4=slightly agree  5= agree  6= strongly agree

Disagree          Agree

1. My job permits me to decide on my own how to go about using my workstation. 1 2 3 4 5 6

2. My job gives me considerable opportunity for independence and freedom in how my workstation is set-up. 1 2 3 4 5 6

3. My job denies me any chance to use my personal initiative or discretion in setting up my workstation. 1 2 3 4 5 6

4. The organization values my contribution to its success. 1 2 3 4 5 6

5. The organization strongly considers my goals and values. 1 2 3 4 5 6

6. Help is available from the organization when I have a problem. 1 2 3 4 5 6

7. The organization really cares about my well-being. 1 2 3 4 5 6

8. The organization is willing to help me when I need a special favor. 1 2 3 4 5 6

9. The organization cares about my general satisfaction at work. 1 2 3 4 5 6

10. The organization cares about my opinions. 1 2 3 4 5 6

11. The organization takes pride in my accomplishments at work. 1 2 3 4 5 6

12. The organization tries to make my job as interesting as possible. 1 2 3 4 5 6
WORK ORGANIZATION QUESTIONNAIRE

13. How often do you have more than one week’s work piled up for you to do?  
   Never  Occasionally  Often  Always
   1  2  3  4

14. How often do you feel pushed by deadlines?  
   1  2  3  4

To what extent do you face the following conditions in doing your own work?

15. Backlog of work  
   None  A little  Some  A lot
   1  2  3  4

16. Work deadlines  
   1  2  3  4

17. Understaffing  
   1  2  3  4

18. Production quotas or expected rates of performance.  
   1  2  3  4

Your code number __________
APPENDIX G
POST-INTERVENTION SYMPTOM SURVEY

1. In the past year (or since you started this job, if you have been working here less than a year) have you had fatigue, pain, aching, stiffness, burning, numbness, or tingling in your head, neck, back, shoulder/upper arm, elbow/forearm, wrist, or hand?

[ ] Yes  [ ] No

If you answered “No” to question 1, skip to question 5.

2. For only those area(s) in which you have had symptoms, please check how often you have experienced the fatigue, pain, aching, stiffness, burning, numbness, or tingling in the past week.

<table>
<thead>
<tr>
<th>Area</th>
<th>Once</th>
<th>Twice</th>
<th>3 to 6 days</th>
<th>Everyday</th>
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3. For **only** those area(s) in which you have symptoms, how long have these symptoms typically lasted **in the past week**?

<table>
<thead>
<tr>
<th>Area</th>
<th>Less than 1 hour</th>
<th>One hour up to 1 day</th>
<th>More than 1 day up to 3 days</th>
<th>More than 3 days up to 1 week</th>
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4. For **only** those area(s) in which you have symptoms, describe the typical intensity of the fatigue, pain, aching, stiffness, burning, numbness, or tingling **during the past week**.

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<thead>
<tr>
<th>Area</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Worst ever</th>
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5. Have you made **any** changes in your computer workstation in the past three weeks?

[ ] No  [ ] Yes

6. If you answered “yes” to question 5, please state the changes you made to your workstation.

__________________________________________________________________
__________________________________________________________________
7. During the past three weeks, did you observe co-workers making workstation changes or discuss making workstation changes with co-workers?

[ ] No   [ ] Yes

8. Have you requested any workstation accessories or equipment in the past three weeks?

[ ] No   [ ] Yes

9. Have you received any workstation accessories or equipment since the researcher did the first workstation observation?

[ ] No   [ ] Yes

10. Did you make any changes in the organization of work tasks or rest breaks in the past three weeks?

[ ] No   [ ] Yes

11. Did you start or add any exercises in the past three weeks?

[ ] No   [ ] Yes

Your code number: __________
Active Ergonomics Training
For Computer Users

Brenda Greene, PT, MMSc, OCS

Department of Health Promotion and Behavior
University of Georgia
Overall Course Objectives

Given the participant’s workstation, the participant will be able to:

- State the risk factors for musculoskeletal disorders;
- State the warning signs of musculoskeletal disorders;
- Use an ergonomic checklist to identify physical stressors at the workstation;
- Identify and implement solutions to correct physical stressors at the workstation;
- Describe work organization strategies and exercises to prevent musculoskeletal disorders.

Session 1 (3 hours)

9:00-9:30 Introduction and forms
9:30-9:50 Risk factors, impact, & signs of WMSD
9:50-10:05 Anatomy

10:05-10:15 Break

10:15-10:30 Principles of body mechanics
10:30-10:50 Workstation design and demonstration of an ergonomic checklist

10:50-11:00 Break

11:00-11:30 Group practice in workstation assessment
11:30-12:00 Begin to identify workstation solutions
   Assign ergonomic checklist for own workstation

Session 2 (3 hours)

9:00-9:15 Discuss workstation assessments
9:15-9:50 Workstation solutions

9:50-10:00 Break

10:00-10:30 Group problem-solving of workstation solution strategies
10:30-11:00 Office exercise

11:00-11:10 Break

11:10-11:30 Work practices
11:30-12:00 Wrap-up and forms
Learning Sub-objectives Session 1

- Define musculoskeletal disorder (MSD)
- Differentiate between traumatic and cumulative trauma types of MSD
- State the risk factors for cumulative trauma disorders (CTD)
- Describe the role of ergonomics in decreasing risk factors for CTD
- Perceive the potential outcomes of CTD
- State the warning signs and symptoms of MSD
- State three principles of body mechanics
- State the elements of good computer workstation design
- Perform a workstation analysis with an ergonomic checklist

Musculoskeletal Disorders (MSD)

MSD can be defined as diseases and injuries affecting the musculoskeletal, peripheral nervous, or neurovascular systems.

1. Traumatic MSD are due to a single injurious event, such as a fall or being struck by an object.

2. Cumulative trauma MSD are due to chronic exposure to low-level forces, such as long-distance running or jogging.

Other common terms for cumulative trauma disorders are: repetitive motion injury (RMI), repetitive strain injury (RSI), repetitive injury disorders, and repetitive trauma disorders.

Nature of cumulative trauma disorders (CTD) in computer users:
- Due to chronic exposure to low level forces
- More likely to occur in the presence of multiple risk factors
- Influenced by physical demands, individual knowledge and beliefs, and work organization.

Risk Factors for CTDs (Bernard, 1997; Stobbe, 1996)

1. Repetitive movements
2. Awkward postures
3. Prolonged or fixed postures or exertions
4. Forceful exertions
5. Vibration
Ergonomics definition: the science of fitting workplace conditions, job demands, and equipment to the capabilities of the working population. (Cohen, Gjessing, Fine, Bernard, and McGlothlin, 1997)

Warning Signs/Symptoms of CTDs

1. Localized fatigue or feeling of heaviness
2. Soreness/pain during or after activity, that recurs regularly, or interrupts sleep
3. Actual or perceived swelling or fullness in the hand or arm
4. Decreased range of motion in neck or upper extremity joints
5. Decreased coordination or control of upper extremity movements

Anatomy and Biomechanics

Figure 0.1 Normal Spinal Curves
(Reprinted from Fritz: Mosby’s Fundamentals of Therapeutic Massage, 2000)
Figure 0.2 Neck and Upper Extremity
(Reprinted from Goss: Gray’s Anatomy, 1973)
Anatomy Insights

- Interconnectedness of cervical, thoracic, lumbar, and pelvic regions of the spine
- Interconnectedness of the cervical spine to the arms
- Deep muscles generally function for stability, muscles closer to the skin generally function more for mobility
- Individual variation in structure and capacity

Principles of body mechanics for computer users

**Principle 1:** The more neutral the joint during function, the less external load to be resisted, and the less muscle activity required.

Neutral posture: Joints are aligned so that there is minimal muscle activity required to maintain that position.

![Figure 0.3 Neutral Lumbar Spine](image)

*Figure 0.3 Neutral Lumbar Spine*

(Reprinted from Moore: Clinically Oriented Anatomy, 1980)

**Principle 2:** Work organization strategies and use of tools or devices can minimize the external load thereby decreasing muscle activity.

**Principle 3:** Fine hand movements are often related more to muscle coordination than to muscle force.
Spectrum of methods to minimize CTD risk factors

1. Engineering - Workstation design and arrangement
2. Work practices – task arrangement, microbreaks, office exercises
3. Lifestyle – recreational activities, nutrition, exercise, ergonomics

Elements of good workstation design

Figure 0.4
Workstation Ergonomic Checklist

Purpose: 1) for employer and employees to recognize and control workplace CTD hazards; 2) for employees to build confidence and skill in minimizing CTD risk factors at work.

Ergonomics Checklist

1. Chair Interface
   a. Able to achieve feet flat position ___ ___
   b. Thighs parallel with the floor ___ ___
   c. Space (1”-4”) between the back of knees and front of the seat ___ ___
   d. Low back support present ___ ___
   e. Low back support located in the small of the back ___ ___
   f. Low back support used at least 80% of the time ___ ___
   g. Arm rests present ___ ___
   h. Arm rests allow you to sit with shoulders relaxed and by the side of the body ___ ___
   i. Arm rests low enough to allow closeness to work ___ ___

2. Monitor Position
   a. Distance between monitor and eyes 18”-28” ___ ___
   b. Monitor directly in front of the worker ___ ___
   c. Top of the computer screen at or just below eye level (depending on glasses) ___ ___

3. Keyboard/Work surface Interface
   a. Forearms parallel to the floor ___ ___
   b. Upper arms perpendicular to the floor ___ ___
   c. Work surface is large enough for stable keyboard and input device ___ ___
   d. Hands in line (upwards & downwards) with the forearm ___ ___
   e. Hands in line (side to side) with the forearm ___ ___
   f. Arms do not rest on sharp or square edges ___ ___
4. Accessories

   a. Mouse (or equivalent) at the same level as keyboard ___  ___
   b. Use of adjustable document holder ___  ___
   c. Use of wrist rest that has tapered edges and places the wrists in neutral position ___  ___
   d. Use of headset ___  ___
Workstation Cases

Small group discussion questions:

1. Use the checklist to identify CTD risk factors for your photographic case.

2. Identify work factors that will impact the effect of the CTD risk factors?

3. Identify personal factors that will impact the effect of the CTD risk factors?
The Decision to Make Workstation Changes

- Benefits of workstation changes
- Barriers to workstation changes

Body Mechanics When Changing Your Workstation

- Position yourself close to the load and in the direction to which you are moving
- Avoid bending and twisting of the back by using your legs and moving your feet
- Bend your knees to lift with your legs
- Tighten your stomach muscles when lifting
Session 2

Learning Objectives

- Identify ergonomics risk factors at your own computer station
- State solutions to workstation design risk factors
- Explain the benefits of diaphragmatic breathing
- Demonstrate diaphragmatic breathing
- Demonstrate exercises for the trunk and extremities to reduce the risk of MSD
- Describe changes in work practices to minimize risk factors for MSD

Workstation Solutions

Based on problems identified from the ergonomics checklist and individualized to the available equipment.

Chair

- Foot rest/ 3” or 4” notebook high side away from you/ telephone book
- Scoot chair close to the work surface
- Use back support/ lumbar support/ taped towel roll
- Seat pan sloped neutral or slightly forward/ small ischial roll if seat pan is not adjustable
- Vary knee height and pelvic tilt throughout the day
- If you use arm rests, arms should be supported, not weight bearing

Monitor

- Placed at the correct height with a shelf or phonebook
- Adjust work space so that monitor is directly in front of you
Keyboard/ Work surface

- Flat, may elevate the front of the keyboard to achieve this position
- If you don’t use the numeric pad of the keyboard, center yourself with the alphabetic side of the keyboard only, not the entire keyboard
- Keyboard tray if the work surface is too high and can’t adjust seat height
- Alternative keyboards
- Angled work surface

Input device

- Placed at the correct height
- Functions to minimize the number of inputs needed
- Alternative devices such as joystick and trackball

Workstation Cases

Small group discussion questions:

1. Suggest workstation changes to decrease the CTD risk factors in your photographic case.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

2. Identify other potential areas for change (in addition to the workstation) to decrease the CTD risk factors.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
Write down 2-5 changes you plan to make at your workstation this week.

1. __________________________________________________
2. __________________________________________________
3. __________________________________________________
4. __________________________________________________
5. __________________________________________________

Breathing awareness exercise

Place one hand in contact with your chest and one hand in contact with your abdomen, just below your ribs. Breathe normally for a few minutes and notice which hand moves first when you inhale. Which hand rises the most?

Diaphragmatic breathing benefits are:

1. more oxygen delivery to the muscles and organs;
2. more waste products, such as lactic acid, are removed;
3. decreased tension in the front neck muscles;
4. decreases the body’s adverse response to stress through general relaxation.

Diaphragmatic breathing technique:

Start practicing the breathing technique lying on your back with your arms and legs comfortably supported. Progress to practicing this technique while sitting in a supported position in a quiet area and then practice it in a hectic situation.

: Inhale through your nose, let the breath start in the abdomen and fill up into the chest.
: After a deep and full breath in, exhale slowly, allowing the chest to empty first and the abdomen to empty last.
: Repeat for a few minutes.
: Do not force the breath, just allow your body the privilege of comfortable and full breaths.

Note: Always stretch using gentle and controlled movements. If you experience discomfort or pain, discontinue stretching and consult a healthcare professional. If you are under the care of a healthcare professional, check with them prior to doing any of these exercises.
Cable Stretch:

**Purpose**: To decompress the spine, increase circulation around the vertebral segments, and increase postural awareness.

![Cable Stretch Image](image)

Figure 0.5

(Reprinted from: The StayWell Company, 1993)

> Notice your sitting posture.
> Now imagine you have a cable attached from the top back part of your head to the sky. Feel the cable pull your head and trunk up toward the sky, making you taller and straighter.
> Hold this new position for a few seconds, take a deep breath, and then relax to your original position.
> Repeat 3 times and at the end of the third time maintain a position more upright than your original sitting posture.

Sitting Pelvic Rock

**Purpose**: To increase circulation around the vertebral segments, increase postural awareness, and alter sitting pressures.

> Sitting upright with your buttocks slightly away from the back of your chair, but with your upper back in contact with the back of the chair, slowly allow your pelvis to rock back (as in a slumped posture) and rock forward accentuating the arch in your back.
> Slowly repeat the motion 3-5 times. On the last repetition, scoot your buttocks back in the chair and maintain a neutral pelvic position (not slumped or over-arched).
Backward Bending in Standing

**Purpose:** To reverse the pressures of prolonged sitting and increase range of motion in extension.

---

**Figure 0.6**

(Reprinted from: Kisner & Colby: Therapeutic Exercise, 1990)

Backward Bending in Standing (Continued)

- Stand with feet shoulder width apart and hands on the back of your hips.
- Keeping your knees straight and your head looking forward, lean your trunk backwards, bending at the waist with the pelvis shifting forward. Hold the stretch for a few seconds.
- Repeat 3 times.
Shoulder Half Circles

**Purpose:** To activate muscles that adduct and depress the scapulae, relax muscles that elevate the shoulder girdle, and increase postural awareness.

Figure 0.7

(Reprinted from: Krames Communication, 1991)

- Find your neutral head and neck position from the cable stretch exercise.
- Visualize the face of a clock on your shoulder with the tip of your shoulder at the center of the clock.
- Raise your shoulders up toward your ears and then bring your shoulders slowly back and down. Imagine the tip of your shoulder touching every number on the clock from 12 to 6.
Shoulder Blade Squeeze

**Purpose:** To stretch the front of the chest, strengthen the muscles that adduct the scapulae, improve sitting posture.

![Shoulder Blade Squeeze Image](image)

**Figure 0.8**

(Reprinted from: The StayWell Company, 1993)

- Find your neutral head and neck position from the cable stretch exercise.
- Raise your arms up and out to your side with the elbows bent and the fingers pointing toward the ceiling.
- Squeeze your shoulder blades together, allowing your upper arms to go backward. Hold for a few seconds, take a deep breath.
- Repeat 5 times.
Forearm Stretch

**Purpose:** To stretch the muscles on the front and back of the forearm.

- Find your neutral head and neck position from the cable stretch exercise.
- Place your arm by your side with the back side of your hand on the chair seat, next to your hip. Press the back of the hand into the seat until you feel a comfortable stretch on the back of the forearm, keeping the elbow straight. Hold for a few seconds, take a deep breath, and release the stretch.
- Repeat 3 times.
- Place your arm by your side with the palm of your hand on the chair seat, next to your hip. Press the palm of the hand into the seat until you feel a comfortable stretch on the inside of the forearm, keeping the elbow straight. Hold for a few seconds, take a deep breath, and release the stretch.
- Repeat 3 times.
Finger Tendon Glide

**Purpose:** To stretch tendons to the fingers and increase circulation to the finger tendons.

![Finger Tendon Glide](image)

Figure 0.9

(Reprinted from Pascarelli & Quilter, 1994)

- Place your arms in any comfortable position, keep the wrist neutral.
- Straighten your fingers out and spread them apart.
- Bring the fingertips in toward the palm, as if you were making a fist (but don’t squeeze).
- In the fist position, straighten the end of your fingers so that your fingertips touch the base of your palm.
- Bring your fingertips up keeping your knuckles bent so that your fingertips touch the top of your palm.
- Straighten your fingers out and spread them apart.
- Repeat 3 times.
Work Practices

General strategies

- Plan tasks ahead to provide as much variety as the job allows
- Pace yourself
- Examine how the task is organized
- Use computer macros or other functions to decrease the amount of keying
- Take a 30 second to 1 minute break every 20-30 minutes to rest or stretch your hands
- When your work is interrupted, consciously take your hands out of the work position and rest them

Typing/Mousing Technique

- Clean mouse to avoid unnecessary drag or sluggishness
- Adjust mouse settings – click and motion speed
- Use the lightest touch necessary to accomplish task
- Keep neck and trunk muscles relaxed through sitting alignment

Additional Resources


http://cancertrials.nci.nih.gov/beyond/evaluating.html
http://www.ama-assn.org/about/guidelines.htm

http://www.osha.gov/index.html
http://www.libs.uga.edu/ergo/info.html
http://www.ergoweb.com/
http://ergo.human.cornell.edu/CUEHinfo.html
Every effort has been made to select websites with accurate information, but it is the responsibility of the consumer to evaluate the information obtained from these websites. For this reason, the first three websites provide information on how to evaluate health information obtained from the Internet.

References


## APPENDIX I
### ERGONOMICS CHECKLIST

#### 1. Chair Interface

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Able to achieve feet flat position</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>Thighs parallel with the floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>Space (1”-4”) between the back of knees and front of the seat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>Low back support present</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>Low back support located in the small of the back</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f.</td>
<td>Low back support used at least 80% of the time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g.</td>
<td>Arm rests present</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h.</td>
<td>Arm rests allow you to sit with shoulders relaxed and by the side of the body</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i.</td>
<td>Arm rests low enough to allow closeness to work</td>
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<td></td>
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</table>

#### 2. Monitor Position

<table>
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<tbody>
<tr>
<td>a.</td>
<td>Distance between monitor and eyes 18”-28”</td>
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</tr>
<tr>
<td>b.</td>
<td>Monitor directly in front of the worker</td>
<td></td>
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</tr>
<tr>
<td>c.</td>
<td>Top of the computer screen at or just below eye level (depending on glasses)</td>
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#### 3. Keyboard/Work surface Interface

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<tbody>
<tr>
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<td>Forearms parallel to the floor</td>
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<td></td>
</tr>
<tr>
<td>b.</td>
<td>Upper arms perpendicular to the floor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c.</td>
<td>Work surface is large enough for stable keyboard and input device</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d.</td>
<td>Hands in line (upwards &amp; downwards) with the forearm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e.</td>
<td>Hands in line (side to side) with the forearm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f.</td>
<td>Arms do not rest on sharp or square edges</td>
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</table>

#### 4. Accessories

<table>
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<tr>
<td>a.</td>
<td>Mouse (or equivalent) at the same level as keyboard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b.</td>
<td>Use of adjustable document holder</td>
<td></td>
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<tr>
<td>c.</td>
<td>Use of wrist rest that has tapered edges and places the wrists in neutral position</td>
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<tr>
<td>d.</td>
<td>Use of headset</td>
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### APPENDIX J

DESCRIPTIVE STATISTICS FOR THE PRIMARY INTERVAL LEVEL OUTCOME MEASURE AT BASELINE FOR THE FOUR TRAINING GROUPS

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## APPENDIX K

**FACTOR LOADINGS FOR SELF-EFFICACY AND OUTCOME EXPECTATIONS**

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<tr>
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Note: PCA with varimax rotation

**Items:**

1. Adjusting the workstation for good postural alignment is an important aspect of preventing musculoskeletal discomfort.

2. I have confidence in my ability to use an ergonomic checklist to identify ergonomic stressors at my workstation.

3. Once musculoskeletal discomfort begins, workstation changes or changes in work habits will help.

4. I have confidence in my ability to identify solutions to improve ergonomic stressors at my workstation.

5. I feel confident that making workstation changes will help prevent musculoskeletal discomfort.

6. I have confidence in my ability to correctly adjust my workstation.
## APPENDIX L

### WORK ORGANIZATION SCALES

<table>
<thead>
<tr>
<th>Item</th>
<th>Control/Autonomy</th>
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<td>Question 18</td>
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<td>.42</td>
</tr>
</tbody>
</table>

Note: PCA with varimax rotation
Work Organization Items

1. My job permits me to decide on my own how to go about using my workstation.

2. My job gives me considerable opportunity for independence and freedom in how my workstation is set-up.

3. My job denies me any chance to use my personal initiative or discretion in setting up my workstation.

4. The organization values my contribution to its success.

5. The organization strongly considers my goals and values.

6. Help is available from the organization when I have a problem.

7. The organization really cares about my well-being.

8. The organization is willing to help me when I need a special favor.

9. The organization cares about my general satisfaction at work.

10. The organization cares about my opinions.

11. The organization takes pride in my accomplishments at work.

12. The organization tries to make my job as interesting as possible.

13. How often do you have more than one week’s work piled up for you to do?

14. How often do you feel pushed by deadlines?

To what extent do you face the following conditions in doing your own work?

15. Backlog of work

16. Work deadlines

17. Understaffing

18. Production quotas or expected rates of performance