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ABSTRACT

Research regarding risk factors and correlates of work-related upper extremity (WRUE) symptoms and disorders have identified important ergonomic, workplace pychosocial, and individual psychosocial factors in their etiology, exacerbation and maintenance. Elevated levels of job stress have been frequently reported in this population, and epidemiological studies indicate job stress is associated with symptom severity, functional limitations, and lost work time in individuals with a variety of work-related upper extremity disorders. Although plausible pathophysiologic mechanisms exist linking the stress response to WRUE symptoms, little is known about the specific effects of stress on potential musculoskeletal and sympathetic nervous system mediators and how they may impact WRUE symptoms. Additionally, it is unclear if workers with these difficulties respond differently to stressors than asymptomatic workers. The present study was an exploratory investigation designed to address four primary questions: 1) do individuals with WRUE symptoms report higher levels of job stress and ergonomic exposure than asymptomatic individuals, 2.) do workers with WRUE symptoms respond with greater musculoskeletal, neuroendocrine, and psychological responses than asymptomatic workers, 3) can ergonomic, psychosocial and physiological variables significantly discriminate between symptomatic and asymptomatic workers, and, 4) if they can discriminate between the groups, are the discriminating factors associated with general and WRUE-specific clinical outcomes. Female computer-users (n = 30; 16 symptomatic and 14 asymptomatic controls matched for age, body mass index, and job type) completed self-report measures of general health status, symptoms, job stress, and ergonomic exposure and kept a 2-week diary of stressful work events and symptoms. At the end of the two-week monitoring period, participants were exposed to a laboratory-based job stress recall task while bilateral forearm activity (extensor and flexor), blood pulse volume, salivary cortisol levels, and self-report measures of symptoms and distress were monitored. Analyses of the self-report and job stress diary data indicated no significant differences between the groups on the frequency or intensity of job stress. However, symptomatic workers reported significantly greater distress in response to their peak stress event. Psychophysiologic data indicated significant group main effects for heart rate and forearm flexor muscle activity, where symptomatic workers exhibited higher tonic heart rate and flexor activity across all time periods. No group main effects were observed for forearm extensor, salivary cortisol, distress or symptoms, and no significant group by period interactions were observed for any of the measures. Canonical discriminant function analyses revealed that ergonomic exposure and job/family stress and coping were relatively poor discriminators between the groups while psychophysiologic response to the job stress recall task and a multifactorial model combining significant discriminators from all three domains (i.e., percent of work time at a computer workstation, the Impact of Events Scale-Revised, nondominant flexor activity during the stressor period, and heart rate during the recovery period) were good discriminators between the groups, classifying 89% and 92.3% of the sample respectively. Stepwise multiple regression analyses indicated this multifactorial model accounted for a significant amount of the variance in WRUE-specific outcomes (i.e., self-reported UE pain, functional limitations, and UE symptom severity), but not general physical or mental health. Results suggest that important ergonomic, psychosocial and physiological differences exist between these groups, including potential tonic heart rate elevations, tonic forearm musculature hyperarousal, and a tendency to experience prolonged cognitive and behavioral consequences to stressful events. These differences not only discriminate between the two groups but also are also associated with WRUE-specific clinical outcomes. Theoretical implications as well as questions for future research are discussed.

Job Stress Reactivity and Work-Related Musculoskeletal Symptoms

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DEDICATION

This project is dedicated to my family who have modeled for me persistence, integrity, and personal sacrifice, and who, by their unconditional love and support, have taught me more than any textbook.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Work-related upper extremity musculoskeletal disorders (WRUEDs) are defined as an aggregation of disorders that 1) affect the soft-tissues (e.g., muscles, tendons, ligaments, peripheral nerves, and/or the vascular system) of the upper extremities (i.e., the hands, wrists, arms, shoulders, and/or neck), 2) are causally related to the work environment or the performance of work tasks, and 3) are not the result of an acute injury or event (Hales & Bernard, 1996; OERC, 1998). Symptoms of these disorders are often distressing and include pain, fatigue, numbness, discomfort and/or functional impairment (Rempel, Harrison, & Barnhart, 1992; Rempel, 1998).

Generally, these disorders are categorized into muscle/tendon related disorders (e.g., tendonitis, epicondylitis and neck torsion syndrome) and nerve-related disorders (e.g., carpal tunnel syndrome [CTS], cubital tunnel syndrome, hand-arm vibration syndrome; Rempel et al., 1992, Punnett & Bergqvist, 1997). In recent history, the terms cumulative trauma disorder and repetitive strain injury have been used interchangeably with upper extremity musculoskeletal disorder. However, as new insight has been gained into the multifactorial nature of these disorders, researchers and clinicians alike have begun to avoid phraseology that suggests a singular universal cause for all of these disorders (OERC, 1998).

The scientific literature, which will be reviewed in the following sections, suggests that these disorders affect a significant number of workers in industrialized nations, exact substantial medical, social, and organizational costs, and are associated with a number of medical, ergonomic, psychosocial and demographic factors.

Epidemiology of Work-Related Upper Extremity Disorders

Although encouraging news from the Bureau of Labor Statistics (BLS) annual survey of occupational illnesses and injuries suggests a slight decline in private industry incidence of some WRUEDs since 1994 (CTS incidence: 1994 = 4.8; 1997= 3.4 per 10,000 workers; BLS, 1996, 1999), these disorders continue to impact a significant number of people. Recent estimates by the BLS suggest the incidence rate for disorders associated with repeated trauma in the workplace is approximately 27.3 per 10,000 full-time workers in 1998 (BLS, 2000). These disorders accounted for 4% of the 5.7 million total workplace injuries and illnesses reported in 1998 by the BLS (BLS, 2000). Additionally, the National Health Interview Study (NHIS) found that 8% of the 127 million active workers in the United States report prolonged (greater than 20 days in the past year and greater than 7 consecutive days in the past month) hand discomfort in the past year (Tanaka, Wild, Cameron, & Freund, 1997).

Prevalence estimates for CTS, the most common of the work-related upper extremity disorders, indicate approximately 4.2% of women and 1.3% of men in the U.S. general population are affected by CTS (Stevens, Sun, Bear, O Fallon, & Kurland, 1988; Cherniak, 1996). In an investigation of physical signs and symptoms of CTS in the general workforce, 39% of an occupationally diverse sample of male and female workers were found to have pathological nerve findings in the hand, wrist, and forearm (i.e, slowed conduction of the median nerve) consistent with CTS (Nathan, Takigawa, Keniston, Meadows, & Lockwood, 1992). The period prevalence for CTS in an adult working population is estimated to be between 1-2% with women having a higher percentage than men (Tanaka et al., 1997).

These prevalence and incidence rates are of particular concern in light of recent data suggesting painful symptoms of the hand and wrist are underreported in workers compensation and other mandatory reporting systems. These conditions likely affect a much larger number of people in the workforce than indicated by available statistics (Biddle, Roberts, Rosenman, & Welch, 1998; Pransky, Snyder, Dember, & Himmelstein, 1999; Rosenman et al., 2000).

In addition to the numbers effected in the general workforce, workers employed in certain occupations, such as grocery store workers, meat fish and poultry workers, dentists, administrative/ clerical workers, keyboard operators, and sign language interpreters appear to be at increased risk for these disorders (Osorio et al., 1994; Masear, Hayes, & Hyde, 1986; Hagberg, Morganstern, & Kelsh, 1992; Cohn, Lowry, & Hart, 1990; Nordstrom, DeStefano, Vierkant, & Layde, 1998). In the current age of computer workstations, it appears that office workers, especially those using keyboards, are at increased risk for these disorders (Hagberg et al., 1992; Punnett, 1995; Nordstrom et al., 1998). Investigators from the National Institute for Occupational Safety and Health found work-related musculoskeletal disorders in 41% of a sample of newspaper employees (Burt, Hornung, Fine, Silverstein, & Armstrong, 1990). Self-reported upper extremity symptom prevalence in this sample ranged from 10% for the elbow region to 25% in the neck region (Bernard, Sauter, Fine, Peterson, & Hales, 1994). In general, the relative risk for shoulder, arm and hand disorders in workers using a keyboard in excess of 4 hours per day is estimated to be greater than 2.0 (Punnett, 1995).

Also of concern is the recent trend in WRUED claims across the nation. WRUED claims not related to computer use have been decreasing slightly since 1994 (BLS, 1998). However, during this same time period, the reporting of computer-related WRUEDs has been on the rise. Although these claims represent a minority of all WRUED claims from all industries and job types (approximately 20% in 1996; Brogmus, 1998), this trend suggests computer-related WRUEDs are on the rise and that unique demographic, ergonomic, or psychosocial factors may be relevant to this population.

Economic and Social Impact of Work-Related Upper Extremity Disorders

Regardless of the type of worker affected, these disorders can exact heavy social and economic costs for affected individuals, employers, and health care organizations. With over 29,000 cases involving lost work time (BLS, 2000), and average costs per claim for the two most prevalent WRUEDS (CTS and enthesopathies of the elbow) in excess of $6,200 per claim (Feuerstein, Miller, Burrell, & Berger, 1998), WRUEDs are among the most prevalent and costly occupational health problems (Brogmus, Sorock, & Webster, 1996).

An investigation of workers compensation claims in the federal workforce during FY 1994 revealed the average total costs (i.e., medical costs and indemnity costs) for the two most common WRUED claim types (CTS and elbow enthesopathy) to be $7,890 and $6,250 per claim respectively (Feuerstein et al., 1998). Health care costs were estimated to account for between 40 and 50% of these total cost estimates (Feuerstein et al., 1998).

Medical management for WRUEDs may involve a wide range of interventions, including physical therapy, medication, surgery, orthotics (e.g., wrist splinting), and occupational rehabilitation (Feuerstein, Burrell, Miller, Lincoln, Huang & Berger, 1999). In a review of clinical and occupational outcomes for various treatments of the most prevalent WRUED (CTS), these common interventions, including surgical techniques, were revealed to have strikingly little empirical support (Feuerstein et al., 1999).

A survey of physicians who treat CTS indicated that approximately one-third of patients continue to experience pain and functional limitations postsurgically (Duncan, Lewis, Foreman, & Nordyke, 1987), especially in individuals reporting non-classical symptoms such as musculoskeletal pain and tenderness in the wrist, elbow, or shoulder as their primary complaint (Lazaro, 1997). One study of Washington State workers compensation recipients who underwent surgical carpal tunnel release reported that 14% of these workers reported no improvement in symptoms postsurgically (Adams, Franklin, & Barnhart, 1994). Additionally, self-reported post-operative satisfaction has not been found to be directly related to improvement in electrophysiologic abnormalities (Lazaro, 1997) nor to functional improvement and return to work (Katz, Keller, et al., 1998). This finding supports the concept that symptomatology and disability related to CTS specifically, and perhaps WRUEDs in general, may be multiply determined by factors other than physiological pathology (Katz, Keller, et al., 1998).

In spite of the paucity of empirical support, and even data to the contrary, the most common treatment for CTS is surgical carpal tunnel release. This surgical intervention has become one of the most common procedures performed in the United States (vonSchroder & Botte, 1996) and accounts for approximately 43% of the health care costs for treatment of CTS (Feuerstein et al., 1998).

A proportion of the medical costs of these disorders are associated with diagnostic tests which have also been shown to be problematic. Diagnosis of WRUEDs has been shown to be unreliable, suffering from poor predictive validity and specificity (Homan, Franzblau, Werner, Albers, Armstrong, & Bromberg, 1999; Nathan et al., 1994; Franzblau, Werner, Valle, & Johnston, 1993). For example, nerve conduction studies have long been deemed the best indicator of median nerve entrapment (the cardinal sign of CTS; Dorwart, 1984) in a clinical population. However, in a recent analysis of the concordance among various case definitions for CTS, including nerve conduction testing, Homan et al. (1999) reported extremely poor agreement, with kappa values ranging from 0.0 - 0.18 between the procedures. In addition to poor agreement among health care providers, it appears that there is not a direct correlation between physical signs and symptoms in CTS. Recent investigations suggest that among healthy workers as many as 16% will have abnormal electrodiagnostic findings without symptomatic evidence of CTS. Additionally, about 10% of individuals reporting clinical symptoms consistent with CTS will have normal nerve conduction studies (Grundberg, 1983). In summary, these data suggest that WRUEDs are costly to diagnose and treat, somewhat unresponsive to common interventions, and are often manifest in the absence of identifiable physical pathology.

Notably, costs associated with WRUEDs are not merely related to medical claims. Occupational and social costs are often significant for these patients. In 1998, over 300,000 upper extremity illness cases of the wrist, hand or fingers involved at least one day away from work (BLS, 2000). Of these cases, CTS and tendonitis accounted for over 43,000 instances in which a worker lost a work day. Although the total number of WRUED cases involving days away from work has been decreasing since 1993, the number of computer-related WRUEDs involving lost work time has been on the rise (Brogmus, 1998; BLS, 2000).

In an analysis of 1994 upper extremity claims within the federal workforce, Feuerstein, Miller, Burrell, & Berger (1998) reported the two most prevalent types of claims were for CTS and elbow enthesopathies. For these types of claims, the mean days off work were 84 and 79 days, respectively. In 1995, reported work absences for individuals with CTS were the lengthiest reported for any major type of job-related illness or injury covered by the Bureau of Labor Statistics Survey of Occupational Illnesses and Injuries (BLS, 1997; Personick, 1997). In addition to prolonged work disability, workers with WRUEDs often face vocational shifts or job changes, even if their symptoms are treated successfully (Katz, Lew, et al., 1998; Cheadle et al., 1994; Adams, Franklin, & Barnhart, 1994; Nancollas, Peimer, Wheeler, & Sherwin, 1995; Higgs, Edwards, Martin, & Weeks, 1995).

The distribution of claims costs and lost days has been recently described for WRUEDs (Hashemi, Webster, Clancy, & Courtney, 1998; Brogmus et al., 1996; Feuerstein, et al., 1998), and a few interesting trends emerged. Both claims costs and lost workdays are considerably skewed, with approximately a quarter of the claims representing a large proportion of lost workdays and claim costs (Hashemi, et al., 1998; Brogmus et al., 1996). Additionally, data suggest that many individuals with WRUEDs, especially CTS, are likely to continue working in spite of the pain and discomfort of their symptoms. Feuerstein et al. (1998) found that the majority of federal work force claimants in 1994 received health care benefits only (i.e., no disability benefits). Hashemi et al. (1998), in a 2.5 year prospective study of work-related upper extremity disorder disability claims of a large workers compensation insurance company, discovered that 55% of claims were for medical benefits only and that 7% of the claims accounted for 75% of the total disability days. These data suggest two trends that may be characteristic of WRUEDs. First, the majority of workers with these problems continue to work with pain, either claiming only medical expenses or making no workers compensation claim at all. Second, the majority of the costs associated with medical care and lost work time appear to be the result of intractable cases whose symptoms do not remit after a barrage of traditional medical treatments.

Risk Factors/Correlates of Work-Related Upper Extremity Disorders

Research in the past decade regarding the biopsychosocial precursors and correlates of musculoskeletal disorders have yielded growing agreement in the multifactorial nature of these problems. The medical, occupational and scientific communities are becoming more convinced that no singular, direct cause-effect relationship exists among specific exposures, physiopathologic processes, and upper extremity musculoskeletal disorders. Both workplace and individual factors have been identified in the literature as potential contributors to the etiology and/or maintenance of WRUED s.

Workplace Risk Factors

Musculoskeletal disorders of the upper extremity can be described as work-related when an individual s work tasks or work environment contribute significantly to their development or maintenance (World Health Organization, 1985). There exists considerable evidence that specific work-task characteristics, as well as psychosocial characteristics of the work environment, affect the incidence of upper extremity symptoms (Feely et al, 1995; Fish & Morris-Allen, 1998) and disorders (Ferreira, Conceicao, & Saldiva, 1997; Cherniak, 1996; Hales & Bernard, 1996; Hagberg et al., 1992).

Biomechanical Risks

Work tasks involving intense gripping, awkward upper extremity postures, the use of vibrating tools, and repetitive movements have long been implicated in the etiology of WRUEDs (Putz-Anderson, Doyle, & Hales, 1992; Rempel, 1992). The biomechanical model of WRUEDs asserts that prolonged exposure to any of these biomechanical stressors can place excessive strain on the muscles and/or soft tissues of the neck, arm, elbow, forearm, wrist, and/or fingers, causing microtears and trauma (Rempel et al., 1992). The resulting injury and inflammation may lead to tendon/synovial tissue disorders, nerve entrapment, or muscle tears (Armstrong, Castelli, Evans, & Diaz-Perez, 1984; Lundborg, 1988; Rempel et al., 1992; Armstrong, et al., 1993; Rempel, Dahlin, & Lundborg, 1999).

More specifically, high gripping forces may place extreme tension on the flexor tendons which in turn can increase pressure in the carpal canal (Armstrong & Chaffin, 1979; Silverstein, Fine & Armstrong, 1987; deKrom, Kester, Knipschild, & Span, 1990; Chiang, Ko, Chen, Yu, Wu, & Chang, 1993; Hales & Bernard, 1996; Armstrong et al., 1993; Keir, Bach, & Rempel, 1998) placing individuals at risk for tendonitis, tenosynovitis and/or CTS. Nonneutral wrist positions, specifically extreme extension or flexion of the wrist, can distend the nerve leading to microruptures and impaired blood perfusion in the nerve with symptomatic consequence (deKrom et al., 1990; Weiss, Gordon, Bloom, So, & Rempel, 1995; Armstrong et al., 1993; Werner, Franzblau, Buchele, Albers & Armstrong, 1997; Rempel et al., 1999). Also, sustained, low-level compressions of the median nerve that can result from nonneutral wrist positions may impair intraneural blood flow and interfere with the axonal transport necessary for cell nutrition and viability (Rempel et al., 1999). Lastly, extreme wrist postures combined with finger flexion (e.g., gripping tasks) may increase the friction between the tendons and their sheaths, potentially damaging the synovium and increasing carpal tunnel pressure as a result of inflammation and/or edema (Armstrong & Chaffin, 1979).

Similarly, exposure to hand/arm vibration via occupational tools has also been associated with certain types of WRUEDs, especially those affecting the nerves and vasculature, although the pathophysiological processes involved remain to be clarified. Some evidence exists that exposure to vibration may increase intracarpal pressure via edema caused by increased protein leakage from the blood vessels (Armstrong & Chaffin, 1979; Wieslander, Norback, Gothe, & Juhlin, 1989, Tanaka, Wild, Seligman, Halperin, Behrens, & Putz-Anderson, 1995; Cannon, Bernacki, & Walter, 1982; Armstrong et al., 1993) or may directly affect the nerve structure via demyelination and the loss of axons (Rempel et al., 1999). It has also been suggested that vibrating tools may indirectly cause increases in carpal tunnel pressure as a result of the reflexive intensification of grip force often used to employ such tools (Armstrong et al., 1993). Vibration has also been associated with the development of thoracic outlet syndrome (proximally) and Raynaud s disease (distally) by damaging the vasculature (Piligian, Herbert, Hearns, Dropkin, Landsbergis, & Cherniak, 2000).

Lastly, repetitive tasks have been shown to result in sustained, static loads that may cause collagen, a primary component of healthy tendons, to atrophy (Ashton-Miller, 1999). Alternatively, non-repetitive tasks with fluctuating loads may promote collagen turnover, healing, and remodeling (Ashton-Miller, 1999).

In addition to the singular effects that grip force, extreme wrist extension/flexion and vibration have been shown to exert on a worker s WRUED risk, activities requiring two or more of these factors may result in a synergistic, even multiplicative, risk, especially when combined with excessive force (Armstrong & Chaffin, 1979; Silverstein, Fine, & Armstrong, 1986; deKrom et al., 1990; Chiang et al., 1993; Hales & Bernard, 1996; Armstrong et al., 1993), high levels of repetition (Punnett, Robins, Wegman, & Keyserling, 1985; Silverstein et al., 1987; Wieslander et al., 1989; Chiang et al., 1993; Werner et al., 1997), and/or long duration (i.e., few rest periods). CTS provides a good example of this phenomenon. Silverstein et al. (1987) found individuals with highly repetitive jobs to be 5 times as likely to be diagnosed with CTS than individuals with low-repetition jobs. However, for individuals whose job tasks required both high force and high repetition, the odds ratio increased to 15 when compared with low force, low repetition tasks.

Some theoretical and methodological difficulties exist in research based solely on the biomechanical model of WRUEDs. Methodologically, studies of biomechanical risk factors suffer from significant risk estimate inconsistencies. Estimated odds ratios for the same task characteristic can vary considerably from one study to the next (e.g., vibration exposure, OR = 1.8, Tanaka, et al., 1995; OR = 21.3, Bovenzi, 1994). Hales & Bernard (1996) attribute these variations primarily to imprecise diagnostic criteria and unsophisticated measures of exposure. Although improvements in study methodology would significantly enhance the reliability and validity of these studies, difficulties with the biomechanical theories of WRUEDs would remain.

Although the link between biomechanical exposures and WRUEDs is physiologically plausible, in practice there exists a critical disconnect between biomechanical exposure and clinical outcome. Biomechanical models assume the proximal causal entity for a specified pathological outcome can be found external to the organism in the physiological demands of a task, yielding a one to one correlation between pathological states and symptom expression (Maeda, 1977). Implicit in such a theory is the belief that there exists a level of exposure that is both necessary and universally sufficient for the pathological outcome (Melin & Lundberg, 1997).

Despite decades of research, however, such an exposure has yet to be discovered. In fact, the epidemiological literature instead points to trends that are contradictory to a purely biomechanical model of WRUEDs. Hales et al. (1994) found self-reported overtime work and increasing hours of work at a video display terminal (VDT) to be associated with decreased upper extremity symptoms and total keystrokes per day to be unassociated with upper extremity symptoms and disorders in a sample of telecommunications workers. Additionally, as many as one quarter of active American workers may evidence slowing of the median nerve, more than half of which do not report sensory or motor symptoms (Franzblau et al., 1993). Most interestingly, when followed longitudinally, it appears that these asymptomatic workers with abnormal nerve conduction studies are at no greater risk for developing hand and/or finger symptoms than control workers without evidence of abnormal nerve conduction (Werner, Franzblau, Buchele et al., 1997). Lastly, studies of biomechanical risks have consistently shown that work-related physical load can only partially explain the incidence of WRUEDs (Bongers, de Winter, Kompier, & Hildebrandt, 1993), with most logistic regression models accounting for less than 15% of the variance (Werner, Franzblau, Albers, & Armstrong, 1998).

Biomechanical models of WRUEDs link exposure to biomechanical risks, muscle, tendon, vasculature, and/or nerve pathology (i.e., slowed nerve conduction velocities), and WRUE symptoms in a necessarily sequential and causal chain of events. The studies presented above, however, have significantly weakened the viability of this chain by bringing into question the existence of a direct, causal relationship both between exposure to biomechanical risks and soft-tissue pathology, and between soft-tissue pathology and WRUE symptoms.

Psychosocial Risks

In addition to workplace ergonomic factors that have been associated with strain on the musculoskeletal system, many studies suggest a relation between musculoskeletal complaints and work organization factors. Identified factors include monotonous work tasks, frequent deadlines/time pressure, uncertain job futures, highly variable workload, heavy workload demands, high mental workload, high work pace, low co-worker and supervisory support, low worker autonomy, low decision latitude, and low work group cohesion (Fredriksson et al., 1999; Houtman, Bongers, Smulders, & Kompier, 1994; Bernard et al., 1994; Faucett & Rempel, 1994; Bongers et al., 1993; Sauter & Swanson, 1996; Bongers & de Winter, 1992; Sauter et al., 1993).

Bongers et al. (1993), in a review of the literature on psychosocial factors and musculoskeletal disorders, identified monotonous work, high workload, time pressure, lack of job control, and lack of social support as important work organization characteristics that are related to musculoskeletal symptoms. Although these factors are often correlated with high mechanical loads, psychosocial factors appear to be important even after controlling for physical load (Bongers et al., 1993). In a 10-year follow-up study, Leino & Hanninen (1995) found that work content, work control, social relationships at work, and high mental workload to be associated with and predictive of the change in occurrence of musculoskeletal disorders even after controlling for age, gender, social class, and physical work load.

Although it has been suggested that workplace psychosocial factors are more strongly associated with musculoskeletal symptoms and signs of central body regions such as the neck and back than with symptoms in peripheral body regions (Toomingas, Theorell, Michelsen, & Nordemar, 1997), other investigations focusing specifically on upper extremity complaints have shown self-reported job stress to be related to upper extremity symptoms, disorders, and disability (Huang, Feuerstein, Berkowitz, & Peck, 1998; Polanyi et al., 1997). In a prospective investigation of demographic, physical, occupational psychosocial and individual psychosocial contributors to work-related upper extremity disorders and disability in soldiers, Huang et al. (1998) found frequency of self-reported job stress to be predictive of work disability. Similarly, Polanyi et al. (1997) in a cross-sectional study of newspaper workers with extensive VDT use discovered lower social support, lower skill discretion, and higher psychological demands at work (defined as fast work pace and conflicting demands) to be independently associated with work-related upper extremity symptoms.

In 1989, Hales and colleagues conducted a cross-sectional study of telecommunication employees working at VDTs for at least 6 hours per day and discovered correlations between the type of job stress an employee reported and the site of their upper extremity disorders. High information processing demands were related to disorders of the hand/wrist, while fear of being replaced by computers, low decision-making latitude, increasing work pressure, and lack of a production standard were more consistently associated with neck, shoulder and elbow disorders (Hales et al., 1994). Similarly, in an attempt to relate the site of upper extremity complaints to specific psychosocial factors, Sauter et al. (1993) reported that a fear of being replaced by computers was related to neck and elbow symptoms while high information processing demands were related to symptoms of the neck, hand, and wrist in a sample of telecommunications workers and newspaper employees.

Individual Risk Factors

As the inability of workplace ergonomic and psychosocial exposures to account completely for the prevalence of work-related upper extremity disorders became undeniable, the search began for other potential contributors. It has been increasingly recognized that factors inherent in the individual worker play a significant role in the development and maintenance of WRUEDs. Although these factors and WRUEDs have been shown to be statistically related, very little is currently known about the mechanisms by which they impact the genesis and/or course of these disorders. These factors have generally been classified as either modifiable (e.g., pain/stress coping style, personality factors, obesity and smoking status) or nonmodifiable (e.g., gender and age) risk factors (Hales & Bernard, 1996).

Non-Modifiable Risk Factors

Gender.

Many studies of WRUEDs across all ages and multiple occupational categories have reported an overrepresentation of these disorders among women (Cherniak, 1996, Brogmus et al., 1996; de Zwart, Broersen, Fring-Dresen, van Dijk, 1997; Strasser, Lusk, Franzblau, & Armstrong; de Zwart, Frings-Dresen, & Kilbom, 2001, Bergqvist, Wolgast, Nilsson, & Voss, 1995). Additionally, in 1999, 70% of the CTS and 62% of the tendinitis cases reported by the BLS were female, although men accounted for a slightly larger proportion of the total illnesses and injuries based on their hours worked (BLS, 2001).

The relationship between female gender and musculoskeletal disorders is one that has thus far evaded explanation. Many theories exist, however, ranging from the physiological to the cultural, without conclusive evidence as to why higher rates of WRUEDs are consistently found in female workers. Generally, the high prevalence of WRUEDs in women has been explained in terms of cultural or biomechanical factors (Polanyi et al., 1997). Women more often report a lack of work autonomy, low job control, immobility at workstations, and engagement in repetitive tasks (Meekosha & Jakubowicz, 1986; Messing, Lippel, Demers, & Mergler, 2000), suggesting greater exposure to ergonomic and psychosocial risk factors for WRUEDs. It also has been noted that as women entered the workforce, they were forced into work stations ergonomically designed for male height and reach capabilities, potentially exposing women to greater biomechanical risks (Hales & Bernard, 1996). In support of this theory, an investigation of industrial workers failed to observe a gender difference in WRUEDs when exposure factors were controlled (Silverstein et al., 1987).

Other potential factors have also been proposed. Hormonal fluctuations have been hypothesized as a factor in the overrepresentation of women among individuals with CTS, as well as chronic pain syndromes and autoimmune diseases (Melzack, 1999; Dieck & Kelsey, 1985). Cyclical variations in estrogen output and their effects on cortisol levels throughout the menstrual cycle are well-documented (Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999, Marinari, Leshner, & Doyle, 1976). However, it is unclear whether the changes in estrogen throughout the menstrual cycle or the age-related decrease in overall estrogen levels is the relevant factor (Dieck & Kelsey, 1985; Melzack, 1999). Additionally, although estrogen levels may contribute to exacerbation or maintenance of these disorders, it is unlikely that this mechanism is specific enough to be a singular, causal factor in WRUEDs.

Another theory involves a gender-specific difficulty in accessing medical treatment. It has been suggested that women are more likely to report pain and seek medical treatment than men (Hales & Bernard, 1996). Some have conjectured that this help-seeking behavior may lead to the minimization of symptoms by some health care providers and hindered access to physical therapy and rehabilitative interventions (Armstrong et al., 1993).

Lastly, differences in wrist morphology between males and females have been proposed as a causal factor for the unequal gender distribution of CTS (Gerr & Letz, 1992). Smaller carpal canal area has been associated with CTS in some studies (Bleecker, Bohlman, Moreland, & Tipton, 1985). However, others have failed to find an association between wrist circumference and CTS (Winn & Habes, 1990).

Age.

Many upper extremity-related studies have suggested older age to be associated with greater risk for WRUEDs. The National Health Interview Survey reported that the likelihood of having medically diagnosed carpal tunnel syndrome increases with age among people who are 18 years or older and who have been employed at some time in their adult lives (Tanaka et al., 1994). In a particular study of WRUEDs and office workers, self-reported upper extremity disorders were more frequent among older workers who used visual display units (Bergqvist et al., 1995). There also appears to be a relationship among gender, age, and WRUEDs, with older women being at significantly greater risk than younger women and men of any age (de Zwart et al., 1997).

Little speculation in the literature has occurred regarding the nature of the relationship between chronologic age and WRUE disorders and symptoms. However, there is some suggestion that this relationship is not unique to WRUE disorders, and chronologic age is related to all work-related health complaints across a variety of occupations (Broersen, de Zwart, van Dijk, Meijman, & van Veldhoven, 1996). It is likely that time at current work tasks (i.e., a index of long-term exposure to biomechanical and psychosocial risks), as well as age-related compromises in immune system function and tissue healing (Yung, 2000; Meydoni, Wu, Santos, & Hayek, 1995; Buckwalter, 1997), mediate the relationship, although no direct pathophysiologic data has been collected to support or refute such an interpretation.

Modifiable Risk Factors

Obesity.

There appears to also be a relationship between obesity and the most common WRUED, CTS. Investigations of patients with CTS have revealed a consistent relationship between being overweight and 1) having a mononeuropathy of the median nerve, 2) being diagnosed with CTS, and 3) undergoing surgical intervention for CTS (Stallings, Kasdan, Soergel & Corwin, 1997; Nordstrom, Vierkant, DeStefano, & Layde, 1997; Tanaka et al., 1997; Werner & Franzblau, 1994). Workers with a body mass index (BMI; kg/m^2) greater than 25 have been shown to be four times as likely to present with a median mononeuropathy than coworkers with a BMI less than 25 (Werner, Franzblau, Albers, & Armstrong, 1997). Additionally, it has been shown that carpal tunnel release patients are twice as likely to have a BMI > 25 than the general population (Lam & Thurston, 1998).

Although the nature of the relationship remains unclear, it has been suggested that being overweight may serve to increase the amount of fatty tissue within the carpal canal or to increase hydrostatic pressure through the carpal canal (Werner et al., 1997). However, to date there has not been a systematic study of the anatomy of the carpal tunnel in obese versus normal weight people. It has also been hypothesized that overweight individuals may place more mechanical stress on their hands and wrists via increased exertions to compensate for the loss of dexterity due to fatty tissue on the hands and fingers (Werner et al., 1997). This may explain the differential relationship Letz & Gerr (1994) reported between body weight and median nerve function and body weight and the function of other peripheral nerves. Although a positive relationship was reported between body weight and compromised median nerve functioning, a slightly negative relationship between body weight and the sural, ulnar, and peroneal nerves was observed (Letz & Gerr, 1994). Lastly, obesity may merely reflect an individual s overall level of physical conditioning, which may influence the functioning of the median nerve (Werner et al., 1997).

Personality constructs.

Certain stereotypical ways of responding to emotional and environmental challenges have been theoretically and empirically linked to various adverse health outcomes in the behavioral health literature. There exists a great deal of support for the idea that these patterns of responding, whether they be labeled as personality traits, personality characteristics, or coping styles, may moderate the stressor-strain relationship. Constructs including the type A behavior pattern (especially hostility), negative affectivity, neuroticism, and self-monitoring have been shown to impact physical, emotional, and behavioral stress sequelae in and outside the work environment (e.g., Schaubroeck, Ganster, & Fox, 1991; Fox & Dwyer, 1995; Lawler & Schmied, 1987; Glasscock, Turville, Joines, & Mirka, 1999; Bru et al., 1993; Salminen, Pentii, & Wickstrom, 1991).

The characteristic competitiveness, impatience, vigorous speech, and hostility of the type A behavior pattern have been positively associated with higher mortality from various causes (Friedman & Rosenman, 1959; Smith, 1992). It has additionally been shown to predict muscle, endocrine, and cardiovascular reactivity to stressors of various types. Glasscock et al. (1999) in a study of performance on elbow flexion isometric trials found that type A men and women consistently showed significantly greater sEMG levels for forearm extensor muscles (i.e., muscular antagonism) than subjects who did not exhibit the type A behavior pattern. Similarly, Salminen et al. (1991) observed that metal industry employees reporting tenderness in the neck and shoulders more often emitted type A behaviors than those who did not report such symptoms.

Although the type A behavior pattern appears to be related to physiological reactivity to acute stress, it also appears to interact with current levels of life stress. Lawler and Schmied (1987) exposed a group of female clerical workers to a series of laboratory stressors and found that type A individuals had higher overall baseline levels of systolic and diastolic blood pressure and a trend toward greater frontalis sEMG reactivity to a mental arithmetic and a vigilance task. However, in this sample, cardiovascular and sEMG reactivity were significantly related to self-reported levels of life stress (i.e., life change unit score over the past year) where women without type A behaviors who had experienced a large number of stressors in the past year were more reactive than women with type A behaviors who reported relatively few life stressors. These findings suggest that although personality type may be a predictor of reactivity to stress exposure, stressful life events may contribute to reactivity to stressors regardless of an individual s predominant personality type.

Hostility has also been associated with lost work time subsequent to stress exposure. Kivimaki, Vantera, Koskenvuo, Uutela, & Pentti (1998), in a prospective investigation of government workers in Finland, found that over a 5-year follow-up period, women high in hostility who experienced severe organizational stressors (e.g., downsizing, increased job demands, negative changes in the work environment) had greater days of lost work due to musculoskeletal disorders and to illness in general. Specifically, women high in hostility who reported high levels of job insecurity, high job demands, and significant changes in job demands had greater lost work days due to musculoskeletal disorders. Hostility in men facing similar stressors was associated with increased work absences only after exposure to traumatic injury (Kivimaki et al., 1998).

Psychopathology.

Many recent studies have investigated the prevalence of psychological diagnoses in individuals with musculoskeletal symptoms and disorders. Ursin, Endresen, & Ursin (1988), in a study of male and female workers in various occupations, found anxiety and depressive symptoms to be positively related to musculoskeletal symptoms. Additionally, Spence (1990) found higher levels of anxiety in both chronic and acute upper extremity pain patients compared to a normal sample (Spence, 1990).

Most recently, Mathis, Gatchel, Polatin, Boulas, & Kinney (1994) reported 77% of a sample of CTS patients to have at least one lifetime psychological diagnosis, the most prevalent of which were the anxiety disorders (45%). This was striking in comparison to the low back pain cohort in which only 12% received a current anxiety disorder diagnosis. None of these studies permit causal attribution for CTS to be made to psychopathology. However, the short duration of carpal tunnel symptoms (less than 6 months) reported by the CTS patients in Mathis et al. (1994) suggests many of these patients likely had a diagnosable anxiety disorder prior to experiencing upper extremity symptoms.

Integrative Models of Work-Related Upper Extremity Disorders

Efforts to place these physiological, ergonomic and psychosocial factors within a meaningful context have resulted in many theoretical models linking job stress to the problem of work-related upper extremity disorders.

Balance Theory of Job Design and Stress (Smith & Carayon-Sainfort, 1989; Figure 1)

The balance theory of job design and stress provides a framework for examining the relationships and interactions among work organization, ergonomic exposure, job stress, and work related upper extremity disorders. In this model, Smith & Carayon (1996) identify important factors in the three general domains of the human stress response, namely the biophysiological domain, the behavioral domain, and the psychological or cognitive domain. More specifically, this model proposes that job stressors produce short term emotional (e.g., adverse mood states), behavioral (e.g., smoking, excessive use of force in work tasks), and physiological (e.g., increased muscle tension, elevated blood pressure, elevated cortisol/catecholamine levels) reactions. For certain individuals who are chronically exposed to job stress, these reactions can lead to increased risk for adverse health outcomes which may include, but are not limited to, work-related upper extremity disorders. This model also incorporates individual characteristics such as age and personality that may influence the stress response. Additionally, this model emphasizes feedback loops among disease/illness, stress reactions, and stressors, uniquely considering the experience of symptoms as a stressor in and of itself, which can increase stress reactivity and lead to further adverse mental and physical health outcomes (Smith & Carayon, 1996).

(Insert Figure 1 About Here)

The Biopsychosocial Model of Job Stress (Figure 2, Melin & Lundberg, 1997)

Incorporating classic and state-of-the-art psychological and physiological stress research, Melin & Lundberg (1997) have proposed a biopsychosocial model of stress and musculoskeletal disorders that was designed to be uniquely applicable to individuals performing light physical work (e.g., data entry and clerical). In this model, job stress (biomechanical and/or psychological stressors) is defined as any task or situation for which an individual s resources are too great or too small (Frankenhaeuser & Gardell, 1976). These job stressors produce physiological responses including muscle tension and increased cortisol and catecholamine secretion. Theoretically, in individuals who have the opportunity to relax and unwind after work, these responses will dissipate and are not likely to result in adverse health outcomes. However, for workers who have physical or psychological demands that extend beyond the workday (e.g., household work, child care, second jobs), these physiological responses may be sustained or may diminish much more slowly, putting these individuals at increased risk for musculoskeletal disorders.

(Insert Figure 2 About Here)

Ecological Model of Musculoskeletal Disorders (Figure 3; Sauter & Swanson, 1996)

Sauter & Swanson (1996) proposed a model that integrates the psychosocial stress process into the traditional biomechanical model of musculoskeletal disorders. This model includes biomechanical and psychosocial factors with a cognitive component mediating biomechanical strain and the development of musculoskeletal disorders. According to their model, work-related musculoskeletal disorders can be ultimately traced to work technology, which includes the nature of tools and work systems.

(Insert Figure 3 About Here)

Additionally, this model shows a direct path between work organization and psychosocial strain (stress) that influences musculoskeletal outcomes via two routes. First, psychological strain is hypothesized to produce muscle tension and other autonomic effects that compound biomechanical strain induced by task-related physical demands. Second, psychological strain is hypothesized to moderate the relationship between biomechanical strain and the appearance of symptoms via symptom perception, attribution and appraisal without directly impacting physical pathology. For example, in the execution of dull, routine, or repetitive tasks competition for attention might be reduced, increasing the probability that symptoms, that might have gone unnoticed under more stimulating circumstances, will be detected. As with the appraisal of any stimulus, once it is perceived, explanations are sought (Schacter & Singer, 1962). In a litigious or aversive work environment, these symptoms of discomfort are more likely to be attributed to one s job. In this manner, job stress and the psychosocial work environment may increase the probability of help-seeking and injury reporting without exerting a direct influence on the underlying pathology. Finally, the model suggests that the experience of musculoskeletal symptoms feeds back to influence stress at work (this is the pathway between physical environmental factors and stress).

<u>Workstyle Model of Job Stress and Musculoskeletal Disorders (Figure 4; Feuerstein 1994)</u>

Another model was proposed by Feuerstein (1994) to explain the relationship among job stress, ergonomic exposure, and work-related upper extremity disorders. The model proposes the importance of workstyle, or how an individual performs work, in response to work demands. Workstyle consists of cognitive, behavioral and physiological components that are consistent with the frequently reported mulitcomponent stress response. The behavioral component represents the overt manifestations of movement, posture, and activity. The cognitive component refers to the thoughts, feelings, appraisals, and the worker s evaluation of the success/failure of his/her responses. The physiological component represents the biological changes that accompany the behavioral and cognitive reactions, including increased muscle tension, increased tendon force, increased catecholamine and/or cortisol release, and stress induced changes in immune function (Feuerstein, Huang, & Pransky, 1999). In a stressful psychosocial work environment, individuals with a high-risk workstyle may continually exert excessive levels of effort, exposing themselves to chronic physiological, cognitive, and behavioral stress sequelae.

(Insert Figure 4 About Here)

Various preliminary measures of the workstyle construct have been shown to be associated with symptom severity, functional limitations, and work disability in individuals exposed to hand intensive work (Feuerstein et al., 1997; Haufler, Feuerstein, et al., in press). Additionally, workstyle has been associated with increased biomechanical exposure, including excessive key force, fewer rest periods, and excessive wrist deviations from neutral (Feuerstein, Armstrong, Hickey, & Lincoln, 1997; Feuerstein & Fitzgerald, 1992). The construct appears to have external validity. However, currently there are no data available that documents the physiological correlates of high-risk workstyle. Since this construct is linked to reaction to stress, additional research on physiological response to stress in various clinical groups with work-related upper extremity disorders should shed light on the potential psychophysiological mechanisms related to this construct.

Possible Mechanisms Linking Stress and Work-Related Upper Extremity Disorders

The individual and workplace psychosocial factors described above appear to play a complex role in the development and maintenance of upper extremity musculoskeletal disorders that the current empirical literature cannot fully explain. However, many theoretical positions suggest that the common effect of these factors on upper extremity disorders may be found in the psychophysiological sequelae of the human stress response (Smith & Carayon, 1996).

Stress and the Response of the Musculature

Some investigators have recently proposed that muscle tension, secondary to job stress, may account for a proportion of the relationship between psychosocial factors and musculoskeletal disorders (Ursin, Endresen, Svbak, Tellnes & Mykletun, 1993; Waersted, Bjorklund & Westgaard, 1991). However, the notion that muscle tension can increase in response to the psychological characteristics of the environment is not a new concept (Jacobson, 1927,1930a, 1930b; Goldstein, 1972). In a series of studies that began in the late 1920s, Jacobson found significant, localized muscle action potentials (MAPs) during the imagination of specific muscle movements. Shaw & Kline (1947) confirmed Jacobson s finding that muscle tension increases with mental activity. However he failed to find the muscle group specificity reported by Jacobson. Similar to Jacobson, Shaw found the largest number of MAPs in the muscle groups involved in the imagined movement. He also found, however, simultaneous

MAPs throughout the subjects bodies in almost every area tested. These investigations provided the earliest evidence that mental activity can affect general muscle activity in the absence of overt physical movement.

Subsequent investigations by Jacobson and others revealed that muscle activity is involved in a variety of mental activities and can be related to the nature of such activities (Jacobson, 1932). For example, in 1961 Eason & White discovered muscle tension during task performance to be directly related to task difficulty, external performance demands, and the subject s skill at performing the task, even for tasks requiring insignificant levels of physical exertion. More recently, via the manipulation of the complexity of a choice reaction time task, Westgaard & Bjorklund (1987) identified significant levels of surface electromyogram (sEMG) activity in the trapezius muscles that could be singularly attributed to the psychological demands of the task. Additionally, Lundberg, Kadefors, Melin, Palmerud, Hassmen, Engstrom, & Dohns (1994) found mental stress alone (i.e., mental arithmetic) significantly increased trapezius muscle tension. Lundberg et al. (1994) also reported that subjects participating simultaneously in a mental stress task and a low-load physical activity task evidenced a synergistic increase in sEMG activity in the upper trapezius.

The previously described studies were all laboratory-based experimental investigations. However, in an effort to enhance the external validity of these findings, some investigators have moved outside of the laboratory. In an *in vivo* study of muscle activity response to task demands, Lundberg et al., (1999) measured upper trapezius sEMG activity in cashiers during a single workday. They reported that physical work load in this sample was uncorrelated with upper trapezius muscle tension. These studies taken as a whole suggest factors independent of the physical exertion required by a task (e.g., individual characteristics, psychological task demands) may be important determinants of upper extremity sEMG response both in the laboratory and on the job (Lundberg et al., 1999).

Many studies of the stress/muscle activity relationship investigate the muscle activity of the middle and upper trapezius. Other studies have looked more closely at the muscles of the forearm, including the forearm extensors and flexors. A great deal of hand and finger motion is provided by the forearm extensors and flexors, and many of the tendons responsible for finger flexion and extension pass from these muscles through the carpal canal where they attach to the phalanges (Concannon, 1999), where fatigue or trauma could lead to various WRUEDs such as CTS and tendinitis. Therefore, the reactivity of these muscle groups to psychosocial factors could also be an important factor in the relationship between stress and WRUEDs.

Gomer, Silverstein, Berg, & Lassiter (1987) studied keyboard operators performing sorting tasks with varying levels of visual and memory demands. More demanding tasks were associated with reports of increased mental strain, spectral changes in the forearm EMG, increased forearm tremor, and increased musculoskeletal discomfort. Arndt (1987) collected sEMG data from the forearm flexor muscles of workers performing a highly repetitive machine-paced manual task. Not only were faster work paces accompanied by higher muscular tension and slower work paces with lower muscular tension, but attempts to speed up or slow down with no absolute changes in work pace yielded similar increases and decreases in muscular tension. This study suggests that non-biomechanical factors (e.g., the perception of increased work pressure or decreased work pressure) and not work pace per se may be important determinants of task-related muscular responses.

Why does increased muscle activity accompany increases in psychological stress? One theory that seems to be particularly pertinent to upper extremity disorders has been offered by van Galen & colleagues (van Gemmert & van Galen, 1997; 1998). They suggest that increased muscle tension serves as a biomechanical filter in response to increased information processing demands. Founded on the assumption that all human cognitive activities involve varying degrees of neuromotor noise (which is analogous to waste thermal warmth in a power plant), they propose that increased processing demands (either physical or mental) placed upon a task which has a motor output requirement (e.g., typing, handwriting, performing music, or drawing) serve to increase the level of neuromotor noise and cause undesirable variability in motor output (van Gemmert & van Galen, 1997; 1998). Muscle tension, then, appears to be a biomechanical mechanism by which an individual may attempt to counteract the deleterious effects of added processing demands in order to reduce the impact on motor control (Van Den Heuvel, van Galen, Teulings, & van Gemmert, 1998; van Gemmert & van Galen, 1997).

Another theory linking stress and muscle tension has been proffered by Donaldson and colleagues (Donaldson, Nelson, Skubick, & Clasby, 1998). They propose that stress may trigger forearm muscle hyperactivity via the reemergence of a reflexive muscle phenomenon known as the tonic neck reflex. The tonic neck reflex is a muscle co-contraction phenomenon (i.e., a synergistic activation of the muscles controlling a movement; Radwin & Lavender, 1999) that involves the extension and abduction of upper and lower extremities in the direction of head rotation with corresponding adduction and flexion of the contralateral upper and lower extremities (Brett & Kaiser, 1997). In other words, excitation of the neck muscles (specifically the sternocleidomastoid muscles) on one side of the body results in muscle contractions in the upper and lower limbs on the opposite side. In the upper limbs, this reflex primarily impacts the muscle activity of the forearm flexors and extensors (Basmajian & De Luca, 1985).

Most observable in infants and small children, this tonic neck reflex typically attenuates with age as motor control acquisition is achieved through the increasing inhibition of antagonist activity relative to that of the muscles primarily involved in a movement (Basmajian & De Luca, 1985). It is, however, observable in adults to a limited extent, and it can reemerge as a dominant factor in upper extremity motor control under conditions of stress or with increasing age (Basmajian & De Luca, 1985).

Donaldson et al. (1998) proposed that the reemergence of the tonic neck reflex is the result of dysregulation of the normal inhibitory feedback mechanism which may lead to hyperactivity of the muscle after contraction, excessive electrical activity during movement, and/or inappropriate coactivation with other muscles during movement. In many cases the co-contraction is between muscles working fully or partially in opposition to one another. From a biomechanical perspective, it is a way in which joints can be stiffened, stabilized, and moved in a well-controlled manner; it can also significantly increase mechanical loads (compression, shear, or torsion; Radwin & Lavender, 1999). This is because any co-contraction of fully or partially antagonistic muscles requires increased activation of the agonist muscles responsible for generating or resisting the desired external load. Thus, co-contraction increases joint loading by the antagonistic force and by the additional agonist force required to overcome this antagonistic force. As a result, work activities where co-contractions are more common impose greater loads on the tissues of the musculoskeletal system. Although preliminary evidence of the hazards of the co-contraction phenomenon during physical tasks has been reported, at present there are no studies investigating the occurrence of the phenomenon in the absence of physical activity.

Although the idea that the psychological demands of a task can directly impact muscle tension has been widely acknowledged for some time, the notion that stress-induced muscle tension and the consequent tendon load might expose an individual to increased biomechanical risk for musculoskeletal disorders has been a relatively recent proposal (Skubick et al., 1993). Chronic forearm muscle tension that can result from psychosocial stressors may place sustained tension loads on the tendons in the wrist. Tendons are the connective tissues linking muscle to bone and therefore transmit muscle forces to the skeletal system to produce voluntary movements and exertions (Radwin & Lavender, 1999). Armstrong & Chaffin (1979) likened the relationship between muscle force, tendon load, and wrist angle to a pulley and a belt in which the greater the radius of curvature of the pulley (i.e., the angle of wrist deviation from neutral), the greater the tendon load.

Because circulation in the tendon is inversely proportional to the applied tension, circulation can cease at greater tensions (Armstrong et al., 1993), and repeated, prolonged exertions with insufficient recovery time can lead to deformation of tendons and reduced perfusion (Radwin & Lavender, 1999). Such insults to the tendon structures and vascular supply could be the first step towards a number of upper extremity symptoms and/or disorders.

Another potential mechanism linking forearm muscle tension and WRUEDs may involve the fatiguing of low-level motor unit neurons as suggested by Westgaard & Bjorklund (1987). Waersted, Bjorklund, & Westgaard (1987; 1991), after extensive investigation of the stress-muscle tension relationship, observed that stress-induced muscle contraction patterns typically involve the activation of small motor units. When chronically experienced, this chronic tension (.4 - 2.5% of maximal voluntary contraction [MVC]) could lead to musculoskeletal discomfort or injury via the fatigue of small motor units (Westgaard & Bjorklund, 1987; Waersted et al., 1991). Support for this hypothesis was provided by Westgaard & de Luca (1999). While examining the activity pattern of low threshold motor units in the trapezius muscles during low level contractions, Westgaard & de Luca found that in normal subjects there are often periods of inactivity in these low-threshold motor units in which they are substituted by motor units of a higher recruitment threshold. During these times of substitution, gaps in the low frequency EMG signal can be observed. These frequency gaps are believed to serve a protective function for the low threshold motor units during sustained, low-level muscle activity. However, these gaps are often less frequent or unobservable in individuals with musculoskeletal symptoms in the observed muscles, indicating chronic, invariable activation and inevitable muscle fatigue.

One way this fatiguing of activated muscles can impact the genesis and/or maintenance of WRUEDs is via alternative muscle recruitment. If the muscles needed to perform a task have been overtaxed by chronic, low-level muscle tension, an individual may be forced to use compromised postures and awkward exertions of less suitable muscles in order to perform the required task. Thus, utilization of less suitable muscles and awkward postures could cause or maintain WRUEDs via exposure to harmful biomechanical risks (Sjogaard, 1996; Radwin & Lavender, 1999).

At least one model has proposed a specific muscular mechanism for a specific WRUED, CTS. Donaldson and colleagues, who proposed the tonic neck reflex theory of stress-induced forearm muscle hyperactivity, assert that muscle hyperactivity in the upper extremities may lead directly to CTS. While not all of the mechanisms are fully identified, it is believed that excessive electrical activity and inappropriate coactivation with other muscles during movement are the chief correlates of disinhibition that are linked to the reemergence of the primitive reflex activity. Over time, dysfunction of the sternocleidomastoid muscles results in increased forearm flexor and/or extensor activity which leads to increased tendon load, potential tenosynovitis, and an increase in carpal tunnel pressure (Skubick, Clasby, Donaldson, & Marshall, 1993).

Preliminary support for this theory was reported by Skubick et al (1993). Eighteen symptomatic CTS patients were treated with neuromuscular retraining aimed at decreasing the muscular asymmetry in the neck via sEMG readings for the sternocleidomastoid muscles. Reduction of sternocleidomastoid asymmetry was associated with decreased forearm flexor sEMG activity and a decrease in all nerve conduction measures for every subject. Due to the exclusion of a no treatment and standard treatment control groups, however, it is impossible to rule out other nonspecific factors potentially responsible for the improvement in these subjects. Although these investigations are somewhat limited methodologically, they provide important insights into neuromuscular response to and regulation of task demands and may provide a link between job stress and CTS.

Stress and the Cardiovascular/Circulatory Response

In addition to associations with muscle tension, many workplace factors have been shown to affect cardiovascular and circulatory responses (including increases in heart rate, systolic, and diastolic blood pressures). Early evidence suggests that being at work generally elevates ambulatory blood pressure (Pickering et al., 1982; White, 1986). However, more recent investigations highlight specific factors, such as work posture (e.g., standing vs. sitting) and social circumstances (e.g., being with family vs. strangers) that can evoke significant changes in cardiovascular measures (Gellman et al., 1990; Spitzer, Llabre, Ironson, Gellman, & Schneiderman, 1992). Specifically, Gellman et al. (1990) observed significant effects of place and mood only when subjects were sitting but not when they were standing. Also, Spitzer et al (1992) found that systolic and diastolic blood pressure levels varied significantly depending on the social situation. Blood pressure levels were lowest when subjects were with family and highest when with strangers, accounting for as much as 37% of the variance in seated blood pressure levels.

Although many factors related to the work environment can affect hemodynamic reactivity, whether or not such reactivity is uniquely related to the genesis and/or maintenance of WRUEDs is unclear. A potential link between WRUEDs and stress-induced cardiovascular reactivity may exist in the relationship between cardiovascular reactivity and an individual s threshold for pain. Specifically, a recent investigation conducted by Caceres & Burns (1997) sought to elucidate this relationship. High and low cardiovascular reactors (measured by change in mean arterial pressure [MAP] in response to a mental arithmetic task) were exposed to a mental arithmetic task and, one minute afterwards, a cold pressor task. High cardiovascular responders showed lower post-stressor pain thresholds and decreased pain tolerance than low cardiovascular responders exposed to the same conditions, suggesting an individual s hemodynamic response to stress may be related to increased sensitivity to subsequent painful stimulation. A similar study of post-stressor pain sensitivity conducted by Levine, Krass, & Padawer (1993) discovered that all stressors do not universally have the same effects on pain thresholds. Levine and colleagues observed that an individual s perception of failure on a stressor task, not task difficulty per se, was related to a diminished pain threshold.

Both the Levine et al. (1993) and Caceres & Burns (1997) studies were conducted in a laboratory environment using subjects without pain complaints. However, a recent cross-sectional *in vivo* study of female supermarket cashiers found that women who reported pain in the neck and/or shoulders reported more work stress and evidenced higher daytime blood pressures than women who did not report musculoskeletal pain (Lundberg et al., 1999). Although the directionality of the relationship remains unclear, these studies taken together provide some evidence that increased cardiovascular activity may co-occur with increased pain sensitivity as a result of stress/perceived failure in a work situation. In individuals with WRUEDs, this may lead to the exacerbation of the pain experience.

The previous studies suggest a relationship between job stress, cardiovascular reactivity, and pain, a primary symptom of WRUEDs. One study directly explored the relationship between hemodynamic variables and median nerve function. The median nerve is a primary nerve in the arm and, when entrapped at the wrist, is responsible for the symptoms of CTS. Szabo, Gelberman, Williamson, & Hargens (1983) reported a relationship between mean arterial pressure and the critical tissue pressure level required for nerve dysfunction in the median nerve. They discovered that in individuals with elevated blood pressure, significantly greater acute, localized compression forces were required to instigate nerve dysfunction as compared to normotensives. Although it remains to be seen if the findings of this study are equally applicable to temporary, stress-induced elevations in mean arterial pressure, the findings suggest hypertension may result in continued nerve function in the face of significant compression forces. Although nerve function would initially persevere, these high compression forces could place hypertensive individuals at greater risk for structural damage to the soft tissues (e.g., tendon strain or mechanical nerve injury), precipitating inflammation and potential tenosynovitis which can further increase tissue pressure in the carpal tunnel and ultimately lead to median nerve compression and dysfunction.

Stress and the Biochemical Response

Another potential factor linking WRUEDs and job stress may involve the biochemical sequelae of stress exposure. These sequelae primarily involve the release of the catecholamines, epinephrine and norepinephrine, and the corticosteroid, cortisol. The catecholamines are secreted by the adrenal medullae and neurons throughout the nervous system, and cortisol is secreted by the adrenal cortex (Frankenhaeuser, 1983). Although serum levels of cortisol, epinephrine, and norepinephrine typically rise and fall throughout the day (Melin, Lundberg, Soderlund, & Granqvist, 1999; Kirschbaum & Hellhammer, 1989), investigations into psychological and environmental correlates of stress hormone levels have discovered that the sympathetic nervous system stimulates the release of these hormones as differential responses to the specific demands of a stressor. In general it has been reported that the catecholamines appear to be related to the positive (i.e., motivating or challenging) mental and physical demands of a stressor. Specifically, epinephrine output appears to be particularly sensitive to mental stress, while norepinephrine appears to reflect primarily physical demands and body posture (Lundberg & Johansson, in press). On the other hand, cortisol appears to be generally related to negative aspects of the stress response, including negative affectivity, the anticipation of negative consequences, and the perception of events as novel, uncontrollable, and/or unpredictable (Mason, 1968; Brantley, Dietz, McKnight, Jones, & Tulley, 1988; VanEck, Berkhof, Nicolson, & Sulon, 1996; Kirschbaum & Hellhammer, 1989; Smyth, Ockenfels, Porter, Kirschbaum, Hellhammer, & Stone, 1998).

In a review of the literature concerning psychological stress and salivary cortisol levels, Kirschbaum & Hellhammer (1989) identified two psychological triggers that seem to stimulate the release of cortisol by the adrenal cortex. These are the determination that a particular goal or task is important to one s self concept (i.e., the evaluation of threat) and the anticipation of unpleasant events or outcomes. Frankenhaeuser & Johansson (1986) identified two similar variables they labeled effort and distress which were found to affect differential catecholamine reactivity. They discovered that activities which involved only effort (i.e., engagement, interest, and determination), resulted in increased catecholamine levels while activities involving only distress (i.e., dissatisfaction, boredom, uncertainty, and anxiety) resulted in significant increases in cortisol and only slight increases in catecholamines (Frankenhaeuser, 1986, Frankenhaeuser & Johansson, 1986). Activities involving both effort and distress were accompanied by increases in both catecholamines and corticosteroids.

These patterns have also been shown to hold true outside the laboratory. Specific tasks and job characteristics appear to elicit different biochemical responses across individuals. For example, Lundberg et al. (1999) reported on-the-job increases in both epinephrine and norepinephrine by as much as 75% in a sample of supermarket cashiers, whereas individuals in data entry and clerical occupations have typically shown only slight increases in norepinephrine levels throughout the work day (Frankenhauser, Lundberg, Fredrikson, Melin, Tuomisto, & Myrsten, 1989; Lundberg & Frankenhaeuser, 1999; Johansson & Aronsson, 1984). Such differences have been attributed to the physical demands of the work task, specifically postural demands (Lundberg et al., 1999).

In addition to physical job demand characteristics, the psychosocial characteristics of the work environment, such as task repetitiveness and rigid work arrangements, also appear to affect circulating catecholamine levels. Lundberg, Melin, Evans, & Holmberg (1993) found that deactivation (i.e., recovery to baseline) of catecholamines, especially epinephrine, was slower after a repetitive data entry task than after a stimulating, self-learning task. Melin et al. (1999) reported that catecholamine levels in male and female assembly workers who were given the opportunity to work in autonomous groups and to influence their work pace decreased more rapidly after work than catecholamine levels in individuals who worked in the traditional work organization with fixed work stations and short, repetitive work cycles.

In this study, as well as others, the pattern of heightened reactivity and delayed recovery has been especially salient in female workers and even more marked in female workers who have children at home. Luecken et al. (1997) reported a significant main effect of parental status on 24-hour cortisol secretion, with women with at least one child living at home secreting more cortisol than women without children, independent of marital status or social support. These studies suggest a potential interaction among gender, paid and unpaid work demands, and biochemical stress reactivity and recovery (Melin et al, 1999; Lundberg & Frankenhaueser, 1999). If WRUEDs are found to be effected by the biochemical sequelae of sympathetic arousal, female workers with children at home could be at increased risk. Although the direct physiological link has not been established, at least one investigation of visual display terminal workers reported women with children at home to be at greater risk for the occurrence of musculoskeletal disorders (Bergqvist et al., 1995).

In addition to the gender and psychosocial factors discussed above, potential physiological and biomechanical mechanisms have been identified that could link work organization factors, circulating stress hormone levels, and WRUEDs. Higher levels of catecholamines and cortisol may be involved in the etiology of WRUEDs via their catabolic effects on muscles, tendons, and ligaments (Faucett & Werner, 1999). In addition to the direct structural effects of these hormones on the body s soft tissues, norepinephrine release allows individuals under stress to perform tasks faster and more vigorously, potentially increasing their exposure to biomechanical risks (Smith & Carayon, 1996). Lastly, in individuals with pre-existing injury to the soft tissues in the upper extremities, cortisol that is released in response to both psychological stress and physical injury may decrease the local immune response (especially the inflammatory response) thereby hindering the recovery of the damaged tissues (Melzack, 1999; Sapolsky, 1996). Melzack (1999) proposed, based on these identified interactions involved in the homeostasis-maintaining mechanisms in the human body, that any site of increased cytokine activity and inflammation could become the focus of cortisol action and soft-tissue destruction.

Stress and the Psychological Response

Various psychological stress sequelae including adverse mood states (e.g., depression, anxiety, and anger) have been shown to be related to the physiological stress response (e.g., changes in immune functioning, increased muscle tension, and catecholamine and cortisol release; Baum, Gatchel, & Krantz, 1997; Jacobsen, 1932; Irwin, Patterson, Smith et al., 1990). Theorell, Harms-Ringdahl, Ahlberg-Hulten, & Westin (1991) studied the effects of work stressors on emotions, endocrine states, muscle tension, and musculoskeletal symptoms in the back, neck, and shoulders and discovered that work stressors were related to negative emotions (e.g., worry), as well as other self-reported physical reactions such as muscle tension and pain.

Sauter Gottlieb, Rohrer, & Dodson (1983) proposed that mood states may be a mediating factor among work organization stressors, such as job uncertainty, poor social support, high work-load demands, and physiological reactivity, and musculoskeletal symptoms in visual display terminal (VDT) users. An alternative explanation has been offered by Fox and Dwyer (1995). They attribute the relationship among mood states, work organization, and physiological stress responses to the personality construct of self-monitoring (Snyder, 1974). Defined as the extent to which an individual attends to his/her environment, self-monitoring was found to be related to greater self-reported indices of depression and anxiety as well as salivary cortisol levels in a group of nurses reporting high work demands and high numbers of job-related stressors (Fox & Dwyer, 1995).

Stress Appraisal and Coping Style

The unique psychological, social, and biomechanical milieu that potentially impacts WRUEDs directly may also play a role in the perception, attribution, and interpretation of WRUED symptoms. Cioffi (1991) contends that the development and reporting of symptoms is not a direct result of an internal physiological event but rather a behavioral response elicited by multiple biopsychosocial events. These events, occurring within a unique physical, occupational, and social context, include the experience of the symptoms and the generation of theories regarding their causes and effects. Sauter and Swanson (1996) describe this as the iatrogenic process in musculoskeletal disorders. This theoretical process supposes that environmental forces, including medical practitioners, social and cultural factors, legal compensation systems, and workplace industrial relations, create an atmosphere that affects the appraisal of musculoskeletal discomfort as signs of underlying injury, thereby promoting the development of sick roles and disability (Hadler, 1990; 1999). In this perspective, job stress does not directly contribute to the pathophysiology of WRUEDs, but to the misinterpretation of normal, universal discomfort as a potentially disabling disorder. Although theoretically viable, this process has not been tested empirically (Sauter & Swanson, 1996).

Others have suggested that job stress and its resultant physiological and emotional arousal impact perception and attribution of WRUED symptoms via attentional focus. There exists some evidence that attentional focus, and not anxiety, may increase the experience of pain.

This hypothesis received some support in a recent investigation of psychophysiological reactivity to different types of stressors. Moulton and Spence (1992) reported that musicians experiencing upper extremity pain (i.e., pain in the fingers, hands, wrists and/or forearms) evidenced greater trapezius sEMG and forearm flexor sEMG reactivity and delayed recovery to baseline sEMG levels in response to a pain memory recall task than to a neutral alphabet task and a generic stressor task. Musicians reporting upper extremity symptoms also evidenced greater reactivity to the pain memory recall task than an asymptomatic control group exposed to a pain memory recall task. This study suggests that pain may persist for those who respond to pain with learned muscle reactivity as a result of the continuous pairing of the environmental stimuli, muscle tension, and pain (Arntz, Dreessen, & Merckelbach, 1991; Moulton & Spence, 1992).

Another stress appraisal response that appears to be important in the development and maintenance of WRUEDs is catastrophic thinking, or the tendency to view circumstances in an extremely negative manner and without hope for future improvement. Catastrophic thinking appears to be especially important in patients who hold such beliefs regarding their physical condition. In a cross sectional investigation of patients with soft tissue injuries in the neck, shoulders, or back related to work or an automobile accident, Sullivan, Stanish, Waite, Sullivan, and Tripp (1998) found catastrophizing to be significantly correlated with pain intensity, perceived disability, and employment status. Additionally, catastrophizing has been shown to predict health outcomes. Feuerstein, Huang, et al. (2000) found that the tendency to catastrophically interpret work-related upper extremity disorder symptoms (e.g., pain) prospectively predicted poor health outcomes at 1, 3, and 12-month follow-ups.

Behavioral Responses to Stress

Baum et al. (1997) discuss three basic mechanisms that link behavior to illness: direct physiological effects, behavioral changes due to stress, and behaviors that affect access to and compliance with the treatment of illness. The potential physiological effects linking behavioral responses to stress and WRUEDs have been previously discussed. The remaining two mechanisms, often labeled behavioral coping responses, will be discussed here.

Evidence from research on various chronic pain complaints suggests that inadequate coping skills may play an important role in the maintenance of the disorder (Rosenstiel & Keefe, 1983). Vogelsang, Williams, and Lawler (1994) recruited patients with CTS from a variety of occupations identified as high risk (e.g., automotive parts assembly workers, keyboard operators, electronics industry workers, garment industry workers, and sign language interpreters) and matched them with controls on age, gender, race, height, weight, body type, job duties, and length of time at job. In comparing these groups, they observed that individuals with CTS reported greater perceived stress, greater number of stressful life events, and a lack of personal and professional goal directedness more often than the controls. They suggested that a lack of goal-directedness may be related to poorer lifestyle organization and diminished self-efficacy, which may indicate a decreased ability to cope with life stressors (Vogelsang, et al., 1994). Additionally, some indirect evidence of the effect of coping on WRUE symptoms and maintenance exists that suggests that interventions aimed at enhancing coping skills (e.g., stress management and pain management) may be beneficial in producing reductions in pain and disability in occupational upper limb pain (Spence, 1989, 1991; Swerissen, Matyas, & Thomas, 1991). Lastly, there is evidence that suggests prolonged or chronic exposure to an uncontrollable stressor may result in decreased coping in the form of hopelessness and decreased motivation to seek medical attention (Baum et al., 1997; Smith & Carayon, 1996). This delay in treatment could foster disease progression, leading to help-seeking behavior only when the condition has been significantly exacerbated, resulting in longer work absences and poorer outcomes. Others have suggested that symptom reporting and help seeking are behaviors that can be increased by the psychological characteristics of a situation (i.e., perceived failure; Levine, Krass, & Padawer, 1993), although no prospective, empirical data exists to support such a notion in relation to WRUE symptoms or disorders.

Rationale For the Proposed Study

Although specific behavioral, psychological and physiological processes linking job stress and WRUEDs have been proposed, there is a paucity of data supporting differences in symptomatic and asymptomatic workers. Few studies have attempted to establish the intermediary effects, either physiological or psychological, that are essential to identify specific pathways linking stress and pathological musculoskeletal outcomes (Bongers & de Winter, 1992; Sauter & Swanson, 1996). Research investigating the physiological consequences of job stress and their relation to WRUE symptoms and disorders has been especially sparse.

Some research suggests that task-related physical loads and ergonomic exposure typically account for less than 15% of the variance in WRUED occurrence (Werner et al., 1998), and psychosocial occupational stressors (e.g., monotonous work tasks, low co-worker and supervisory support, lack of job control, and perceived time pressure) have been shown to be only modestly related to the occurrence, exacerbation and maintenance of WRUE symptoms and disorders. It appears that a more complex interaction among ergonomic, workplace psychosocial, and individual factors, including individual differences in response to stress, is at work in the etiology and maintenance of these problems. Demonstration of differential physiological response to stress in individuals with WRUE symptoms in contrast to healthy, asymptomatic controls is an important first step in identifying the role of upper limb musculature in the pathophysiology of WRUE symptoms and disorders. Additionally, the role of such differences within a complex context of biomechanical exposures and workplace and individual psychosocial factors could lead to more effective management and perhaps prevention of these problems.

The present study was designed to be an exploratory investigation of the complex relationship among these factors in symptomatic workers. Specifically, this study was designed to address four questions:

Question 1: Are there differences between symptomatic and asymptomatic workers in self-reported psychosocial or ergonomic factors?

H1: Symptomatic workers will report greater job stress and more ergonomic exposure than asymptomatic workers.

Question 2: Do individuals with WRUE symptoms demonstrate greater physiological and psychological reactivity to stress than healthy, asymptomatic controls working in similar occupations?

H2: Symptomatic workers will exhibit greater response and a greater delay in recovery to baseline than asymptomatic workers following a laboratory job stress recall task. This greater response and delayed recovery will be evident for self-reported distress, symptoms, heart rate, salivary cortisol, and forearm sEMG.

Question 3: Can ergonomic, psychosocial and physiological indices differentiate symptomatic and asymptomatic workers?

H3a: Differences in ergonomic, psychosocial and physiological response to stress will independently discriminate between symptomatic and asymptomatic workers.

H3b: A combined model, including measures of ergonomic exposure, psychosocial factors, and physiological reactivity to the laboratory stressor will significantly discriminate between the WRUED group and the asymptomatic control group and will do so more effectively than any of the domains independently.

Question 4: Can these identified ergonomic, psychosocial, and physiological indices predict general clinical outcomes and/or WRUE-specific clinical outcomes?

H4: Measures of physiological reactivity to a laboratory stress recall task, combined with measures of ergonomic exposure and role-related stress, will predict an overall rating of upper extremity symptom severity, functional limitations, pain severity, and general physical and mental health.

METHODS

General Procedural Overview

This protocol was reviewed and approved by the Uniformed Services University of the Health Sciences Institutional Review Board. All subjects, prior to participation, were instructed about the protocol procedures and signed informed consent (Appendix A). The protocol involved three phases, 1.) screening/self-report phase; 2.) daily job stress monitoring phase, and 3.) laboratory job stress exposure phase. 79 subjects (48 WRUE symptom, 31 asymptomatic control) were recruited and matched for age, job type, and BMI. Of these subjects, 48 reported (28 WRUE symptom, 20 asymptomatic control) to the laboratory for phase one of the protocol which included a self-report battery consisting of questions regarding general demographics, health status, functioning at work, ergonomic exposure, and job stress. One participant who was recruited as an asymptomatic worker reported upper extremity symptoms during the first visit to the laboratory. Her symptoms were not of sufficient magnitude to qualify her for participation as a symptomatic worker, and her participation in the protocol was terminated.

Of the original 47 subjects, 30 (16 WRUE symptom and 14 asymptomatic control) completed the second and third phases of the protocol. These phases included a two-week daily stressful work events diary and a second visit to the laboratory at the end of the two-week period. During this second visit, subjects recalled the most stressful work event from the previous two-weeks. Bilateral surface electromyography of the forearm flexor and extensor bundles, as well as blood volume pulse, salivary cortisol, and self-reported symptoms and distress were measured before during and after each subject s recall of the stressful event.

Selection Criteria

Participants were recruited through advertisements in written media (e.g., newspapers and health newsletters) in the Washington, D.C. metropolitan area. Interested persons contacted the laboratory via telephone and were administered brief telephone interviews to determine eligibility for the study (Appendix B). Criteria for participation included: 1) female gender, 2) age between 18-50, 3) regular menstrual cycle, 4) currently working at least 20 hours per week, and 5) not self-employed. Exclusion criteria included, 1) current pregnancy, 2) current use of hormone replacement therapy, 3) current use of steroid-based anti-inflammatory drugs, 4) current use of antihypertensive drugs, and 5) past or current diagnosis of medical conditions known to be associated with increased risk for upper extremity symptoms and disorders (e.g., rheumatoid arthritis, gout, systemic lupus erythematosus, diabetes mellitus, hypothyroidism, alcoholism, and/or any chronic or acute endocrine disorders; Atcheson, Ward, & Lowe, 1998).

Control subjects were asymptomatic in the hands, wrists, forearms, elbows, arms, shoulders, and neck. All symptomatic participants met a modified National Institute of Occupational Safety and Health (NIOSH) case definition for a work-related upper extremity disorder, which includes:

1. Symptoms began after employment in current job type (i.e., administrative, clerical, factory work, etc.).
2. Symptoms have lasted for more than one week or at least once per month since their onset.
3. Symptom severity rated at least moderate (i.e., 3) on a 0 (none) to 5 (extreme) scale.

4. No prior accident or acute trauma to the symptomatic area (Atcheson et al., 1998).

Subjects with WRUE symptoms and asymptomatic controls were matched for age, occupation, body mass index (BMI), and self-reported upper extremity ergonomic exposure (upper extremity subscale of the Job Requirements and Physical Demands Survey, Marcotte et al., 1997).

Study Participants

79 subjects (48 WRUE symptom cases and 31 asymptomatic controls) met criteria for participation and were recruited into the study via phone screen. 48 subjects (28 WRUE symptom cases and 20 asymptomatic controls) kept their first appointment at the lab (39.2% no-show/withdrawal rate for first appointment). One subject who was recruited as an asymptomatic control indicated during her first visit that she had upper extremity pain. Her pain was not of adequate intensity or frequency to qualify her to be a member of the WRUE symptom group, and her participation in the study was terminated.

A total of 47 subjects (28 women with WRUE symptoms and 19 asymptomatic women) completed the first laboratory visit. Of those, 30 (16 women with WRUE symptoms and 14 asymptomatic women) completed the second laboratory visit. For the 17 subjects lost to follow-up between Visit 1 and Visit 2, 9 were contacted regarding their reasons for discontinuing. Eight participants stated that time conflicts and/or work demands prohibited them from continued participation. One participant reported that she had to leave town for an extended period of time and did not plan to return before the cessation of the study. The other 7 could not be reached to discuss their reasons for discontinuing. See Table 1 for a summary of the total number of subjects at each stage of the protocol.

One-way Analyses of Variance were conducted to compare 1.) subjects who met criteria for participation but did not present to the laboratory to those who reported for their first visit, and 2.) subjects who presented to the laboratory for the first visit of the protocol but did not complete phases two and three to subjects who completed all phases of the protocol. When all subjects (WRUE symptom and asymptomatic control) were considered together, no differences existed between those who were lost to follow-up after the first laboratory visit and those who completed the entire protocol on age, BMI, years of education, general physical health status, general mental health status, job stress (JSS and LISRES), total workload, or ergonomic exposure (JRPDS-24; number of years at current work tasks, and percentage of work time spent at computer workstation). WRUE symptom subjects who completed the protocol did not differ from the WRUE symptom subjects who were lost to follow-up on age, years of education, BMI, general physical health, general mental health, job stress (LISRES, JSS), total workload, pain coping style, pain severity, ergonomic exposure (JRPDS-24; number of years at current work tasks, and percentage of work time spent at computer workstation), or functional limitation as measured by the work limitations scale. However, significant differences were found for symptom severity (SSS; $\underline{t}$ (26) = 2.56; $\underline{p} < 0.05$) and functional limitations as measured by the upper extremity function scale ($\underline{t}$ (13.40) = 2.17; $\underline{p} < 0.05$) indicating that symptomatic subjects who did not keep their appointments for Visit 2 reported significantly greater symptom severity and greater functional limitations.

(Insert Table 1 about here)

Physiological Measures

Surface Electromyographic (sEMG) Recordings

All sEMG measurements were made in a climate-controlled laboratory (room temperature maintained between 70 and 77 …F, humidity greater than 30% and less than 70%). Prior to all data collection periods, a standardized sine wave was processed through each amplifier. The characteristics of this wave were used to calculate a calibration factor for each amplifier.

16 channels of surface electromyographic (sEMG) activity were measured bilaterally from the forearm extensor and flexor bundles. Recordings were acquired using 4 mm bipolar silver-silver chloride electrodes that were manufactured in pairs, ensuring uniformity of spacing from subject to subject across all sites (Norotrode sEMG electrodes by Noromed¤, Tukwila, Washinton). Electrodes were pre-gelled with water-soluble conductive gel and mounted in pairs on hypoallergenic adhesive. All sEMG monitoring sites were cleaned with a sterile alcohol pad and lightly abraded with an over-the-counter skin cleanser (Brasivol) before affixing the electrodes. Impedence between the electrode and the surface of the skin was measured and less than 10 k_ was achieved at all sites prior to data acquisition. The acquired signals were amplified and filtered using isolated bioamplifiers (Coulbourn Instruments L.L.C. Model V75-04; input impedence = $10^9\Omega$, common mode rejection ratio = 105dB, and gain = 10,000). The amplifiers contained built-in bandpass filters (set at 8-1,000 Hz) and 60 Hz notch filters. Data were digitized at 2000 Hz using a 12-bit A/D converter board (DI-400 PGH/PGL; Dataq Instruments; Akron, Ohio) installed inside an IBM compatible computer (Compaq Desktop 450 MHz EP/SB Series with Pentium II¤ processor). WinDaq—Pro Software for Windows, Version

2.30 (DATAQ Instruments Akron, OH) was used to track and process the acquired signals. Data were collected from all sites continuously throughout the protocol.

Electrode Placement

In order to monitor the general level of forearm muscle tension, bilateral forearm flexor/extensor were measured with a 3 cm center-to-center spacing. For the extensor bundles, the electrodes were placed 5 cm distal from the elbow parallel to the muscle fibers and in the center of the muscle mass that appeared on wrist extension. For the flexor bundles, the electrodes were placed 5 cm distal from the center of the elbow joint parallel to the muscle fibers and at the center of the muscle mass that emerged on wrist flexion (Cram, et al., 1997; Lippold, 1967).

Digital Blood Volume Pulse

Digital blood volume pulse (DBVP) was measured using a phototransistor (Coulbourn Instruments, L.L.C. Model V95-01) connected to a pulse monitor/optical densitometer (Coulbourn Instruments, L.L.C. Model V71-40). The phototransistor was positioned over the distal phalange of the second finger of the dominant hand. DBVP was monitored continuously throughout the protocol. Heart rate was derived from this measure.

Salivary Cortisol

In order to assess sympathetic arousal, salivary cortisol was measured during the laboratory protocol. Salivary cortisol has been shown to be a reliable indicator of free cortisol in plasma (Vining McGinley, Maksvytis, & Ho, 1983; Kirschbaum, Pirke, & Hellhammer, 1993).

Additionally, *in vivo* studies of cortisol reactions to stressors suggest salivary cortisol increases between 6-12% from baseline levels although large individual differences in reactivity are often observed (Smyth et al., 1998).

Sample Collection Procedures

In order to control for menstrual cycle variations in cortisol levels, the second visit to the laboratory occurred on day 4, 5, 6, or 7 of the subject s menstrual cycle. Additionally, to control for diurnal variations in cortisol levels, all physiological assessments began between the hours of 1 p.m. and 3 p.m. and ended by 5 p.m. (Kirschbaum, Steyer, Eid, Patalla, Schwenkmezger, & Hellhammer, 1990).

Subjects were instructed to avoid smoking, physical exercise, major meals, alcoholic beverages, dairy products, and soft drinks for one hour prior to the start of the psychophysiological assessment (Kirschbaum, Strasburger & Langkrar, 1993; Kirschbaum et al., 1993), and all participants verbally confirmed adherence to these instructions prior to the onset of the laboratory protocol.

Saliva samples for cortisol assays were collected 4 times during the protocol. The first sample was an anticipatory baseline measure and was collected immediately after the subject reported to the laboratory. The second sample was collected after the adaptation and baseline periods and was a pre-task baseline measure. A reactivity sample was collected 12 minutes after the completion of the job stress task, and the recovery sample was collected 50 minutes after the end of the stressor task. These sample collection times were selected based on research which has plotted the time-course of salivary cortisol in response to laboratory psychological stress tasks (Kirschbaum et al., 1993; Clow, Patel, Najafi, Evans, & Hucklebridge, 1997). The task used in these studies involved a stress task known a the Trier Social Stress Test which lasts approximately 20 minutes and includes an anticipatory stress component prior to a social evaluative speech task followed by a verbal subtraction math task.

Saliva samples were obtained using Salivette tubes (Salimetrics, LLC, PA). Salivette tubes are centrifuge tubes which contain a swab within an insert. The swab was removed from the insert and chewed by the subjects for 45 seconds. The swab was then returned to the insert which was placed inside the centrifuge tube and firmly closed with a stopper. Samples were stored at —80 C in a locked freezer until they were shipped to the Behavioral Endocrinology Laboratory (BEL) at Pennsylvania State University for assay.

Salivary Cortisol Assay

All samples were assayed for cortisol at the Behavioral Endocrinology Laboratory (BEL; Pennsylvania State University; University Park, PA) using a high-sensitive enzyme immunosassay (Salimetrics, LLC, PA). This test has a lower limit of sensitivity of .007µg/dl, range of sensitivity from .007 to 1.2 µg/dl, and average intra- and inter-assay coefficients of variation of 4.13% and 8.89%, respectively. Values from matched serum and saliva samples show a strong linear relationship ($r(17) = .94$, $p < .001$). Performance has been shown to be robust for samples with pHs ranging from 4.0-9.0 (Schwartz, Granger, Susman, & Laird, 1998). The assay was designed by the Pennsylvania State University Behavioral Endocrinology Laboratory and has been independently verified by researchers at the University of California Los Angeles, Center for Health Science. All samples were assayed in duplicate to insure the reliability of the assay.

Clinical Instruments and Self-Report Measures: First Laboratory Visit

Self-Report Battery (Appendix C)

The self-report battery that was administered in the initial laboratory visit was a modified version of the battery administered by Feuerstein, Huang, Haufler, and Miller (2000). The battery included general demographic, occupational, and medical items, and scales assessing symptoms, function, ergonomic exposure, workplace psychosocial environment, and imaginal ability which are described in detail in the following sections.

Demographic Characteristics

Demographic information was obtained, including age, height, weight, education level, marital status, and ethnicity.

Occupational Status

Questions regarding occupational status included type of job (i.e., clerical worker/teller, insurance/real estate sales, management/administration, professional/ technical/scientist, craftsman/carpenter, machine operator/factory worker, service worker, or private), duration at current job, and hours per week at job.

Medical History/Status

This section of the self-report battery contained items relating to WRUED s, including prior workers compensation injuries, number of past diagnosed upper extremity disorders, time between onset of present WRUE symptoms and seeking medical attention, number and types of therapies obtained, and whether or not surgery had been recommended for the symptoms. Also, questions regarding health problems (e.g., diabetes, gout, alcoholism, lupus, kidney problems, and hypothyroidism) as well as various health behaviors (e.g., tobacco, alcohol, and prescription medication usage) shown to be related to certain WRUED s were included in this section.

The Standard Form — 12 Health Survey (SF-12; Ware Kosinski, & Keller, 1996). The SF-12 is a 12-item measure that was developed as a population-based measure of general health status and normalized using known clinical and health populations. It was empirically derived from the longer SF-36 in order to reduce respondent burden (Ware, Kosinski, & Keller, 1996). Both the SF-12 and SF-36 have been shown to be a valid descriptor of health status in a wide range of clinical and non-clinical populations (Johnson & Coons, 1998), and they have also been shown to be sensitive measures of treatment outcome in longitudinal studies of individuals with various physical disorders (Jenkinson, Layte, Jenkinson, Lawrence, Petersen, Paice, & Stradling, 1997), including work-related upper extremity disorders (Bessette, Sangha, Kuntz, Keller, Lew, Fossel, & Katz, 1998). For the current protocol, SF-12 scores were used to describe the physical and mental health status of the study participants.

Symptoms/Function

Symptom Severity Scale (Levine, Simmons, Koris, et al., 1993). This scale is an 11-item self-report questionnaire for the assessment of severity of pain, numbness, tingling, and weakness in patients with carpal tunnel syndrome. The scale has been shown to be highly reproducible (test-retest over 2 successive days; Pearson $r = 0.91$) and internally consistent (Cronbach $\alpha = .89$). This scale was used to assess the severity of symptoms and functional status of general work related upper extremity disorders.

Upper Extremity Function Scale (Pransky, Feuerstein, Himmelstein, Katz & Vickers-Lahti, 1997). This self-report scale consists of 8 common, daily activities which are rated for degree of difficulty on a scale from 1 (No problem performing) to 10 (Can t do at all) and has been validated as a measure of functional limitation for individuals with upper extremity symptoms. This scale has been demonstrated to have good internal consistency (Cronbach s alpha > .83), and good convergent validity (r = .81 with validated measure of function for arthritis patients) and was used for describing the functional status of the sample.

Ergonomic Exposure

Job Requirements and Physical Demands Survey - 24 (JRPDS-24; Dane, Feuerstein, Huang, Dimberg, Ali, & Lincoln, in press). In order to assess self-reported ergonomic exposure, each participant completed a series of questions related to job requirements and job physical demands. The JRPDS-24 was derived from a longer, 38-item test (JRPDS; Marcotte et al., 1997) and has been shown to have good internal consistency (Cronbach s alpha = 0.82) compared to an on-site observational worksite assessment checklist (Dane et al., in press). Reliability and validity testing to date suggest the survey is stronger in assessing upper extremity demands (i.e., activities and symptoms involving hands/wrists/arms and shoulder/neck) than demands in the trunk or lower limb (Marcotte et al., 1997).

Workplace Psychosocial Environment

Job Stress Subscale of the Life Stressors and Social Resources Inventory (LISRES; Moos & Moos, 1994). In order to assess occupational psychosocial stressors, the Job Stress Subscale of the LISRES was administered. The LISRES-JS is a 6-item self-report subscale that contains items on work-related conflicts, physical environment, and perceptions of work pace. This measure, as part of a composite model including measures of pain, functional limitations, mental health, and lost work time, has been shown to prospectively predict poor outcome at 3 months (Feuerstein et al., 2000) in a community sample of workers with a range of work related upper extremity disorders.

Job Stress Survey (JSS; Spielberger & Vagg, 1999). In order to assess the frequency and severity of stressful events at the workplace, all subjects completed the JSS. The JSS consists of 30 common work situations that are often considered stressful (e.g., inadequate support by supervisor; inadequate or poor quality equipment, etc.). Each of these 30 events were rated for general perceived severity by the subject on a 1 (least stressful) to 9 (most stressful) scale, with Assignment of disagreeable duties serving as a midpoint of 5 (JSS Form A). After completing the severity ratings, the subjects reported how often each event was experienced in the previous 6 months using a scale from 0 (did not occur) to 9 (9 or more days); JSS Form B; Spielberger & Vagg, 1999). The JSS has been factor-analyzed across multiple occupations and across genders (Vagg & Spielberger, 1998). In each sample, two stable factors have been consistently identified, namely job pressure (JP; items 4,7,9,11,16,23,24,25,26,27) and lack of organizational support (LS; items 3,5,6,8,10,13,14,18,21,29). The JSS has been administered in a variety of occupational settings, and in a sample of university faculty, administrators, and clerical staff, internal consistency alpha coefficients were .89 or higher for the total scale and subscale scores (Spielberger & Reheiser, 1994).

Both the structure and the content of the JSS made it useful for this study. First, the JSS was designed specifically to assess generic sources of work-related stress experienced by workers in a variety of occupational settings (e.g., business, industrial, educational). Secondly, the JSS was designed in checklist format. Because checklists rely on event recognition instead of recall, they are often more accurate and efficient structured assessment tools than open-ended assessments of daily events (Stone, Neale, & Shiffman, 1993).

Family Stress

Total Workload Scale (Mardberg, Lundberg, & Frankenhaeuser, 1990). The Total Workload Scale consists of 124, 7-point rating scales that assess an individual s combined load of paid and unpaid duties (especially duties related to home and family). Specifically, it was designed to assess the characteristics and perceived load from paid work, household duties, childcare, other responsibilities, time spent on different duties, and positive and negative aspects of the total work situation. Reliability analyses yielded internal consistency reliabilities (alpha coefficients) from 0.70 to 0.92 (Mardberg et al., 1991).

Pain Coping Style

Catastrophizing Subscale of the Coping Strategies Questionnaire (Rosenstiel & Keefe, 1983). The catastrophizing subscale is a 6-item measure which assesses an individual s reaction to pain (e.g., overwhelming, whether it will ever end, ability to keep living with the pain, etc.). This measure has been shown to predict poor clinical outcomes at 1, 3 and 12 months in individuals with work-related upper extremity disorders (Feuerstein et al, 2000) and was included in this study as a potential discriminator between individuals with WRUE symptoms and asymptomatic controls.

Potential Confounder

Absorption Scale of the Multidimensional Personality Questionnaire (TAS; Tellegen, 1982). Because physiological and emotional reactivity to the job stress recall task to elicit a stress response may depend upon the subject s ability to imagine, re-experience, or lose him/herself in the recall experience (Kovach, 1988), differences in imaginal ability were assessed using the TAS. The TAS assesses absorption, which has been conceptualized as a trait variable that reflects an individual s propensity for immersion/involvement in sensory and imaginative experiences (Tellegen, 1982). The TAS has been found to be predictive of hypnotic susceptibility and symptom relief following guided imagery (Nadon, Hoyt, Register, & Kihlstrom, 1991; Kwekkeboom, Huseby-Moore, & Ward, 1998).

Work Events Diary (Appendix D)

At the end of each workday for 2 weeks, subjects completed the Work Events Diary. This diary was designed to assess daily work-related stressful events and their physical and emotional consequences which enabled the standardized selection of the job stress event that was used in the laboratory job-stress recall task.

The first page of the diary contained the items from the Job Stress Survey (JSS; Spielberger & Vagg, 1999). Using the ratings indicated by that subject on the JSS Form A completed during the first visit to the laboratory, the events rated as a 5 or higher in intensity were highlighted. The subjects were asked to indicate the frequency of each of the highlighted events at the end of each workday for 10 workdays (2 weeks). For each event that occurred during a workday, the subject completed Page 2 of the daily diary which was designed to assess the nature of the event as well as the subject s affective and symptomatic responses to that event. It contained open-ended questions regarding the details of the event, an 11-point stress rating scale asking the subjects to rate how stressful this event was overall (0 = not at all stressful, 10 = extremely stressful), a mood checklist, and a symptom location/severity measure which are described in detail below. If multiple significant stressors occurred during one workday, the subjects were asked to pick the three most stressful and describe only those three.

The Profile of Mood States Tension and Anger-Hostility Factors (POMS; McNair, Lorr, & Droppleman, 1992)

Because affect has been hypothesized to mediate the effects of stressors on cortisol levels (van Eck et al., 1996; Smyth et al., 1998), a measure assessing the subjects affective responses to stressors was included on Page 2 of the Work Events Diary. Prior research has found self-reported negative affect (i.e., irritation, tenseness, and tiredness) to be associated with elevated workday and momentary cortisol levels (Lundberg, Granqvist, Hansson, Magnusson, & Wallin, 1989; Smyth et al., 1998).

Two factors of the POMS were chosen to assess negative affectivity in response to the stressor. The Tension Factor contains 9, 5-point adjective rating scales (tense, shaky, on-edge, panicky, relaxed (reversed scored), uneasy, restless, nervous, and anxious) and has been shown to be significantly correlated with established measures of distress and anxiety (McNair et al., 1992). The POMS Anger-Hostility Factor contains 12, 5-point adjective rating scales (angry, peeved, grouchy, spiteful, annoyed, resentful, bitter, ready to fight, rebellious, deceived, furious, and bad-tempered).

An additional item from the POMS was added to the mood checklist: depressed/blue. This item was added based on prior research which suggested, in addition to adjectives indicating tension and anger, that reactive sadness or feeling down may be associated with physiological reactivity to daily hassles (McNair et al., 1992). Although the POMS was originally developed to be used in a one-week, retrospective format, it has also been shown to be sensitive enough to detect situational and experimental effects on mood (McNair et al., 1992; Pillard, Atkinson, & Fisher, 1967).

For each of these 21 adjectives, the subjects were asked to rate how they felt in response to the stressor being described (0 = Not at All, 4 = Extremely). In general, positive affective states have not been shown to be related to cortisol levels or reactivity, and they were not assessed in the diary (van Eck et al., 1996; Smyth et al., 1998; Hubert & deJong-Meyer, 1991).

Forearm and Hand Diagrams

The daily stress diary also included diagrams of the palmar and dorsal surface of the left and right forearms and hands that were divided up into 4 zones (i.e., elbow, forearm, hand/wrist, and fingers/thumb). Subjects were asked to mark the location of all symptoms they experienced during the stressor by placing an X on the corresponding location on the diagram. They also indicated the type of symptom (pain/soreness, numbness/tingling) and the severity of the symptom by checking the appropriate box in the corresponding zone. A total symptom severity index was calculated for each stress event recorded by summing the intensity rating for pain/soreness and numbness/tingling over all sites. This hand diagram allowed for the rapid assessment of symptom location and severity, and it has been shown to be an adequate indicator of task-related upper extremity symptoms in previous studies (Feuerstein et al., 1997; Snook, Vaillancourt, Ciriello, & Webster, 1995).

Clinical Instruments and Self-Report Measures: Second Laboratory Visit

During the psychophysiological assessment, subjects completed 3 types of self-report: the Impact of Events Scale (Revised), visual analog indicators of psychological distress and physical symptoms in the upper extremities, and a visual analog indicator of task credibility.

Impact of Events Scale-Revised (IES-R; Weiss & Marmar, 1997)

The IES-R was used as a measure of the psychological impact of the peak stressor selected from the subjects diaries. Each subject completed the IES-R based on their cognitive, behavioral, and affective responses to that event since it occurred. The IES-R is a 22-item self-report measure designed to assess the level of distress related to symptomatic responses to a specific life event. The IES-R was modified from the original IES (Horowitz, Wilner & Alvarez, 1979) by the addition of 7 new items that add the domain of hyperarousal and more closely parallel the DSM-IV diagnostic domains for Acute Stress Disorder and Posttraumatic Stress Disorder. The subscales of IES-R have evidenced high internal consistency (Intrusion alpha = .91; Avoidance alpha = .84; Hyperarousal alpha = 0.90) and high test-retest correlations for recent events (i.e., within 6 months; Intrusion = 0.94; Avoidance = 0.89, and Hyperarousal = 0.92). Although the IES was designed for the assessment of responses to acute stressors, it has been shown on at least one occasion to be effective for the assessment of avoidance (cognitive and behavioral) and intrusiveness (cognitive and affective) associated with nontraumatic stressors (Ohrbach, Blascovich, Gale, McCall, & Dworkin, 1998).

Task-Related Symptoms and Psychological Distress

Symptoms were assessed at the end of the baseline period, after the job stress recall task, and at 2-minute intervals during the recovery phase using a visual analog scale. Participants were asked to verbally indicate their current level of pain, soreness, numbness or tingling on a scale from 0 = none to 10 = extreme. In addition, a visual analog distress scale was presented, and the subjects were asked to verbally rate, How distressed do you feel right now? (0 = not at all, 5 = moderately, 10 = extremely).

Task Credibility

The degree to which the job stress recall stressor task was similar to the actual event was assessed in 2 ways. First, a visual analog scale was presented to the subjects immediately following the recall task asking them to rate the degree that their reaction to the stress-recall task was similar to what they actually experienced at the time the stressor occurred (0 = not at all, 5 = moderately, 10 = extremely). Also, self-reported distress at the time of the laboratory assessment was compared to self-reported distress at the time of the stressor recorded in the subject s diary.

Job Stress Recall Task

The job stress recall task used in this protocol was a modified version of the Social Competence Interview (SCI; Ewart, Suchday, & Sonnega, 1995). The original SCI is a semi-structured interviewing technique that, using guided imagery, assists participants in recalling, discussing, and problem-solving regarding an emotionally arousing event with the goal of re-experiencing the event. The interview used as the laboratory stressor was modified in two primary ways to make it more appropriate to address the research questions at hand. First, stressful events were limited to work-related events occurring within the previous 2 weeks and recorded in the subject s diary. Second, the problem-solving component of the interview was eliminated, leaving the full 8-minutes to assist the subject in reexperiencing the event. The protocol guidelines for this semi-structured interview can be found in Appendix E.

The original SCI has been shown to predict ambulatory blood pressure responses to stressful situations (Ewart & Kolodner, 1993) and to elicit physiological reactivity greater than other non-social tasks (e.g., mirror drawing and mental arithmetic; Ewart & Kolodner, 1991). In addition to these findings, recollections of negative events have been used successfully as a stressful stimulus in many studies (Flor, Birbaumer, Schulte & Roos, 1991, Flor, Turk, & Birbaumer, 1985; Ohrbach, Blascovich, Gale, McCall, & Dworkin, 1998; and Feuerstein et al., 1982).

This job stress recall task was chosen over a standardized laboratory stress stimulus based on the findings of Ohrbach et al (1998). In this study, subjects exposed to a standardized reaction time task manifested only a physiological stress response, whereas subjects exposed to stressors that were highly relevant to them (i.e., recall of a stressful event which the subject recently experienced) produced both a physiological stress response and high levels of self-reported distress.

The Job Stress Recall Task was administered by a research assistant who was trained in the technique and who was blind to case status. Participants were asked to recall and discuss the most stressful event that occurred on their jobs in the previous two weeks. The interview had a duration of 8 minutes and self-report measures were completed at minute 30 of the protocol.

Experimental Protocol

Each participant reported to the laboratory on two separate occasions occurring at least 2 weeks apart. During the initial visit, after providing informed consent (Appendix A), participants were administered a clinical interview assessing psychological and physical symptoms and completed a self-report battery (Appendix C) that included demographic information, occupational status, medical history/status, measures of symptoms, current function, ergonomic exposure, and measures of job stress. Subjects were given the following instructions:

This is a questionnaire that contains questions about your medical history, your current occupation, and your work environment. Please read all instructions carefully and answer the questions as best you can. Feel free to ask any questions that may arise as you complete the questionnaire.

After completion of the battery, the procedures for the completion of a two-week Work Stress Diary (Appendix D) were explained. All items from the subject s Job Stress Survey Form A that the subject rated as a 5 or higher (i.e., at least moderately stressful) were highlighted on each Page 1 of the Work Stress Diary. Subjects were then given the following instructions:

For the next two weeks, we are going to ask you fill out one of these checklists at the end of every <u>*work day.*</u> *So, if you work 5 days a week, you should have 10 of these checklists completed when you return for your second visit. You probably recognize this first page from the questionnaire you completed earlier. I have highlighted the items you indicated would be at least moderately stressful to you if they were to occur on your job. At the end of each workday,* *indicate the number of times a highlighted event occurred <u>during that</u> day by placing an x next to the appropriate number. For <u>each</u> of the highlighted items that occurred at least once during that day, we want you to fill out page 2 (show her page two) of the diary. If an event occurred more than once, you only need to fill out page 2 for the most stressful one.*

On page two, we want you to give us a little more information about this stressful event. In Part I, write the item number from the checklist that corresponds to this event. In Part II, briefly describe your relationship to the person or people involved in this event, write briefly what you did or tried to do to resolve the situation, and describe what happened. In Part III, we want you to rate how stressful this event was to you overall. If it was the most stressful thing that has ever happened to you, put an x in the box over the 10. If it was the least stressful thing that has ever happened to you, put an x in the box over the 0.

In Part IV, put an x in one of the boxes next to each of the words based upon how you felt during/after this stressful event. If you didn t feel angry at all, place an x next to the 0. If you were highly annoyed, place an x next to the 4.

Lastly, the bottom of the page has two sets of hands. We want to know if you noticed any symptoms in your arms and/or hands during this event. Indicate the location, type of symptom, and the severity by placing an x in the appropriate box. It is very important that you complete this diary on a daily basis because we will use information from your forms during your second visit.

After being administered the above instructions, subjects were asked to think of a recent stressful event, and they completed a practice page of the diary to ensure comprehension of the diary instructions and to demonstrate the brevity of the task. Subjects were also assisted in problem-solving regarding strategies to remember to complete the diary daily (e.g., where to keep the diary, placing reminder notes in various places, etc.). Lastly, the subjects received their appointment time/date and written instructions for the second laboratory visit (i.e., the psychophysiological assessment).

The protocol timeline for the psychophysiological assessment (Visit 2 to the laboratory after the 2-week Work Stress Diary was completed) is graphically presented in Figure 5, and self-report measures are presented in Appendix F and Appendix G. During this visit, an initial saliva sample was taken immediately after the subject entered the laboratory. While the electrodes were being attached, the subject s responses on her Work Stress Diary were entered into a spreadsheet that calculated a weighted score (based upon previous stress reactivity research) for each stressful event recorded in the diary. The event with the highest score was used during the job stress recall interview. Based on the procedure used in Ohrbach et al. (1998), subjects then completed the Impact of Events Scale - Revised (IES-R, Weiss & Marmar, 1997; Appendix G) for the selected event as an indicator of the cognitive, emotional and physiological correlates of the selected stressful work event.

(Insert Figure 5 About Here)

Percent Maximum Voluntary Contraction (MVC) Handgrip Protocol

Normalization of electromyographic measurements is necessary to allow comparisons between subjects and between different muscle sites (Fridlund & Cacioppo, 1986; Knutson, Soderberg, Ballantyne, & Clarke, 1994). One of the most commonly employed normalization procedures utilizes data taken from the maximum voluntary isometric contraction (Yang &

Winter, 1983; Waersted, Bjorklund, & Westgaard, 1991; Vasseljen & Westgaard, 1995) which represents muscle activity as a percent of that muscle s maximum voluntary contraction.

After all electrodes were attached and impedances and signals verified, the subjects completed the maximum voluntary contraction protocol. Percent MVC handgrip was determined according to the methods described in Blackwell, Kornatz, and Heath (1999). Subjects rested the arm to be tested on a horizontal surface with the forearm pronated. They gripped a hand dynamometer (Jamar Hydraulic Hand Dynamometer, Model 5030J1; Jackson, Michigan) with the gripping handles perpendicular to the forearm. After a demonstration by the experimenter, each subject performed 3 MVCs for 3 seconds for both the left and right hands. A 30-second rest period separated each contraction (Petrofsky, 1981; Bystrom & Kilbom, 1990; Blackwell et al., 1999). If the first 2 contractions did not differ by more than 10%, the greater one was accepted; otherwise another contraction was performed (Bystrom & Kilbom, 1990).

Psychophysiological Assessment

Throughout the physiological assessment, sEMG, blood volume pulse and salivary cortisol were measured. sEMG was monitored continuously and bilaterally from the forearm extensor and the forearm flexor muscles. Blood volume pulse was measured from the pad of the index finger of the subject s dominant hand. The duration of the assessment was approximately 70 minutes and consisted of 4 phases: adaptation to the equipment and environment, resting baseline, job stress recall stressor, and recovery.

Adaptation period (minutes -5 through 0). Participants were asked to sit still and quietly in a comfortable chair for a 5-minute adaptation period to allow habituation to the monitoring equipment and to the laboratory environment. No data were collected during this period.

Resting baseline (minutes 0 through 8). After the adaptation period, participants were asked to remain as motionless and quiet as possible for an 8-minute baseline period. sEMG and blood volume pulse data acquisition began at the start of this period and were continuously monitored throughout the baseline, stressor, and recovery periods. Baseline self-report measures of distress and upper extremity symptoms, as well as the baseline saliva sample, were collected between minutes 8 and 12.

Job Stress Recall Task (minutes 14 — 22) After baseline measures were collected, instructions for the job stress interview were read to the participants, and they were given an opportunity to ask questions regarding the interview procedure (minutes 12-14). Once questions were answered satisfactorily, the 8-minute interview began. Using a semi-structured interviewing technique and guided imagery, participants were asked to recall and discuss the most stressful event with the goal of re-experiencing the stressful situation over an 8-minute time period. The stress interview was conducted by a research assistant blind to group status.

Recovery Period (minutes 22-30).

Following the job stress task, participants were asked to sit quietly and as motionless as possible. sEMG and blood volume pulse were continuously monitored and self-reported distress and upper extremity symptoms were assessed at minutes 2, 4, 6 and 8 of the recovery period.

Reactivity and Recovery Cortisol Sample (minutes 32 and 72). Due to the time course of the salivary cortisol response, the stress response saliva sample was collected 10 minutes after the end of the stressor period (i.e., minute 32 of the protocol), and the recovery saliva sample was collected 50 minutes after the end of the stressor period (i.e., minute 72 of the protocol).

Data Reduction and Analyses

Data reduction was accomplished in a 4 step process: 1) signal calibration/conversion to appropriate unit of measurement (microvolts), 2) elimination of movement artifact, 3) full wave rectification/averaging across 30 second epochs, and 4) conversion to percent MVC values.

The first step in processing was calibration/conversion. Each channel was multiplied by the channel/date — specific calibration coefficient to account for amplifier drift or other minor anomalies in signal processing. Each value was also multiplied by an integer (100) to convert output values into microvolts.

Next, movement artifact was removed from each of the channels. Movement artifact was removed from the sEMG signals using a four-step process. First, all periods identified with event markers during the data collection period as visible movements were eliminated. Second, an average sEMG value was calculated for all values in each channel across the entire protocol. This average was calculated using the absolute value for all sEMG measurements and with the eliminated movement values treated as missing values to allow for an accurate average to be calculated.

This average was used to calculate a unique trigger value for that channel, defined as 15 times greater than the signal average. The signal was then processed using a computer program, programmed in C++ (v. 4.01; Bloodshed Software, 2001), that searched the channel for the trigger value. When that value was detected, the program scanned the next 0.05 seconds to determine if the signal crossed zero during that time. If the program did cross zero, the program continued to scan forward in 0.05 second increments until the pattern of high amplitude and frequency movement stopped. Once that pattern ceased, the program scanned ahead a final 0.05 seconds looking for the same criteria. In total this trigger value must have been exceeded at least once in three consecutive 0.05 second time periods, and the signal must have crossed zero in each time period in order to be identified as a movement.

The program inserted event markers at the beginning and end of each identified movement. It then produced a new sEMG channel (with the points between each marker pair eliminated) and a text document that identified the start and stop points of each elimination. This new signal was then exposed to visual inspection, the third step in the artifact elimination process, to verify the accuracy of the eliminations made by the computer program. Any inaccuracies in the elimination segments (e.g., data segments that were eliminated but should not have been, and segments that were not eliminated but should have been) were corrected in the text document, and the sEMG signal was processed through the elimination program a final time, with the corrected elimination times.

Once ECG and movement artifact were eliminated, the program full-wave rectified all sEMG channels. Next, for the forearm sEMG sites only, the values were converted to %MVC values by dividing the full-wave rectified values by the average sEMG value for that site during the maximal voluntary contraction protocol. Lastly, for all sEMG channels, average values were calculated for each 30-second epoch of the three 8-minute periods. The values were then saved in a spreadsheet compatible format (comma separated value or .CSV file).

All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS v. 10.0.5, 1999; Chicago, IL). Missing values for individual items in the self-report battery were replaced with the series mean for that item. Less than 5% of the total sample had missing data for any given item.

Univariate Analyses

Univariate analyses (Analyses of Variance and Chi-square) were conducted to 1.) assess differences between groups on matched variables (i.e., age, BMI, self-reported upper extremity ergonomic exposure) and other demographic variables, and 2.) to identify differences between the groups on measures of pain and function, ergonomic exposure, and job stress collected via the self-report battery and the job stress diary.

Multivariate Analyses

In order to assess differences in autonomic arousal and self-reported distress and symptoms in response to the laboratory stress task, 2 (groups: WRUE symptom vs. symptomatic control group) x 3 (periods: baseline, stressor, recovery) Repeated Measures Analyses of Variance (ANOVAs) were computed for heart rate, self-reported distress, and self-reported symptoms.

Differences in hypothalamic-pituitary-adrenal (HPA) axis activity during the laboratory protocol were assessed via a 2 (groups: WRUE symptomx vs. asymptomatic Control group) x 4 (periods: anticipatory baseline, baseline, stressor, recovery) Repeated Measures ANOVA was computed for salivary cortisol levels.

Additionally, a 2 (groups: WRUE symptom vs. asymptomatic control group) x 2 (muscle site: extensor vs flexor) x 2 (handedness: dominant vs nondominant) x 3 (periods: baseline, stressor, recovery) repeated measures Multivariate Analysis of Variance (MANOVA) was conducted for sEMG %MVC values in order to identify differences in upper limb musculature reactivity to the laboratory stress task.

Multivariate discrimination of cases and controls. Based upon a multidimensional model of the development of work-related upper extremity symptoms and disorders, a series of canonical discriminant analyses (DA s) were conducted to assess the ability of self report measures of exposure, self-report measures of job/ role-related stress, and measures of physiological reactivity to differentiate those with WRUE symptoms from healthy, asymptomatic controls. Three stepwise DA s were conducted first in order to select the most discriminatory variables from each domain. Then, variables within those domains which maximally distinguished the two groups were combined as a single, multidimensional model and subjected to a fourth DA. The purpose of this fourth DA was to assess a multidimensional model s ability to discriminate the two groups, and all variables were entered as a single step.

Prediction of clinical outcomes. Stepwise multiple regression analyses were performed to assess the ability of the variables in the identified multivariate model to predict clinical outcomes. The variables from the multivariate model identified via the discriminant analyses were the independent variables and pain in the previous week, UEFS, SSS, SF-12 PCS and SF-12 MCS were the dependent variables.

RESULTS

Demographics

Categorical demographic variables were analyzed across the two groups using Chi-square analyses. No differences between the groups were found in marital status, education level, race, job category, or smoking status. One-way Analyses of Variance (ANOVAs) assessing group differences on matched variables found no significant group differences on age or BMI (Table 2). However, attempts to match subjects on self-reported upper extremity ergonomic exposure (Upper Extremity Scale of the Job Requirements and Physical Demands Survey; JRPDS) were unsuccessful. Comparison of means revealed the WRUE symptom group reported a significantly higher degree of ergonomic exposure than the asymptomatic control group (Total JRPDS-24, $F = 6.27$, $df = 46$, $p < 0.01$; JRPDS-24 UE, $F = 7.66$, $df = 46$, $p < 0.05$). Therefore, the JRPDS was used in subsequent analysis to determine its role in differentiating between the two groups.

(Insert Table 2 About Here)

Univariate Analyses

Comparisons between groups on symptoms, physical function, and general health (from self-report battery).

As a validation of the clinical status of the symptomatic group, ANOVAs comparing the clinical WRUE symptom group and the asymptomatic control group on measures of pain, function, and general health status were all significant, with the WRUE symptom group reporting greater symptom severity, greater functional limitations, and poorer physical health than the asymptomatic control group. Table 3 summarizes these data.

(Insert Table 3 About Here)

Table 4 describes the general anatomical location of upper extremity symptoms for the symptomatic workers based upon the symptom interview conducted during Visit 1. The most frequently reported symptom site was the hand/wrist area. The second most common site was the neck and shoulder area. Most symptomatic workers reported unilateral pain, regardless of site, except for the neck/shoulder symptoms which tended to be bilateral. Table 5 provides additional information regarding the symptomatic group and the impact of the symptoms on their work. These data suggest that although these workers report significant symptoms, most have not been diagnosed with an upper extremity disorder and all have continued to work in spite of their symptoms. Four of the symptomatic participants reported missed work due to their symptoms. However, only one of the symptomatic participants reported missed work time due to her symptoms in the past month. That participant reported missing one day.

(Insert Table 4 and 5 About Here)

The results of the semi-structured diagnostic interviews conducted during Visit 1 indicated that 14.9% of the total sample met DSM-IV criteria for a mood or anxiety disorder. No differences between the groups were found for the presence of DSM-IV mental disorders. However, differences were found on the SF-12 Mental Component Summary (MCS), with the symptomatic workers reporting poorer mental health than asymptomatic workers. The MCS is a measure of general distress and not an indicator of the presence or absence of psychopathology. Table 6 summarizes these data.

(Insert Table 6 About Here)

Comparisons between groups on job/role-related stress and ergonomic exposure (self-report battery and the work stress diary).

One-way ANOVAs examining job/role-related stress did not find any significant differences between the groups on any measure of the frequency or intensity of job/role-related stress. This finding was consistent in both the retrospective self-report battery and the daily work stress diary. Table 7 summarizes the descriptive data for these measures.

ANOVAs examining ergonomic exposure indicated that the groups were significantly different on self-reported general ergonomic exposure (JRPDS-24, $F = 6.27$, $df = 46$, $p < 0.01$) as well as upper-extremity specific ergonomic exposure (JRPDS-24 UE, $F = 7.66$, $df = 46$, $p < 0.05$). Additionally, symptomatic participants reported spending a significantly greater proportion of their work time at a computer workstation than asymptomatic participants ($F = 5.99$, $df = 46$, $p < 0.05$). Table 8 summarizes these findings.

(Insert Tables 7 and 8 About Here)

Although no group differences were found for job-related stress, item responses were examined for the JSS to determine the types of events associated with higher levels of stress and to determine differences between the groups on sources of job stress. Job stress index scores for the individual items were computed (frequency rating x intensity rating) and subjected to one-way ANOVAs. Table 9 summarizes the top 10 sources of job stress for the sample. These analyses only revealed one significant difference between the groups. The symptomatic group reported significantly higher levels of stress associated with frequent interruptions than the asymptomatic group ($F = 5.29$, $df = 46$, $p < 0.05$).

(Insert Table 9 About Here)

Comparisons between groups on work stress diary entries for peak stressor.

Work stress diary data for the peak stress events and the Impact of Events Scale — Revised scores were examined using one-way ANOVAs. No significant differences were detectedfor stress severity ratings or post-event tension/anxiety or anger/hostility ratings from the work stress diary. As expected, however, significant differences were observed for UE symptom severity following the stressor, with the WRUE symptom group reporting significantly greater symptoms during the peak job stress event than the asymptomatic control group ($F = 8.35$, $df = 32$, $p < 0.01$). Table 10 provides the means and standard deviations for these measures. Although no differences were indicated between symptomatic and asymptomatic workers on responses in the work stress diary, a significant difference was found for general distress in response to the peak stressor event as measured by the Impact of Events Scale — Revised ($F = 12.45$, $df = 35$, $p < 0.001$; Figure 6).

(Insert Figure 6 and Table 10 About Here)

Potential Confounders

Task credibility ratings reported by the participants following the work stress recall task were examined via a one-way analysis of variance. No significant difference between the groups were observed on this rating, with the average rating for controls being 4.53 and for cases, 5.08 (sd = 2.30 and 2.95 respectively; Figure 7).

No differences between the groups were detected for imaginal ability (Tellegen Absorption Scale) suggesting both groups were equally able to recall and re-experience the stressful work event. Additionally, work stress diary data did not indicate any group differences for the time interval between the peak stress event and the second laboratory visit, with the WRUE symptom group averaging 7.94 (5.17) days and the asymptomatic control group averaging 8.36 (5.49) days.

(Insert Figure 7 About Here)

Multivariate Analyses

Self-reported upper extremity symptoms and distress.

2 (groups: WRUE Sx vs. Asymptomatic Controls) x 7 (periods: initial, baseline, post-stressor, recovery minute 2, recovery minute 4, recovery minute 6, recovery minute 8) Repeated Measures ANOVAs were computed for self-reported distress and self-reported upper extremity (UE) symptoms throughout the laboratory protocol. The sphericity assumption for repeated measures analyses was violated for both of these analyses; therefore the Huynh-Feldt epsilon adjustment to the degrees of freedom was used to calculate the observed significance levels. For

small sample sizes, this adjustment has been shown to be more appropriate than the more common Greenhouse-Geisser epsilon (SPSS, 1999).

A significant main effect for period was observed for self-reported distress (F =36.10, df = 3.13, $p < 0.01$). Tests of within-subjects repeated contrasts revealed that self-reported distress did not differ from the initial to the baseline report, but it significantly increased between the baseline and post-stress measurements, and continued to decline significantly through the 2-minute, 4-minute, 6-minute, and 8-minute recovery measurements (see Table 11 and Figure 8). Neither a significant main effect for group nor a group by period interaction was observed for self-reported distress. However, a trend for a group by period interaction was noted (F = 2.56, df = 3.13, $p = 0.056$). Observed post-hoc power for this analysis was 0.63 (_^{2} = 0.07), suggesting this analysis may have been somewhat underpowered to detect the interaction effect. Similarly, post-hoc power for the group main effect analysis was 0.42 (_^{2} = 0.09).

(Insert Table 11 and Figure 8 About Here)

A significant period main effect was also observed for self-reported UE symptoms (F = 4.73, df = 2.79, $p < 0.01$), but tests of within-subjects repeated contrasts revealed a somewhat different pattern than that observed for self-reported distress. Self-reported UE symptoms increased significantly between baseline and post-stressor assessments, and decreased significantly from minute 4 to minute 6 of the recovery period. However, self-reported UE symptoms did not differ significantly between any other periods (see Figure 9). No significant group main effect or group by period interaction was found for self-reported UE symptoms.

Post-hoc observed power for the group main effect analysis was 0.87 ($\_^2$ = 0.12) and observed power for the group by period interaction analysis was 0.46 ($\_^2$ = 0.05).

(Insert Figure 9 About Here)

Heart Rate Response

A 2 (groups: WRUE symptom vs. asymptomatic control group) x 3 (periods: baseline, stressor, recovery) Repeated Measures ANOVA was computed for heart rate. No assumptions for repeated measures analyses were violated, and a significant main effect for periods was observed. Within-subjects repeated contrasts revealed significant differences in heart rate between the baseline and the stress periods and between the stress and recovery periods, with heart rate increasing significantly from baseline to post-stress recall and then decreasing significant from the stress-recall period to the recovery period. Also, a significant main effect was observed for groups where the WRUE symptom group was significantly higher than the asymptomatic control group across all time periods (heart rate: $F = 4.43$, df = 1, $p < 0.05$; Table 12 and Figure 10). No significant group by period interaction was observed. However, the observed power for the interaction analysis was 0.08 ($\_^2$ = 0.01), suggesting that if a true group by period interaction existed, this analysis was significantly underpowered to detect it.

(Insert Table 12 and Figure 10 About Here)

Salivary Cortisol Response

A 2 (groups: WRUE Sx vs. Asymptomatic Controls) x 4 (periods: anticipatory baseline, baseline, stressor, recovery) Repeated Measures ANOVA was computed for salivary cortisol levels. Salivary cortisol levels for one asymptomatic control subject was not used in this analysis due to possible blood contamination in the samples. These data violated the sphericity assumption for repeated measures analyses, and the Huynh-Feldt epsilon adjustment was used to calculate the observed significance levels. Results indicated a significant main effect for period (F = 34.09, df = 2.25, p <0.001), and within-subjects repeated contrasts revealed that cortisol levels decreased significantly from the baseline to the stressor period. No other differences were observed for time period. No significant main effect was observed for group, indicating similar cortisol levels between the WRUE symptom group and the asymptomatic control group, and no cortisol level by group interaction was detected. However, observed power for the between subjects effects and the within subjects effects interaction term were 0.12 and 0.19 respectively (_^{2} = 0.02 for both terms), suggesting these analyses may not have been powerful enough to detect differences if they existed. Table 12 contains cortisol values for each group and each time period, and Figure 11 graphically represents the changes in cortisol levels across the protocol.

(Insert Figure 11 About Here)

Forearm Musculature Response

A 2 (groups: WRUE symptom vs. asymptomatic control group) x 2 (muscle site: extensor vs flexor) x 2 (handedness: dominant vs nondominant) x 3 (periods: baseline, stressor, recovery) Repeated Measures MANOVA was conducted for sEMG forearm %MVC values in order to identify differences in upper limb musculature response to the laboratory stress task. A significant main effect was found for period ($\underline{F}$ = 14.21, df = 1, $\underline{p}$ <0.01) where sEMG (%MVC) significantly increased from the baseline to stress period and significantly decreased from the stress period to the recovery period for all muscle sites (Table 13 and Figures 12 and 13).

A significant main effect was also observed for muscle site ($\underline{F}$ = 36.93, df = 1, $\underline{p}$ <0.01) where flexor muscle activity represented a greater percentage of the muscles maximum voluntary capacity than extensor muscle activity at all muscle sites (dominant and nondominant) and across all periods. A significant main effect was also observed for group status ($\underline{F}$ = 10.64, df = 1, $\underline{p}$ <0.01). Tests of Within Subjects Contrasts revealed across all muscle sites and all periods, forearm muscle activity in the WRUE symptom group was a significantly greater percentage of the muscles maximum voluntary capacities than asymptomatic control group forearm muscle activity.

(Insert Figures 12 and 13 and Table 13 About Here)

<u>Multivariate Discrimination of Symptomatic and Asymptomatic Groups</u>

The descriptive statistics for all data subjected to stepwise canonical discriminant function analyses (DFAs) are presented in Table 14, and correlations among the variables included in the DFAs are presented in Table 15. The results of these analyses are summarized in Tables 16 through 19.

(Insert Tables 14 and 15 About Here)

The first discriminant analysis was conducted using self-report measures of ergonomic exposure. A significant discriminant function was obtained (Wilks Lambda = 0.86, $p < 0.01$; Table 16), with percentage of workday spent at a computer workstation most definitively separating the WRUE symptom group and the asymptomatic control group.

A significant discriminant function was also obtained for the job/family stress domain (Wilks Lambda = 0.73, $p < 0.01$; Table 17). The analysis revealed that the Impact of Events Scale (Revised) most definitively discriminated between the WRUE symptom group and the asymptomatic control group.

The discriminant analysis for the physiological variables also revealed a significant discriminant function (Wilks Lambda = 0.40, $p < 0.01$; Table 18) indicating that nondominant flexor muscle activity (% MVC) during the laboratory stress task and heart rate during the recovery period significantly discriminated between the WRUE symptom and control groups, with the symptomatic group evidencing higher levels of muscle and heart rate activity than the control group.

A final DFA was conducted, entering the significant discriminators from the domain-specific DFAs (i.e., percent of work time at a computer workstation, Impact of Events Scale-Revised, nondominant flexor % MVC during the stressor period, and heart rate during the recovery period) as a unitary model. This model also significantly discriminated between the groups (Wilks Lambda = 0.31, $p < 0.01$; Table 19).

(Insert Tables 16-19 About Here)

Prediction of Symptoms, Pain, Functional Limitation, and General Health

The variables found to maximally discriminate between the WRUE symptom group and the asymptomatic control group (i.e., percent of work time at a computer workstation, Impact of Events Scale-Revised, nondominant flexor percent MVC during the stressor period, and heart rate during the recovery period) were subjected to stepwise multiple regression analyses to assess their association with self-reported symptoms, pain, functional limitation and general physical and mental health. This multidimensional model accounted for a significant amount of the variance in self-reported pain in previous week ($R^2 = 0.50$, $p < 0.01$), functional limitation (the Upper Extremity Function Scale ($R^2 = 0.42$, $p < 0.01$), and symptom severity (Symptom Severity Scale; $R^2 = 0.70$, $p < 0.01$) but not general physical or mental health as measured by the SF-12 Physical Component Summary and the SF-12 Mental Component Summary.

Step-wise analyses suggest that percent of work time spent at a computer work station was significantly associated with self-reported pain level in previous week ($R^2 = 0.18$, $p < 0.05$), the Upper Extremity Function Scale ($\Delta R^2 = 0.14$, $p = 0.05$), the Symptom Severity Scale ($\Delta R^2 = 0.17$, $p < 0.05$). The Impact of Events Scale — Revised was significantly associated with the Upper Extremity Function Scale ($\Delta R^2 = 0.22$, $p = 0.01$), and the Symptom Severity Scale ($\Delta R^2 = 0.45$, $p < 0.01$). Average heart rate during the recovery period was significantly associated with self-reported pain level in the previous week ($\Delta R^2 = 0.12$, $p < 0.05$). Table 20 summarizes the results of these analyses.

DISCUSSION

On the basis of prior research indicating relations among job stress, ergonomic exposure and work-related musculoskeletal symptoms, the present study was conducted to answer the following questions: 1) are there differences between symptomatic and asymptomatic workers in self-reported psychosocial or ergonomic factors; 2) do workers with work-related upper extremity symptoms respond with greater musculoskeletal, neuroendocrine, and psychological responses to job stress than asymptomatic workers; 3) can physiological reactivity, ergonomic, and psychosocial variables significantly discriminate symptomatic and asymptomatic workers; and 4) can these identified discriminators predict both general clinical outcomes, such as physical and mental health, and WRUE-specific clinical outcomes, such as pain, symptom severity, and functional limitations?

Question 1: Are There Differences in Self-Reported Psychosocial or Ergonomic Factors Between Symptomatic and Asymptomatic Workers?

Compared to asymptomatic controls, subjects with work-related upper extremity symptoms reported significantly greater symptom severity, pain intensity, and poorer physical health and function. By self-report, all subjects were free of medical conditions known to be associated with the instigation and exacerbation of upper extremity symptoms and disorders. Additionally, no differences were found between groups on age, body mass index (matched prior to inclusion in the study), marital status, job type or education. These findings confirm the clinical status of the symptomatic group and suggest that it is unlikely that differences between the groups can be attributed to general medical or demographic factors.

Consistent with prior research, the current results indicated differences in ergonomic exposure and emotional distress (as measured by the SF-12 Mental Component Summary) between symptomatic and asymptomatic workers, with symptomatic workers reporting significantly greater ergonomic exposure and greater emotional distress than their asymptomatic counterparts. However, contrary to prior research, the observed difference in emotional distress was not manifest in a higher rate of diagnosable mental disorders. Instead it was limited to the Mental Component Summary (MCS) of the SF-12, which is more of an indicator of general distress than of psychological disorders per se. Additionally, the scores on the MCS, although significantly lower in the WRUE symptom group, were within normal range for both groups (Ware et al., 1996) indicating that the lower scores on the MCS for the symptomatic group were not within the clinical range.

This observed difference in general emotional distress could be due to a couple of factors. It is possible that higher levels of distress are a result of having WRUE symptoms similar to observed decrements in MCS scores in individuals with other types of chronic physical complaints (Ware et al, 1996). Alternatively, this discrepancy in MCS scores could be due to a shared risk factor between WRUE symptoms and emotional distress (e.g., tonic physiological hyperarousal) that could result in both maintainance or exacerbation of symptoms and increased distress. Further investigation is required in order to better understand the relation between psychological distress and WRUE symptoms and disorders.

The current investigation failed to find significant differences in self-reported frequency or intensity of job stress, a finding that was consistent for retrospective measures in the self-report battery and for the responses in the daily work stress diary. In spite of the apparent similarities in job stress exposure and acute ratings of stressor intensity in the work stress diaries, the symptomatic workers reported significantly greater event-specific distress (physiological, cognitive, and behavioral) since the occurrence of the peak stress event (as measured by the IES-R). This apparent conflict between the current findings and prior research could indicate that previously observed increases in job stress were a result of increased symptom severity and/or functional limitation. The symptomatic workers in this investigation may have been too healthy to exhibit such an increase in job stress. An alternative explanation is that the previously reported elevation in job stress could be a function of a third variable that was controlled in this study, such as job category or comorbid medical conditions. Further prospective research is necessary to better explain the relationship between job stress and WRUE symptoms and disorders.

Greater self-reported cognitive and behavioral distress in response to the peak job stressor (as indicated by the IES-R) in the absence of greater levels of job stress frequency or intensity are somewhat more difficult to explain. One possible explanation is that the current results are indicative of individual differences in stress coping style or cognitive processing of the demands of stressful events. Baum et al. (1997) define stress as a two-part process that requires both an environmental threat or challenge and a response from the organism being threatened. This response involves two phases: an acute reaction to the perceived stressor (with physiological, emotional, and behavioral sequelae), as well as, a post-acute cognitive processing of the event (often termed coping in the human stress literature; Lazaurs & Folkman, 1984) with its own physiological, emotional, and behavioral consequences (Baum et al., 1997). In light of this definition, symptomatic and asymptomatic workers could respond similarly to the acute demands of a job-related stressor but then diverge in their post-acute cognitive processing (or coping), and thus experience different long term physiological, emotional, and behavioral consequences.

The differences between the groups on the IES-R may stem from these latter phases of cognitive processing, where individuals with ineffective or inadequate coping skills are less likely to envision or achieve a satisfactory resolution to the current stressor. This perceived lack of ability to solve problems to one s expectations may lead to cognitive perseveration (Lewin, 1927) and protracted stress sequelae as the struggle with these stressors plays out. Therefore, even though in the acute phase symptomatic and asymptomatic workers may respond similarly, symptomatic workers may be more likely to experience the physical, emotional, and behavioral consequences of stress over longer periods of time.

These protracted consequences may impact WRUE symptoms via a variety of mechanisms. They may cause direct soft tissue damage via the damaging effects of catecholamines and cortisol (Faucett & Werner, 1999; Melzack, 1999; Sapolsky, 1996); they may lead to soft tissue damage via stress-related behavioral changes (e.g., increased force, increased speed of work tasks, a reduction in breaks; Skubick et al., 1993), and they may affect symptoms in a more indirect manner via heightened sensitivity to pain or to increased symptom reporting, help-seeking, or time off from work (Cioffi, 1995). The plausibility of these mechanisms in light of the current laboratory results will be discussed more in the next section.

Recent support for this cognitive processing interpretation was reported by Shaw, Feuerstein, Haufler, Berkowitz, and Lopez (2001). In a sample of U.S. Army soldiers working with low back pain, differences in problem-solving style, specifically the tendency to view problems as significant threats to well-being and the tendency toward narrow, harried, and incomplete solutions were associated with loss in pain-related physical function. Additionally, in workers with longer histories of low back pain, the tendency to utilize a problem-solving style characterized by attempts to procrastinate or shift responsibility was also associated with poorer function. Although the results from Shaw et al. (2001) are indicative of problem-solving style in workers with low back pain (a group that has been shown to be empirically different from workers with upper extremity pain) and do not elucidate the specific mechanism(s) by which problem-solving may impact functional status, it suggests that problem-solving may moderate objective outcomes in workers with work-related musculoskeletal symptoms. Replication and further investigation of these findings are necessary in order to glean a better understanding of the nature of this relationship.

Question 2: Do Symptomatic and Asymptomatic Workers Respond Differently to a Laboratory Job Stress?

In the current study, during the job stress recall task, significant changes in the predicted direction were shown for both symptomatic and asymptomatic workers and for all physiological variables except salivary cortisol (i.e., heart rate, forearm flexor bundles and forearm extensor bundles). The symptomatic group evidenced higher heart rate and greater forearm flexor activity across all periods.

The failure to observe elevated salivary cortisol levels in response to the laboratory stressor was likely due to either insufficient stressor intensity and duration or to protocol methodology. Although all protocols were conducted in the afternoon, initial saliva samples were taken as early as 1:20 p.m. in some subjects. Research on the diurnal variation in cortisol levels suggests that, in order for cortisol levels to be at their lowest and most stable levels (and thus be most sensitive to detections of change), samples should be collected at 4:00 p.m. or later (Kirschbaum et al., 1993). Therefore, for some subjects salivary cortisol levels were declining throughout the protocol perhaps masking a cortisol response.

From these data alone, it cannot be concluded that symptomatic and asymptomatic workers respond differently to job stress. However, it is clear that important tonic differences in heart rate and forearm sEMG likely exist between the groups, and the magnitude of these sEMG elevations could have important consequences for workers with WRUE symptoms. The current results indicated forearm flexor activity (sEMG %MVC) in symptomatic workers was between 4 and 6%, compared to 2 - 3.5% in the asymptomatic group. According to the results of previous investigations by Westgaard and Bjorklund (1987) and Waersted et al. (1991), sustained low level muscle activity of the magnitude observed in the symptomatic group can lead to musculoskeletal discomfort, injury, or exacerbation via the fatigue of small motor units.

Tonic elevations in muscle activity and heart rate with proportional increases in response to job stress could theoretically contribute to the occurrence, maintenance or exacerbation of WRUE symptoms. However, hypothesized group by period interactions were not observed for any of the physiological variables, suggesting that all subjects experienced proportionate increases in reactivity during the job stress recall task and decreases post-task. Similar physiological responses between the groups to the job stress recall task on distress ratings, heart rate, and forearm sEMG (% MVC) were consistent with the self-report findings which suggested that the symptomatic and asymptomatic subjects, when asked to assess the acute impact of a stressor, did so similarly. These findings, however, are not consistent with a job stress reactivity model for WRUE symptoms and suggest that general hyperarousal (not reactivity to job stress) potentially contributes to the maintenance or exacerbation of WRUE symptoms in symptomatic workers.

Although the failure to observe any interaction effects in the present study may indicate true null findings, it may also be due to the nature of the stress task employed in this study, the limited sample size, or the limitations of laboratory-based stressor protocols in general. The stress task used in this protocol, although sufficient to elicit statistically significant physiological and emotional responses from the subjects, may not have been of sufficient intensity or duration to elicit differential responses and prolonged recovery between the groups. Additionally, the protocol called for the subjects to, Sit still and quietly while we continue to monitor your physical responses after completing the job stress recall interview. In this synthetic environment, subjects 1) were aware that their muscle, heart rate, and endocrine responses to stress were being measured, and 2) were sheltered from work-related cues that might serve to trigger a protracted physical or emotional response to the event. Neither of these factors exists in their day-to-day work experience and both may have had a calming effect or served to increase the subjects awareness of physical arousal.

A final factor that could be responsible for the lack of significant interaction effects was observed power. Post-hoc power analyses suggest that the interaction analyses were somewhat underpowered to detect the small to medium effect sizes. These potential confounding factors require additional research into the consequences of work-related stress in a more realistic environment in order to draw definitive conclusions regarding the presence or absence of post-stressor group differences.

Question 3: Can Physiological Response to Job Stress, and Ergonomic and Psychosocial Variables Significantly Discriminate Symptomatic and Asymptomatic Workers?

Attempts to discriminate between the two groups using singular models of ergonomic (JRPDS-24; percent of work time at computer work station, number of years performing current work tasks), and psychosocial (job/family stress; pain coping, and distress) indices were minimally successful, yielding statistically significant models but correctly classifying less than 30% of the symptomatic workers. However, the physiological domain (heart rate, salivary cortisol, forearm flexor, and forearm extensor responses to the job stress recall) much more effectively discriminated the two groups, correctly classifying over 85% of the symptomatic workers. Although ergonomic/biomechanical and psychosocial variables have received the onus of the attention in research on WRUE symptoms in the recent past, physiological activity throughout the job stress recall task, specifically nondominant flexor activity during stress and heart rate activity during recovery, more successfully classified symptomatic and asymptomatic subjects than either of the other two domains. These results suggest that physiological variables, a domain that has been relatively ignored in the literature, may be more important discriminators between the groups than ergonomic or psychosocial factors. Replication and further, prospective research is necessary to draw specific conclusion regarding the relationship among these physiological factors, job stress, and WRUE symptoms and disorders.

After examining each domain s (i.e., ergonomic, stress/distress/coping, and psychophysiological reactivity) independent ability to discriminate symptomatic and asymptomatic workers, significant predictor variables from each of the domains were used to assess the ability of a multifactorial model to discriminate between the groups. The variables in the multifactorial model were nondominant forearm flexor activity (sEMG %MVC) during the stress period, heart rate level during the recovery, percent of work time spent at a computer workstation, and general level of distress in response to the peak stress event from the work events diary. As hypothesized by biopsychosocial theories of upper extremity problems in the workplace, this new model more accurately discriminated between the two groups than the single domain models, correctly classifying over 92% of all subjects and nearly 85% of the symptomatic group.

Although the current study design limits speculation regarding the genesis of work-related upper extremity symptoms, these findings are consistent with theoretical models of work related upper extremity symptoms and disorders that emphasize the interplay among biological, psychological, and ergonomic factors in the exacerbation and maintenance of these problems. Further discussion is warranted regarding the specific physiological variables that were found to discriminate between the groups (i.e., nondominant flexor activity during the stress interview and heart rate activity during recovery).

The emergence of nondominant forearm flexor muscle activity, but not dominant flexor or nondominant/dominant extensor activity, as a significant discriminator between the symptomatic and asymptomatic groups was examined in light of the statistical procedures employed and prior research regarding WRUE symptoms and disorders. The answer to the question of dominant versus nondominant is likely to be a statistical one. The singular models were tested using stepwise discriminant function analyses which selected, in a hierarchical fashion, the variables that most significantly discriminated between the groups. However, the nondominant and dominant muscle sites were highly correlated, and once one of the variables was included in the model, very little variance remained to be accounted for by the other site. Therefore, its inclusion could not significantly improve the model, and it was not entered. The results of the multivariate analysis of variance on the forearm musculature support this interpretation which did not find significant differences across the protocol for dominant versus nondominant sites.

In examining why flexor muscle activity, and not extensor muscle activity, discriminated between the groups, it is important to examine more closely the function of the flexor muscles in the forearm. The flexor muscles of the forearm work together in groups contracting and relaxing to produce the fine control needed for movements such as picking up an object or writing. Specifically, the forearm flexor muscles are responsible for the flexion of digits (flexor digitorum superficialis, flexor digitorum profundus, flexor pollicis longus) and for flexion of the wrist (flexor carpi radialis, flexor carpi ulnaris, palmaris longus), two movements integral to keyboarding and mouse use. Recent research by Rempel and colleagues reported that the flexor tendons and muscles are significantly involved in typing (Dennerlein, Mote, & Rempel, 1998) and that the maximum internal tendon forces during keystroke are 4-7 times greater than at the fingertip, and 2-5 times greater than at first suspected (Dennerlein, Diao, Mote, & Rempel, 1999) suggesting these tendons are exposed to significantly more force and greater loads than originally suspected, potentially contributing to the genesis, maintenance, and/or exacerbation of upper extremity symptoms.

More specifically, prior literature implicates the flexor tendons in the pathophysiology of carpal tunnel syndrome (Phalen, 1966; Smith, Sonstegard, & Anderson, 1977). It has been suggested that synovitis around the flexor tendons, the result of hyperactivity of the forearm flexor muscles, can lead to increased tendon load, causing small insults to the tissues of the tendons (Skubick et al., 1993; Schuind, Ventura, & Pasteels, 1990; Phalen, 1966; Smith, Sonstegard, & Anderson, 1977). These insults alone may be sufficient to cause WRUE symptoms, or they may cause inflammation. Inflammation of these tendons at the wrist (i.e., as they pass through the carpal canal) may cause compression of the median nerve, the most pliable of the anatomic structures within the canal. This compression can lead to compromised nerve function and symptomatology known clinically as the carpal tunnel syndrome.

Support for this theory linking heightened forearm flexor activity to WRUE symptoms in general and CTS specifically has been reported previously (Moulton & Spence, 1992; Skubick et al., 1993). Moulton and Spence (1992) noted increased forearm flexor activity in response to the recall of a recent pain event in a sample of musicians with work-related upper limb pain. However, significant findings were not bilateral and were limited to the pain-side flexor. A recent clinical trial also supports a relationship between the forearm flexor muscles and pathologic outcomes. Skubick et al. (1993) conducted a non-controlled clinical trial of muscle biofeedback and CTS. Although Skubick et al. (1993) propose that the ultimate cause of forearm flexor hyperactivity is caused by asymmetry in muscles much more proximal to the forearm (i.e., the sternocleidomastoid muscles of the neck), the results of this research suggested that decreasing this asymmetry resulted in significantly lower forearm flexor activity and reduced symptomatology in subjects with CTS. Although this was an uncontrolled clinical trial, the results of Skubick et al (1993) are consistent with the current findings and suggest that tonic elevation in forearm flexor activity, which may be exacerbated further by stress-related increases in activity, is the primary factor in the relation among muscle activity, stress, and WRUE symptoms and disorders.

Lastly, the emergence of heart rate activity during the recovery period as a significant predictory instead of heart rate during the baseline or stress recall periods was likely a statistical anomaly. Univariate analyses indicated no group differences on heart rate during the recovery period, but group significant differences were noted for heart rate during the baseline. Examination of the variables entered and removed at each step of the physiological discriminant analysis indicated that heart rate activity during the baseline period was originally included in the model but was replaced by heart rate during the recovery period during the final step of the analysis. This was likely due to the high correlation among heart rate activity across the three periods, and interpretation of the multivariate and univariate analyses taken as a whole would suggest that baseline heart rate activity was likely a more important discriminator between the groups.

<u>Question 4: Can Physiological, Ergonomic and Psychosocial Discriminators Predict Both General Clinical Outcomes, such as Physical and Mental Health, and WRUE-Specific Clinical Outcomes such as Pain, Symptom Severity, and Functional Limitations?</u>

The final step in the analyses of the current results assessed the relationship among the model identified by discriminant analyses and clinically relevant outcomes such as pain, symptoms, functional limitations, and general physical and mental health status. The model accounted for a significant amount of the variance WRUE-specific clinical outcomes (e.g., pain severity in the previous week, symptom severity, and functional limitations) but did not account for a significant amount of the variance in general physical health or emotional distress. These findings are consistent with a model of biopsychosocial risks for WRUE symptoms and disorders that are specific to these complaints and not merely nonspecific correlates of poor physical health, chronic physical problems, or mental distress.

Additionally, stepwise analyses revealed some noteworthy patterns and relations among these biopsychosocial domains and WRUE-specific clinical outcomes. Percentage of work time spent at a computer workstation and heart rate during the recovery period accounted for a significant proportion of the variance (30%) in pain severity in the previous week, with larger percentages of work time and higher heart rate associated with greater reports of pain severity. Additionally, percentage of work time spent at a computer work station and cognitive and behavioral distress in response to the peak stress event were significantly associated with symptom severity and functional limitations, with larger percentages of work time and greater post-event distress being associated with greater reports of functional limitation. None of these predictors were associated with general physical health or emotional distress.

Most notable were the magnitudes of the relations between post-event psychological distress and the clinical outcomes of symptom severity and functional limitation. The IES-R alone accounted for 22% of the variance in symptom severity and 45% of the variance in functional limitation. These findings are consistent with recent theories and prior research suggesting that there are specific ergonomic exposures and individual psychosocial factors that are uniquely associated with WRUE clinical outcomes.

Theoretical Implications

Although replication and further research are necessary, two findings from the current study may have significant theoretical implications for the WRUE literature. Evidence of elevations in post-stressor cognitive and behavioral distress in symptomatic workers suggests that individual differences in stress processing and coping likely exist and are not merely a result of organizational psychosocial stressors. Previous models that have considered cognitive variables and/or coping style have generally limited these factors to the perception, interpretation and coping with pain-specific stimuli (e.g., Sauter & Swanson, 1996), or they did not consider individual differences in the perception, interpretation and coping with stress in general (Melin & Lundberg, 1999). However, the current data suggest there may be an additional process that involves individual deficits in problem-solving and coping skills. This could explain the failure to observe differences between the groups on pain coping style and acute assessment of the peak stressor event, while significant differences in the cognitive, physical, emotional and behavioral sequelae subsequent to the stressor were observed. Based upon the current data, differences in cognitive processing/problem-solving style likely exist between symptomatic and asymptomatic workers. However, a great deal of variance existed in the symptomatic workers across all psychosocial and physiological variables included in this investigation. Perhaps an additional individual difference variable exists that may serve to further stratify the symptomatic group. One such factor that would be consistent with the current findings is the workstyle concept.As previously discussed, the workstyle concept is based upon individual differences in how workers perform their work tasks in response to increased work demands, especially in terms of psychological and physiological arousal (Feuerstein, 1996). These individual differences, including cognitive, behavioral, and physiological components, such as feelings of distress, sustained forceful movements or awkward postures, and concomitant heightened levels of muscle tension, interact with workplace psychosocial and ergonomic factors to increase risks for upper extremity symptoms and disorders (Feuerstein et al., 1999). Recently, a self-report measure of workstyle was developed and validated (Feuerstein et al., 2001). In such a heterogeneous population of WRUE symptoms and disorders, this characteristic may help identify important subgroups, reducing variance within the groups and perhaps more successfully predicting important clinical and functional outcomes. The utility of the workstyle concept for these purposes is a question for future research.

Clinical Implications

Although the methodology of the current investigation was exploratory in nature, and application of the results to clinical intervention premature, the increased knowledge of the risk factors for the occurrence and exacerbation of WRUE symptoms and disorders that could be gleaned from this and future studies can be used to develop more effective prevention and/or intervention efforts. The current results suggest possibilities for intervention at both the level of the organization and the level of the individual.

These data indicated that ergonomic interventions aimed at decreasing exposure to known risk factors (e.g., repetitive motion, awkward postures, excessive force, and inadequate rest cycles; Putz-Anderson, 1988; Armstrong et al., 1993; Frederiksson et al., 1999) are likely important interventions, and adequate attention and investment should continue to be made. However, the current results suggest this is likely to be inadequate as a sole intervention for the management of these complex symptoms.

The data also suggest that interventions aimed at developing individual skills for stress management and coping will be effective at improving function and decreasing pain in workers with WRUE symptoms. These may include activity pacing (i.e., taking frequent breaks away from computer), stress management interventions to include cognitive interventions, problem-solving skills, and relaxation techniques to minimize the physiological consequences of stress on the individual. Over the past decade, Susan Spence and colleagues have conducted clinical trials on the efficacy of cognitive and behavioral interventions for chronic pain disorders, including upper limb disorders (Spence & Kennedy, 1989; Spence, 1989; Spence et al., 1995; Newton-John, Spence, & Schotte, 1995; Spence, 1998). These interventions have primarily employed techniques such as goal setting, problem-solving, cognitive restructuring, attention diversion, communication skills, and assertiveness training aimed to enhance coping with chronic pain. These studies have found improvements in self-reported pain, function, and pain-related distress that have persisted through 6 months post-intervention (Spence, 1989)

A unique finding of the current research suggests that reducing physiological arousal and the physiological sequelae of stress will likely be an effective component of WRUE symptom interventions. Recent interventions have begun to examine the role of biofeedback and physiological relaxation techniques in the management of WRUE symptoms and disorders (Spence, Sharpe, Newton-John, & Champion, 1995; Thomas, Vaidya, Herrick, & Congleton, 1993; Garfinkel, Singhal, Katz, Allan, Reshetar, & Schumacher, 1998; Sequeira, 1999; Nord, Ettare, Drew, & Hodge, 2001). In general, significant improvements in symptoms and/or function have been found for various biobehavioral interventions (e.g., progressive muscle techniques, imagery, and yoga). These techniques have been shown to be more effective than splinting alone and no treatment in managing symptoms of WRUE disorders, and benefits from these interventions have been supported over 6 month follow-up periods (Spence, Sharpe et al., 1995). Short-term benefits have been shown to be more robust for relaxation techniques than for biofeedback training (Thomas et al., 1993; Spence, Sharpe et al., 1995). However, both resulted in significant reductions in symptoms post-treatment, and these benefits were maintained through a 6-month follow-up period (Spence, Sharpe, et al., 1995). Additionally, differences between the therapies did not persist at 6-month follow-up suggesting both are equally efficacious for the reduction of symptoms (Spence, Sharpe, et al., 1995).

The most recent trial of a relaxation-based intervention for upper extremity symptoms was conducted by Nord and colleagues (2001). Workers with computer keyboard and mouse-related WRUE symptoms who had failed to respond to a prior course of intervention participated in a trial of Muscle Learning Therapy which is a 12-session biofeedback protocol that teaches workers to control their muscles during work activities. Posttreatment, 86% of the participants reported feeling better overall and 81% reported either working the same and feeling better or working and accomplishing more (Nord et al., 2001). Although this was not a randomized, controlled trial, it is a preliminary finding that suggests the importance of managing muscle activity in the management of WRUE symptoms.

Lastly, findings that suggest individual worker factors may exacerbate the expression of these disorders do not preclude addressing potential organizational contributors. The group scores on the Job Stress Survey, as well as the item analysis, indicate that job stress is distressing to all workers, not just workers with WRUE symptoms. The descriptive item analysis revealed that certain organizational factors are among the highest sources of job stress reported by this sample, regardless of clinical status. These factors included meeting deadlines, insufficient personnel to handle an assignment, poorly motivated coworkers, dealing with crisis situations, and assignment of new or unfamiliar duties. Targeted, organizational interventions aimed at minimizing these common workplace stressors include management training to modify these stressful situations when possible. Additionally, management training in ways to minimize the impact of unavoidable stressors (e.g., personnel shortages, salary cuts) are likely to maximize worker satisfaction and productivity, regardless of their clinical status. Additionally, such interventions will likely serve to reduce the level of preoccupation with work-related stressors and reduce symptoms and functional limitations in those who are affected by WRUE symptoms and disorders.

Based on these data, the most effective intervention will likely be one that addresses the risks associated with each of these domains. An example of such an intervention was employed with symptomatic and asymptomatic sign language interpreters and included interventions targeted at fitness training, biomechanics education, job stress management, pain management, and relaxation (Feuerstein, Marshall, Shaw, & Burrell, 2000). Over a three-year follow-up period, decreases in accident reports, compensation indemnity costs, and medical costs were observed while work demands increased (Feuerstein, Marshall, et al., 2000), suggesting that multidimensional protocols are effective for decreasing the individual and organizational impacts of WRUE symptoms and disorders. A partial rebound was observed in all outcome measures at 3 years post intervention which interestingly was associated with a concomitant increase in physical workload (i.e., increased hours interpreting; Feuerstein, Marshall, et al., 2000). Again, this was not a controlled clinical trial, but it provides important preliminary support for multidimensional approaches to the management of WRUE symptoms and disorders.

Replication of the current results and further research regarding the risk factors for the initiation, exacerbation, and maintenance of WRUE symptoms and disorders are necessary. Additionally, the development of time-efficient and cost-effective multidimensional intervention programs that are based upon such research and that are viable in the workplace is essential. Multidimensional interventions are typically more costly in terms of both time and resources. In order to justify the additional costs associated with such interventions, controlled trials are necessary in order to determine if they have a significantly greater impact on clinical and occupational outcomes than less costly uni-dimensional interventions.

Study Limitations

The primary limitation of the current investigation was the limited sample size. As a result, some of the analyses, including the analyses of many of the interaction terms of the

ANOVAs and MANOVA, had insufficient power to detect differences that may have existed between the groups. Failure to detect significant differences may have been a true null finding. However, limited power calls into question the ability of these analyses to detect true differences if they existed. Effect sizes for many of these variables were moderate, suggesting that a larger sample size would have addressed the observed lack of power, perhaps yielding statistically and clinically significant differences between the groups. Further research with a larger sample size is necessary to verify the interpretation of these results.

Not unrelated to the limited sample size are concerns regarding possible selection and survival biases secondary to participant attrition. A significant number of participants failed to attend Visit 1 or to complete Visit 2. Comparisons of subjects who met criteria for participation but did not present to the lab for Visit 1 to those who did present to the lab indicate a potential selection bias for subjects who spent less time at their computer workstation per day, perhaps indicating a lower degree of ergonomic exposure in study participants. Additionally, comparisons of participants who were lost to follow-up after the first laboratory visit to those who completed the entire protocol suggested a potential survivor bias for the symptomatic subjects, with symptomatic workers who completed the protocol reporting significantly less symptom severity and functional limitation than those who dropped out of the protocol after the first laboratory visit. These potential selection and survival biases could have yielded a sample that was healthier than typical, symptomatic workers and thus limit the generalizability of the current findings. However, inspection of the final sample s clinical outcome and general health indices suggested that the final sample was similar to other samples of symptomatic office workers included in previous investigations (Feuerstein, Huang et al., 2000; Haufler et al., 2000).

An additional concern in the present study was the relatively large number of analyses conducted resulting in an elevated experiment-wise error rate. The experiment-wise type I error rate could be as high as 20% for the repeated measures analyses, the discriminant function analyses, and the multiple regression analyses. However, given the hypothesis-generating nature of the current investigation, it was determined that the potential benefits of conducting these analyses were greater than the costs associated with increased risks for Type I error. The increased risk that the findings in the current investigation may be due to chance compels replication and further investigation.

Finally, the design of the laboratory protocol (i.e., the lack of a generic stress control task) combined with the lack of significant differences between the groups on self-reported frequency and intensity of work stress limit discussion regarding the specificity of the current findings to work-related stress. A recent comprehensive review of psychosocial factors and work-related upper extremity musculoskeletal symptoms conducted by the National Academy of Sciences concluded that perceived work stress and work demands, in addition to nonwork-related worry, tension and psychological distress have been consistently shown to be related to the occurrence of these disorders (National Research Council and the Institute of Medicine, 2001). The findings of this review, coupled with the findings of this study suggest that work-related stress is likely to be an important factor in the etiology, exacerbation and/or maintenance of these problems, but it is unlikely to be the only factor. Further empirical study of this question is required.

Conclusion

The present findings indicate that there are likely to be important ergonomic, psychosocial and physiological differences between symptomatic and asymptomatic workers. In spite of the limitations in the current study, the results point to important differences across ergonomic, psychosocial and physiological domains that are consistent with prior research, that can discriminate between symptomatic and asymptomatic workers, and that are associated with WRUE-specific clinical outcomes. Although the current findings must be replicated and investigated further, the current investigation has also generated important questions for future research. These include further investigation into group differences in response to stress in general and job-related stress in specific, and identification of individual factors, such as workstyle, that might further stratify symptomatic workers and help to reduce variability within the groups and more successfully predict WRUE-specific clinical outcomes.

TABLES

TABLE 1

Number of Subjects Throughout Stages of Protocol

	Symptomatic Workers	Asymptomatic Control Workers	Total N
Phone Screen (met criteria)	48	31	79
Visit 1 (kept appointment)	28	20	48
Visit 1 (completed appointment)	28	19	47
Visit 2 (kept appointment)	16	14	30
Visit 2 (completed appointment)	16	14	30
Percent Lost to Follow-up			36.2%

TABLE 2

Subject Characteristics[a]

	Symptomatic Group (n = 28)	Asymptomatic Control Group (n = 19)	Total Sample (n = 47)
Age (in years) Mean (SD)	36.52 (7.37)	36.47 (7.40)	36.50 (7.30)
Body Mass Index Mean (SD)	27.68 (6.68)	25.55 (5.87)	26.84 (6.68)
	n (%)	**n (%)**	**n (%)**
Job Category			
Managerial/administrative	8 (28.6)	7 (36.8)	15 (31.9)
Professional/paraprofessional/technical	8 (28.6)	5 (26.3)	13 (27.7)
Clerical/administrative support	12 (42.9)	7 (36.8)	19 (40.4)
Education			
H.S. grad/GED	0 (0)	2 (10.5)	2 (4.3)
Some college	13 (46.4)	5 (26.3)	18 (38.3)
2-year degree	3 (10.7)	3 (15.8)	6 (12.8)
4-year degree	3 (10.7)	2 (10.5)	5 (10.6)
Some graduate work	3 (10.7)	1 (5.3)	4 (8.5)
Master's degree	5 (17.9)	3 (15.8)	8 (17.0)
Ph.D., M.D. or Terminal Degree	1 (3.6)	3 (15.8)	4 (8.5)
Marital Status			
Single	5 (18.5)	6 (31.6)	11 (23.4)
Cohabiting	3 (11.1)	2 (10.5)	5 (10.6)
Married	9 (32.1)	9 (47.4)	18 (38.3)
Divorced/separated	9 (32.1)	2 (10.5)	11 (23.4)
Race/Ethnic Representation			
White (not of Hispanic origin)	15 (51.7)	3 (15.8)	20 (41.7)
Black/African American	12 (41.4)	11 (57.9)	23 (47.9)
Asian	1 (3.4)	3 (15.8)	4 (8.3)
White (of Hispanic origin)	1 (3.4)	1 (5.3)	2 (4.2)
Native Hawaiian/Pacific Islander	0 (0)	1 (5.3)	1 (2.1)
Smoking status			
Smoking	23 (82.1)	18 (94.7)	41 (87.2)
Non-smoking	5 (17.9)	1 (5.3)	6 (12.8)

[a] Chi-square analyses indicated no significant differences between groups on any of these variables

TABLE 3

Pain and Function

	Symptomatic Group (n = 28)	Asymptomatic Control Group (n = 19)	
	Mean (sd)	**Mean (sd)**	**p**
Pain Severity VAS (0-100)	34.46 (23.07)	0.00 (0.0)	<0.01
Upper Extremity Function Scale	23.80 (16.41)	8.95 (2.37)	<0.01
Work Limitations Scale	41.64 (16.98)	28.37 (2.71)	<0.01
Levine Symptom Severity Scale	24.73 (7.22)	14.56 (1.29)	<0.01
SF-12 Physical Component Scale	49.09 (7.32)	55.86 (4.31)	<0.01

TABLE 4

Symptom Distribution for WRUE Symptom Group (n = 16)

	n	Percentage
Hand/wrist		
Unilateral	11	68.8
Bilateral	4	25.0
Fingers		
Unilateral	7	43.8
Bilateral	3	18.8
Forearm/Elbow		
Unilateral	9	56.3
Bilateral	2	12.5
Shoulder/Neck		
Unilateral	5	31.3
Bilateral	8	50.0

Note: Subjects could report multiple anatomic regions

TABLE 5

Symptom Impact for WRUE Symptom Group (n = 28)

		n	Percentage
Job Interference			
	Yes	13	46.4
	No	15	53.6
Maintain Work Schedule			
	Yes	26	92.9
	No	2	7.1
Limited/Alternate Duty Status			
	Yes	5	17.9
	No	23	82.1
Work Absence			
	Yes	4	14.3
	No	24	85.7
UE Diagnosis			
	Yes	10	35.7
	No	18	64.3

TABLE 6

Mental Health and Pain Coping Style

	Symptomatic Group (n = 28)	Asymptomatic Control Group (n = 19)	
	Mean (sd)	**Mean (sd)**	**p**
SF-12 Mental Health Component Scale	48.00 (9.72)	53.21 (5.66)	<.05
Catastrophizing Subscale of the Coping Strategies Questionnaire	5.23 (7.11)	2.88 (3.60)	ns
	n (%)	**n (%)**	**p**
DSM-IV Mood Disorder	0 (0)	2 (12.5)	ns
DSM-IV Anxiety Disorder	2 (14.29)	3 (18.75)	ns

TABLE 7

Job/Family Stress Measures

	Symptomatic Group (n = 28) Mean (sd)	Asymptomatic Control Group (n = 19) Mean (sd)	p
Self-Report Battery			
Job Stress Survey			
Job Stress Index	19.36 (11.31)	16.21 (10.99)	ns
Job Pressure Index	24.00 (14.07)	19.36 (10.80)	ns
Lack of Support Index	17.15 (13.09)	16.56 (16.18)	ns
Total Work Load	99.52 (29.13)	84.05 (20.94)	ns
Paid Duties	44.89 (12.20)	38.16 (12.76)	ns
Unpaid Duties	35.32 (16.56)	29.26 (10.32)	ns
LISRES Work Stress	7.76 (3.96)	6.58 (4.88)	ns
Work Stress Diary			
Stressful Events per Work Day	5.15 (5.87)	3.47 (5.04)	ns
Stress Intensity per Event	4.04 (6.16)	3.19 (5.12)	ns
Total Number of Stressful Events	48.72 (57.08)	31.06 (50.73)	ns

TABLE 8

Ergonomic Exposure

	Symptomatic Group (n = 28)	Asymptomatic Control Group (n = 19)	
	Mean (sd)	**Mean (sd)**	**p**
JRPDS-24[a] Total Score	38.14 (11.21)	29.11 (13.42)	<0.01
JRPDS-24 Upper Extremity Subscale	24.82 (5.97)	19.21 (7.33)	<0.01
Percent of Work Time at Computer Work Station	60.74 (20.37)	45.16 (22.50)	<0.05

[a]JRPD = Job Requirements and Physical Demands Survey

TABLE 9

Top 10 Sources of Job Stress[a]

	Symptomatic Group (n = 28)	Asymptomatic Control Group (n = 19)	
	Mean (sd)	Mean (sd)	p
Frequent interruptions	38.61 (27.04)	22.63(16.35)	<0.05
Meeting deadlines	28.25 (22.31)	29.84 (23.48)	ns
Inadequate salary	28.07 (32.25)	28.53 (35.56)	ns
Excessive paperwork	25.18 (22.66)	24.58 (22.32)	ns
Dealing with crisis situations	27.64 (26.55)	19.05 (22.32)	ns
Fellow workers not doing their job	22.25 (20.95)	26.79 (29.58)	ns
Poorly motivated coworkers	26.04 (25.38)	20.42 (21.58)	ns
Insufficient personnel to handle an assignment	24.68 (25.80)	18.42 (24.80)	ns
Assignment of increased responsibility	24.14 (20.02)	17.82 (18.79)	ns
Assignment of new or unfamiliar duties	18.10 (18.88)	21.84 (23.40)	ns

[a] Based on JSS Index Score (frequency x intensity) for each item

TABLE 10

Diary Responses for Peak Job Stressor

Measure (Range)	**Symptomatic Group (n = 16)** Mean (sd)	**Asymptomatic Control Group (n = 14)** Mean (sd)	**p**
UE Sx Severity (0-24)	6.28 (9.75)	0.00 (0.00)	<0.01
Stress Severity (0-10)	6.86 (2.50)	6.50 (2.31)	ns
Post-Event POMS Tension/Anxiety (0-36)	6.94 (6.98)	4.76 (4.82)	ns
Post-Event POMS Anger/Hostility (0-48)	13.06 (10.98)	8.47 (8.35)	ns
Impact of Events Scale – Revised (IES-R; 0-88)	20.06 (12.56)	8.54 (5.82)	<0.01

TABLE 11

Distress and Symptom Response to Job Stress Recall (VAS 0 – 10)

Variable	Initial		Baseline		Stress Recall Task		Recovery Min 2		Recovery Min 4		Recovery Min 6		Recovery Min 8	
	Sympto-matic Group (n = 16)	Asympto-matic Control Group (n = 14)	Sympto-matic Group (n = 16)	Asympto-matic Control Group (n = 14)	Sympto-matic Group (n = 16)	Asympto-matic Control Group (n = 14)	Sympto-matic Group (n = 16)	Asympto-matic Control Group (n = 14)	Sympto-matic Group (n = 16)	Asympto-matic Control Group (n = 14)	Sympto-matic Group (n = 16)	Asympto-matic Control Group (n = 14)	Sympto-matic Group (n = 16)	Asymptomatic Control Group (n = 14)
	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)
Distress	1.44 (2.05)	0.86 (1.57)	0.92 (1.38)	0.42 (1.24)	4.45 (2.37)	2.94 (2.18)	2.82 (2.19)	1.31 (1.67)	1.55 (1.28)	0.89 (1.50)	0.74 (0.95)	0.58 (1.03)	0.32 (0.58)	0.40 (1.03)
Symptoms	1.68 (1.76)	0.00 (0.00)	1.76 (1.86)	0.82 (1.15)	2.68 (2.11)	1.32 (2.17)	2.54 (1.96)	1.37 (2.12)	2.13 (1.79)	1.43 (2.18)	1.61 (1.85	1.43 (2.21)	1.47 (1.98)	1.09 (1.78)

TABLE 12

Heart Rate and Salivary Cortisol Response to Job Stress Recall

Variable	Initial		Baseline		Stress Recall Task		Recovery	
	Symptomatic Group (n = 16)	**Asymptomatic Control Group (n = 13)**	**Symptomatic Group (n = 16)**	**Asymptomatic Control Group (n = 13)**	**Symptomatic Group (n = 16)**	**Asymptomatic Control Group (n = 13)**	**Symptomatic Group (n = 16)**	**Asymptomatic Control Group (n = 13)**
	Mean (sd)	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**
Heart rate (BPM)	N/A	N/A	72.14 (6.02)	65.86 (7.28)	79.88 (9.88)	72.60 (10.74)	71.58 (13.94)	66.10 (8.44)
	Symptomatic Group (n = 16)	**Asymptomatic Control Group (n = 14)**	**Symptomatic Group (n = 16)**	**Asymptomatic Control Group (n = 14)**	**Symptomatic Group (n = 16)**	**Asymptomatic Control Group (n = 14)**	**Symptomatic Group (n = 16)**	**Asymptomatic Control Group (n = 14)**
	Mean (sd)	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**	**Mean (sd)**
Cortisol (nmol/l)	4.68 (2.80)	4.33 (2.24)	3.36 (2.08)	2.50 (1.12)	2.91 (1.86)	2.49 (1.27)	2.65 (1.68)	2.42 (1.66)

TABLE 13

Forearm Musculature Response to Job Stress Recall

Variable	Baseline		Stress Recall Task		Recovery	
	Symptomatic Group n = 16	Asymptomatic Control Group n = 14	Symptomatic Group n = 16	Asymptomatic Control Group n = 14	Symptomatic Group n = 16	Asymptomatic Control Group n = 14
	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)	Mean (sd)
Dominant Forearm Flexor (sEMG %MVC)	4.19 (1.96)	2.66 (1.27)	5.19 (2.41)	3.60 (1.95)	4.55 (2.03)	2.78 (1.20)
Nondominant Forearm Flexor (sEMG %MVC)	5.16 (3.60)	2.82 (1.01)	5.93 (3.68)	3.19 (1.08)	5.15 (3.13)	2.92 (1.02)
Dominant Forearm Extensor (sEMG %MVC)	1.51 (0.85)	0.88 (0.61)	3.61 (3.65)	2.01 (1.71)	1.91 (1.09)	1.14 (0.84)
Nondominant Forearm Extensor (sEMG %MVC)	1.96 (1.13)	1.32 (0.59)	2.76 (1.23)	2.00 (0.90)	2.20 (1.16)	1.43 (0.63)

TABLE 14

Ergonomic, Job/Family Stress, Pain Coping, and Physiological Response to Job Stress Recall Included in Discriminant Analyses

	Symptomatic Group (n = 16)	Asymptomatic Control Group (n = 14)
	Mean (sd)	Mean (sd)
Ergonomic Exposure		
JRPDS-24	40.37 (11.22)	27.21 (12.17)
Years performing current work tasks	6.06 (4.07)	3.43 (4.43)
Percent of work time at computer workstation	64.06 (17.25)	42.43 (19.77)
Job/Family Stress/Pain Coping		
Impact of Events Scale (Revised)	18.87 (11.44)	8.34 (6.41)
Catastrophizing subscale (Coping Strategies Questionnaire)	3.59 (3.25)	3.27 (4.00)
Job Stress Index Score (Job Stress Survey)	19.36 (11.31)	16.21 (10.99)
Job Stress Subscale (LISRES)	7.24 (3.35)	6.21 (4.87)
Total Work Load Scale	93.38 (24.61)	87.43 (23.29)
Physiological		
Heart rate BPM (Baseline)	72.14 (6.02)	65.86 (7.28)
Heart rate BPM (Stress)	79.88 (9.88)	72.60 (10.74)
Heart rate BPM (Recovery)	71.58 (13.94)	66.10 (8.44)
Salivary Cortisol (Initial; µg/dl)	0.17 (0.10)	0.16 (0.08)
Salivary Cortisol (Baseline; µg/dl)	0.12 (0.08)	0.09 (0.05)
Salivary Cortisol (Stress; µg/dl)	0.11 (0.07)	0.09 (0.05)
Salivary Cortisol (Recovery; µg/dl)	0.10 (0.06)	0.09 (0.06)
Nondominant flexor % MVC (Baseline)	5.16 (3.60)	2.82 (1.01)
Nondominant flexor % MVC (Stress)	5.93 (3.68)	3.19 (1.08)
Nondominant flexor % MVC (Recovery)	5.15 (3.13)	2.92 (1.02)
Dominant flexor % MVC (Baseline)	4.19 (1.96)	2.66 (1.27)
Dominant flexor % MVC (Stress)	5.19 (2.41)	3.60 (1.95)
Dominant flexor % MVC (Recovery)	4.55 (2.03)	2.78 (1.20)
Nondominant extensor % MVC (Baseline)	1.96 (1.13)	1.32 (0.59)
Nondominant extensor % MVC (Stress)	2.76 (1.23)	2.00 (0.90)
Nondominant extensor % MVC (Recovery)	2.20 (1.16)	1.43 (0.63)
Dominant extensor % MVC (Baseline)	1.51 (0.85)	0.88 (0.61)
Dominant extensor % MVC (Stress)	3.61 (3.65)	2.01 (1.71)
Dominant extensor % MVC (Recovery)	1.91 (1.09)	1.14 (0.84)

TABLE 15

Correlations Among Ergonomic, Job/Family Stress, Pain Coping, and Physiological Response to Job Stress Recall

	JRPDS -24	No. yrs at current work tasks	% work time at computer	Job Stress (JSS)	Job Stress (LISRES)	Total Work Load	Impact of Events Scale-R	Catastrophizing	Avg HR @ Baseline	Avg HR @ Stress
No. yrs at current work tasks	-0.20									
Percent work time at computer	0.30*	0.11								
Job Stress (JSS)	0.26	-0.24	-0.02							
Job Stress (LISRES)	0.12	-0.18	0.23	0.65**						
Total Work Load	0.26	-0.11	0.221	0.51**	0.50**					
Impact of Events Scale-R	0.30	-0.19	0.29	0.22	0.13	0.37*				
Catastrophizing	0.18	-0.16	-0.12	0.41**	0.38**	0.36*	0.18			
Avg HR (Baseline)	0.25	0.25	0.09	0.16	0.08	-0.24	0.12	0.10		
Avg HR (Stress)	0.33	0.10	0.16	0.16	0.20	-0.28	0.08	-0.01	0.87**	
Avg HR (Recovery)	0.22	0.04	0.12	0.21	0.09	-0.28	0.08	-0.04	0.71**	0.72**
Cortisol (Initial)	0.10	-0.20	-0.27	-0.01	-0.6	0.06	0.11	0.05	0.00	0.00
Cortisol (Baseline)	0.15	0.01	-0.25	0.10	0.13	-0.07	0.12	0.20	0.29	0.23
Cortisol (Stress)	-0.01	0.06	-0.26	0.03	0.01	-0.11	-0.01	0.10	0.10	0.06
Cortisol (Recovery)	0.05	0.03	-0.20	0.02	-0.15	-0.10	-0.06	0.02	-0.06	-0.04
Nondominant flexor % MVC (Baseline)	-0.02	0.36	0.36*	0.01	0.05	0.16	0.30	0.01	-0.04	-0.13
Nondominant flexor % MVC (Stress)	0.07	0.31	0.38*	0.08	0.13	0.27	0.40*	0.08	-0.40	-0.14

TABLE 15 (cont'd)

	JRPDS -24	No. yrs at current work tasks	% work time at computer	Job Stress (JSS)	Job Stress (LISRES)	Total Work Load	Impact of Events Scale-R	Catastrophizing	Avg HR @ Baseline	Avg HR @ Stress
Nondominant flexor % MVC (Recovery)	0.00	0.37*	0.39*	0.03	0.03	0.17	0.35	0.01	-0.02	-0.12
Dominant flexor % MVC (Baseline)	0.20	0.26	0.25	0.19	0.06	0.23	0.32	-0.07	0.06	0.00
Dominant flexor % MVC (Stress)	0.13	0.29	0.36*	0.10	0.10	0.24	0.28	-0.19	0.12	0.13
Dominant flexor % MVC (Recovery)	0.18	0.31	0.30	0.20	0.12	0.23	0.37*	-0.05	0.12	0.07
Nondominant extensor % MVC (Baseline)	0.35	0.10	0.32	0.12	0.01	0.07	0.41*	0.16	0.03	-0.06
Nondominant extesnsor % MVC (Stress)	0.36	0.08	0.28	0.12	-0.02	-0.02	0.39*	0.08	0.07	0.06
Nondominant extensor % MVC (Recovery)	0.32	0.10	0.31	0.11	0.01	0.09	0.49**	0.16	0.09	-0.06
Dominant extensor % MVC (Baseline)	0.49**	-0.03	0.22	0.29	-0.01	0.16	0.34	0.15	0.05	-0.01
Dominant extensor % MVC (Stress)	0.30	-0.02	0.36	0.17	0.07	0.19	0.41*	-0.17	0.08	0.25
Dominant extensor % MVC (Recovery)	0.19	0.11	0.19	0.31	0.00	0.38*	0.31	-0.02	0.12	0.00

* $p < 0.05$ ** $p < 0.01$

TABLE 15 (cont'd)

	Avg HR (Recov-ery)	Cortisol (Initial)	Cortisol (Base-line)	Cortisol (Stress)	Cortisol (Recov-ery)	Nondomin-ant flexor %MVC (Baseline)	Nondomin-ant flexor %MVC (Stress)	Nondomin-ant flexor %MVC (Recovery)	Dominant flexor %MVC (Baseline)	Dominant flexor %MVC (Stress)
Cortisol (Initial)	0.08									
Cortisol (Baseline)	0.23	0.81**								
Cortisol (Stress)	0.13	0.84**	0.85**							
Cortisol (Recovery)	0.07	0.79**	0.65**	0.90**						
Nondominant flexor %MVC (Baseline)	-0.51**	-0.18	-0.08	-0.11	-0.10					
Nondominant flexor %MVC (Stress)	-0.48*	-0.11	0.01	-0.03	-0.06	0.96**				
Nondominant flexor %MVC (Recovery)	-0.43*	-0.16	-0.06	-0.09	-0.08	0.99**	0.96**			
Dominant flexor %MVC (Baseline)	-0.20	-0.11	0.20	0.01	0.03	0.70**	0.79**	0.73**		
Dominant flexor %MVC (Stress)	-0.12	-0.17	0.01	-0.01	-0.04	0.56**	0.61**	0.57**	0.81**	
Dominant flexor %MVC (Recovery)	-0.24	-0.17	-0.02	-0.04	-0.03	0.76**	0.83**	0.77**	0.96**	0.87**
Nondominant extensor %MVC (Baseline)	-0.02	0.02	0.13	0.04	0.03	0.44*	0.49**	0.48**	0.58**	0.39*
Nondominant extesnsor %MVC (Stress)	0.05	0.21	0.33	0.19	0.13	0.26	0.33	0.28	0.45*	0.33
Nondominant extensor %MVC (Recovery)	-0.03	0.07	0.16	0.06	0.03	0.45*	0.49**	0.49**	0.49**	0.31
Dominant extensor %MVC (Baseline)	0.10	0.04	-0.01	0.13	0.29	0.28	0.38*	0.33	0.60**	0.31
Dominant extensor %MVC (Stress)	0.23	0.20	0.20	0.21	0.20	-0.01	0.04	0.01	0.17	0.47**
Dominant extensor %MVC (Recovery)	0.08	0.07	-0.05	0.16	0.25	0.21	0.31	0.25	0.59**	0.53**

* $p < 0.05$ ** $p < 0.01$

TABLE 16

Ergonomic Exposures that Differentiate Symptomatic Cases and Asymptomatic Controls [a]

Number of significant functions	Canonical correlation	Wilks' Lambda	Eigenvalue	Chi-square	df	p
1[b]	0.38	0.86	0.17	6.50	1	<0.01

Discriminating variables	Wilks' Lambda	Correlations between discriminant function and discriminating variables
Percent of work time at computer workstation	0.86[c]	1.00
JRPDS-24[d]	0.90	0.21
Number of years at current work tasks	0.79	-0.05

[a] Variables entered stepwise
[b] 50.0% of sample correctly classified (89.5% controls; 22.2% cases)
[c] p <.02
[d] JRPDS-24 = Job Requirements and Physical Demands Survey-24

TABLE 17

Job/Family Stress and Pain Coping Measures that Differentiate Symptomatic Cases and Asymptomatic Controls[a]

Number of significant functions	Canonical correlation	Wilks' Lambda	Eigenvalue	Chi-square	df	p
1[b]	0.52	0.73	0.37	10.44	1	<0.01

Discriminating variables	Wilks' Lambda	Correlations between discriminant function and discriminating variables
Impact of Events Scale (Revised)	0.73[c]	1.00
Catastrophizing Subscale (Coping Strategies Questionnaire)	0.99	0.14
Job Stress Index Score (Job Stress Survey)	0.99	0.18
Job Stress Subscale (LISRES)	0.99	0.09
Total Work Load Scale	0.95	0.31

[a] Variables entered stepwise
[b] 63.9% of total sample correctly classified (100% controls; 27.8% cases)
[c] p <.001

TABLE 18

Psychophysiological Responses to Job Stress Recall that Differentiate Symptomatic Cases and Asymptomatic Controls[a]

Number of significant functions	Canonical correlation	Wilks' Lambda	Eigenvalue	Chi-square	df	p
1[b]	0.77	0.40	1.47	20.81	2	<0.001

Discriminating variables	Wilks' Lambda	Correlations between discriminant function and discriminating variables
Nondominant flexor % MVC[c] (Stress)	0.92[d]	0.44
Heart rate (Recovery)	0.78[d]	0.25
Heart rate (Baseline)	0.37	0.15
Heart rate (Stress)	0.34	0.02
Nondominant flexor %MVC (Baseline)	0.40	0.37
Nondominant flexor %MVC (Recovery)	0.40	0.46
Dominant flexor %MVC (Baseline)	0.39	0.54
Dominant flexor %MVC (Stress)	0.40	0.38
Dominant flexor %MVC (Recovery)	0.40	0.46
Nondominant extensor %MVC (Baseline)	0.40	0.33
Nondominant extensor %MVC (Stress)	0.40	0.22
Nondominant extensor %MVC (Recovery)	0.40	0.25
Dominant extensor %MVC (Baseline)	0.40	0.25
Dominant extensor %MVC (Stress)	0.39	-0.03
Dominant extensor %MVC (Recovery)	0.38	0.05
Salivary Cortisol (Initial)	0.40	0.05
Salivary Cortisol (Baseline)	0.41	0.16
Salivary Cortisol (Stress)	0.39	0.19
Salivary Cortisol (Recovery)	0.39	0.16

[a] Variables entered stepwise
[b] 88.9% of total sample correctly classified (92.3% controls; 85.7% cases)
[c] % MVC = Percent of Maximum Voluntary Contraction
[d] $p < .001$

TABLE 19

Combined Model of Ergonomic Exposure and Psychological and Physiological Response to Job Stress Recall Differentiating Symptomatic Cases and Asymptomatic Controls

Number of significant functions	Canonical correlation	Wilks' Lambda	Eigenvalue	Chi-square	df	p
1[a]	0.83	0.31	2.27	26.08	4	<0.01

Discriminating variables	Wilks' Lambda	Correlations between discriminant function and discriminating variables
Impact of Events Scale (Revised)	0.68	0.46
Percent of work time at computer workstation	0.68	0.46
NF MVC (Stress)	0.73	0.41
HR(Recovery)	0.93	0.19

[a] 92.3% of total sample correctly classified (100% controls; 84.6% cases)

TABLE 20

Predictors of Upper Extremity Pain, Functional Limitations, and Symptoms

	β	ΔR^2	Model R^2	p[a]
Upper Extremity Pain in Previous Week (VAS)				
Percent of work time at computer work station	0.42	0.18	0.18	<0.05
Impact of Events Scale (Revised)	0.32	0.09	0.27	ns
Non-Dominant Flexor % MVC at Stress	0.38	0.11	0.38	ns
Average Heart Rate at Recovery	0.47	0.12	0.50	<0.05
Upper Extremity Functional Limitation (UEFS)				
Percent of work time at computer work station	0.38	0.14	0.14	0.05
Impact of Events Scale (Revised)	0.49	0.22	0.36	0.01
Non-Dominant Flexor % MVC at Stress	0.14	0.02	0.38	ns
Average Heart Rate at Recovery	0.28	0.04	0.42	ns
Symptoms (SSS)				
Percent of work time at computer work station	0.41	0.17	0.17	<0.05
Impact of Events Scale (Revised)	0.70	0.45	0.61	<0.01
Non-Dominant Flexor % MVC at Stress	0.19	0.03	0.64	ns
Average Heart Rate at Recovery	0.32	0.06	0.70	ns

[a] Refers to the model tested at each level of entry

FIGURES

FIGURE 1
Balance Theory of Job Design and Stress
(Smith & Carayon, 1996)

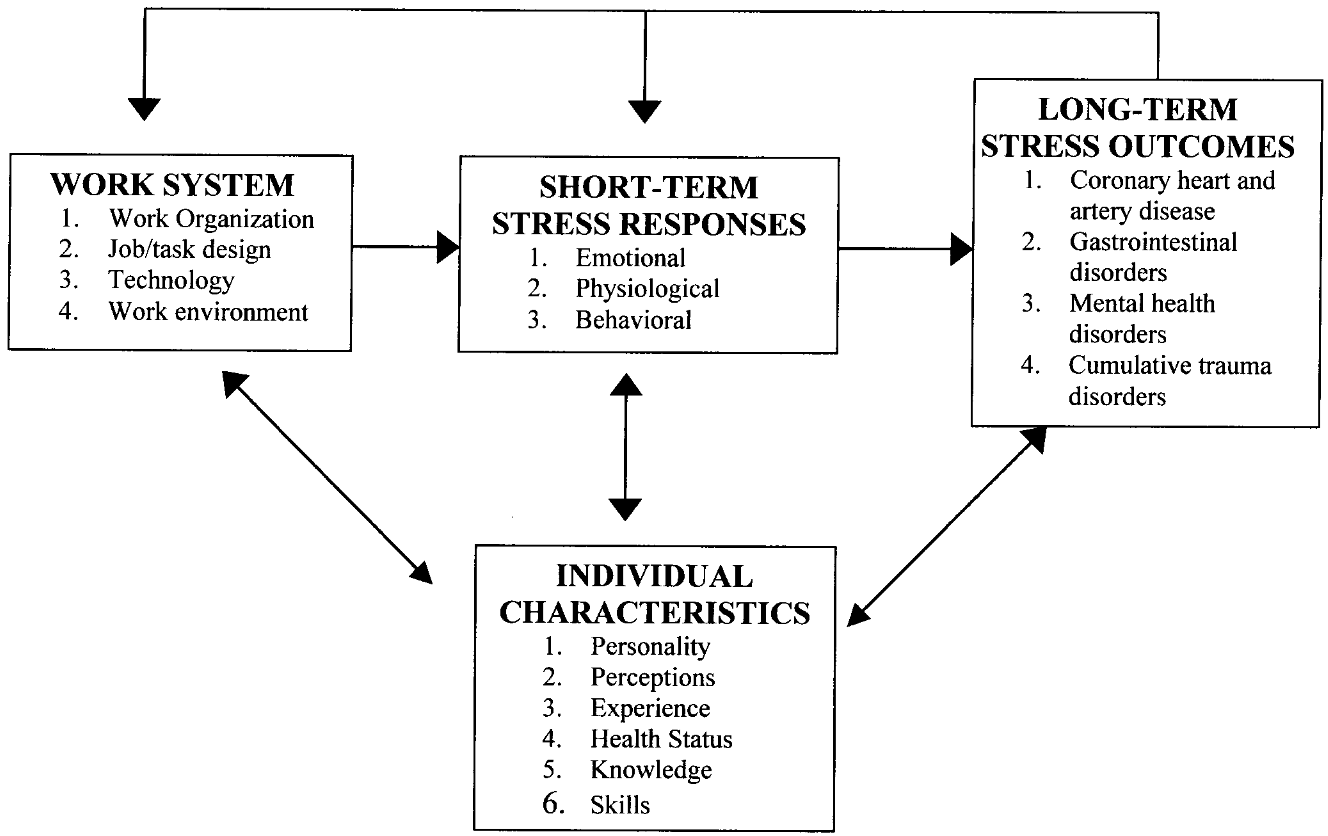


FIGURE 2
Biopsychosocial Model of Job Stress
(Melin & Lundberg, 1997)

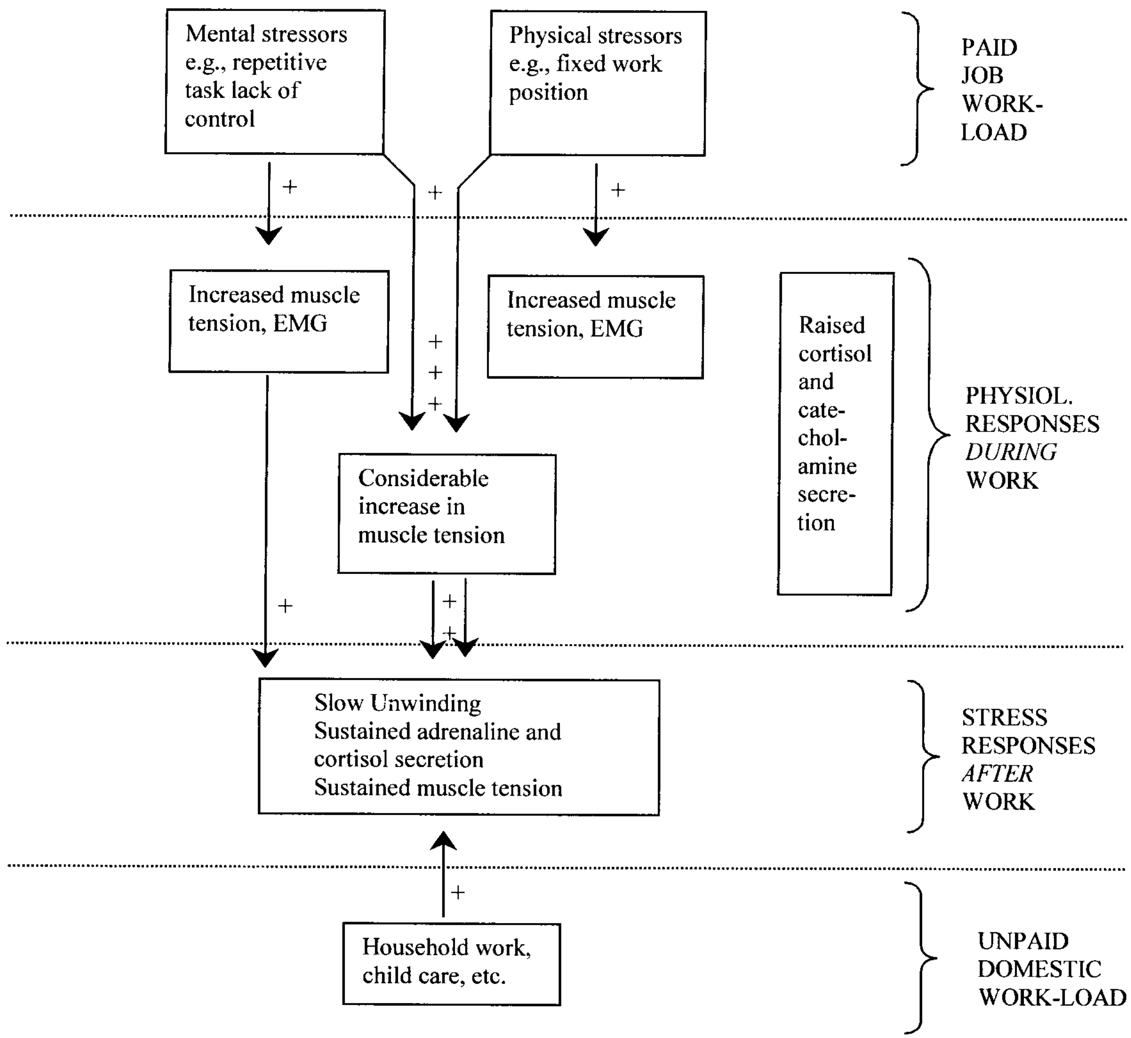


FIGURE 3
Ecological Model of Musculoskeletal Disorders
(Sauter & Swanson, 1996)

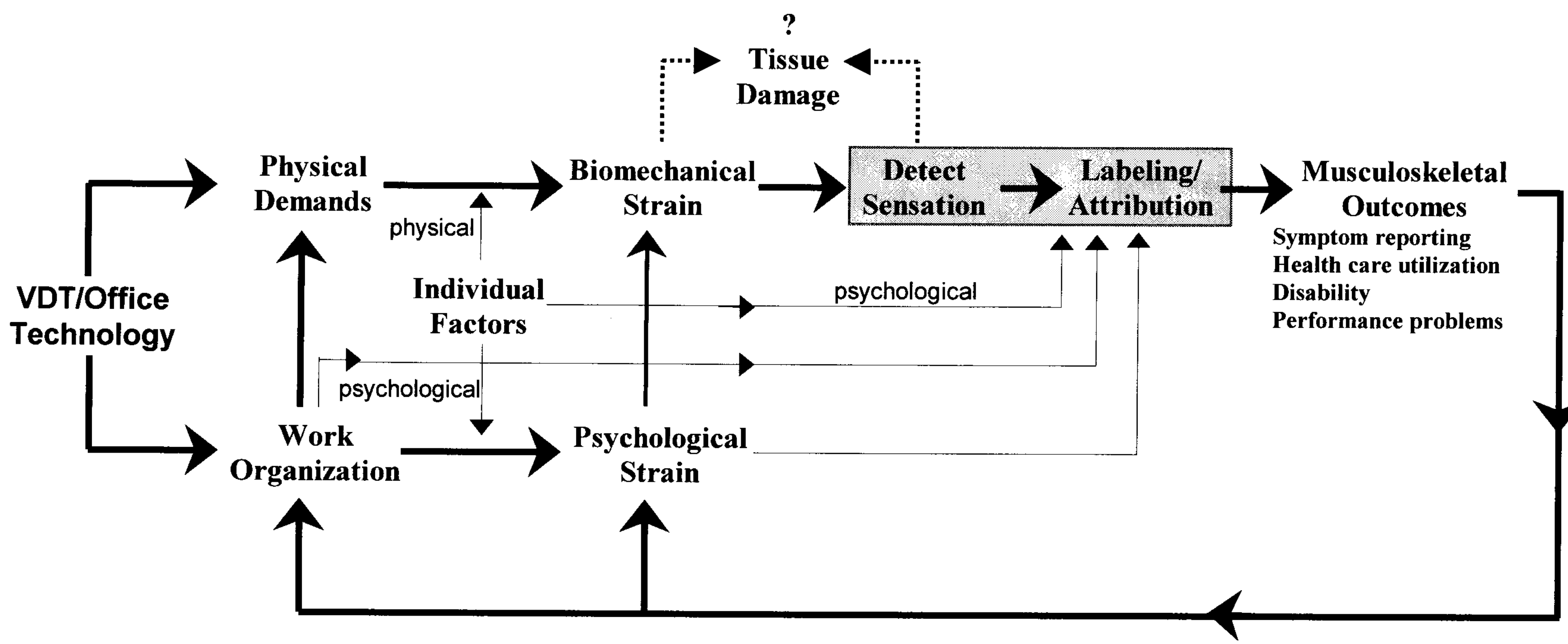


FIGURE 4
Workstyle Model
(Feuerstein, Huang, & Pransky, 1999)

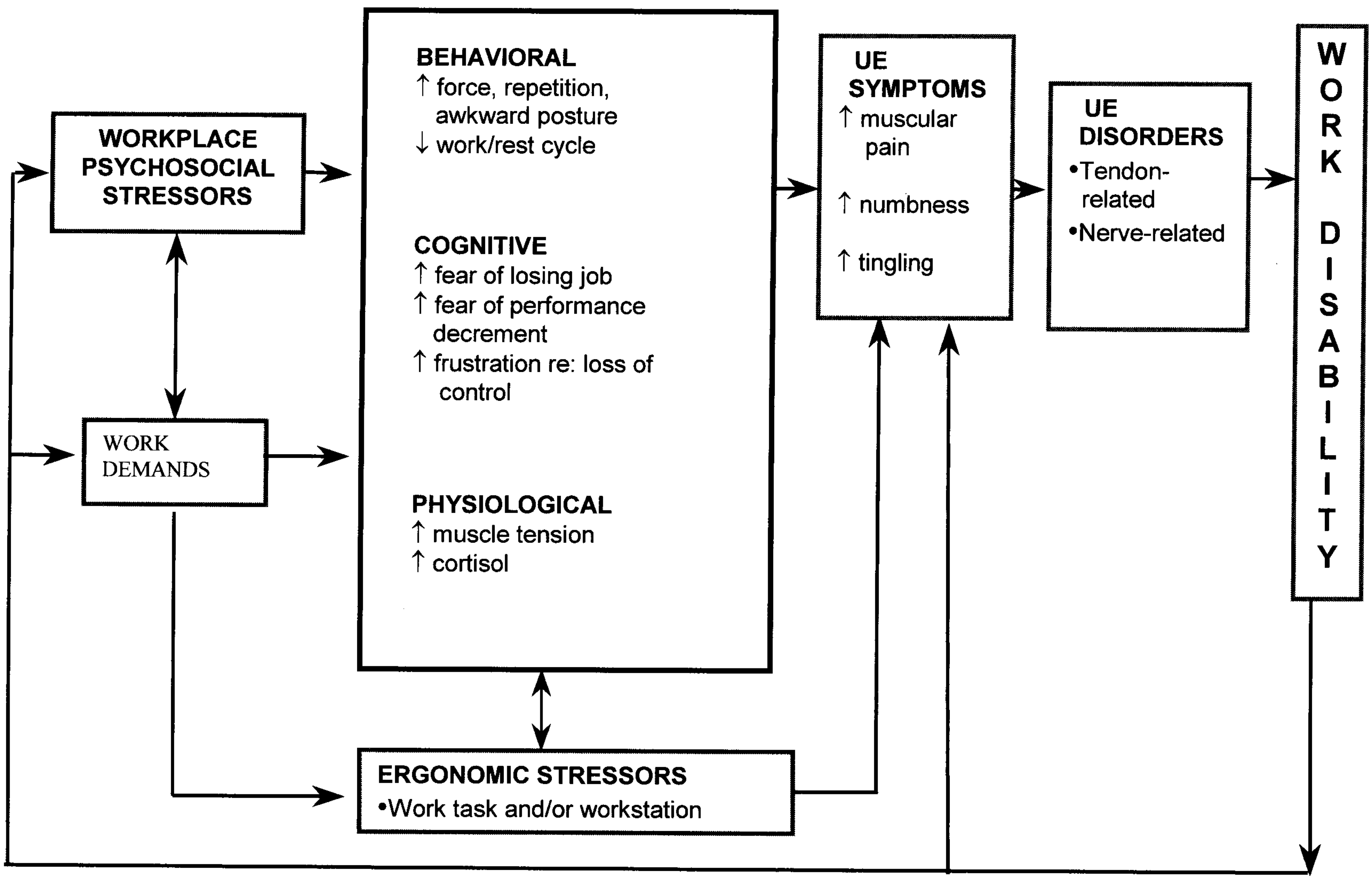
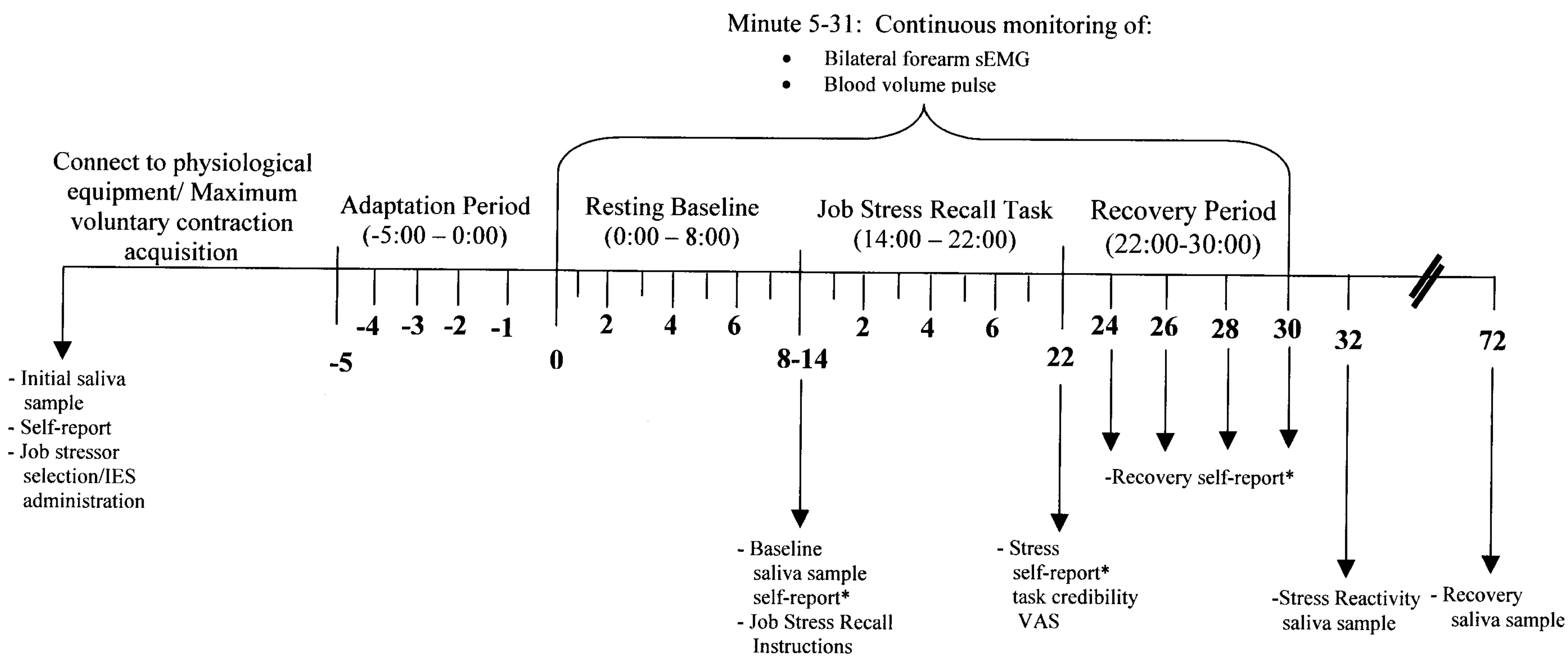


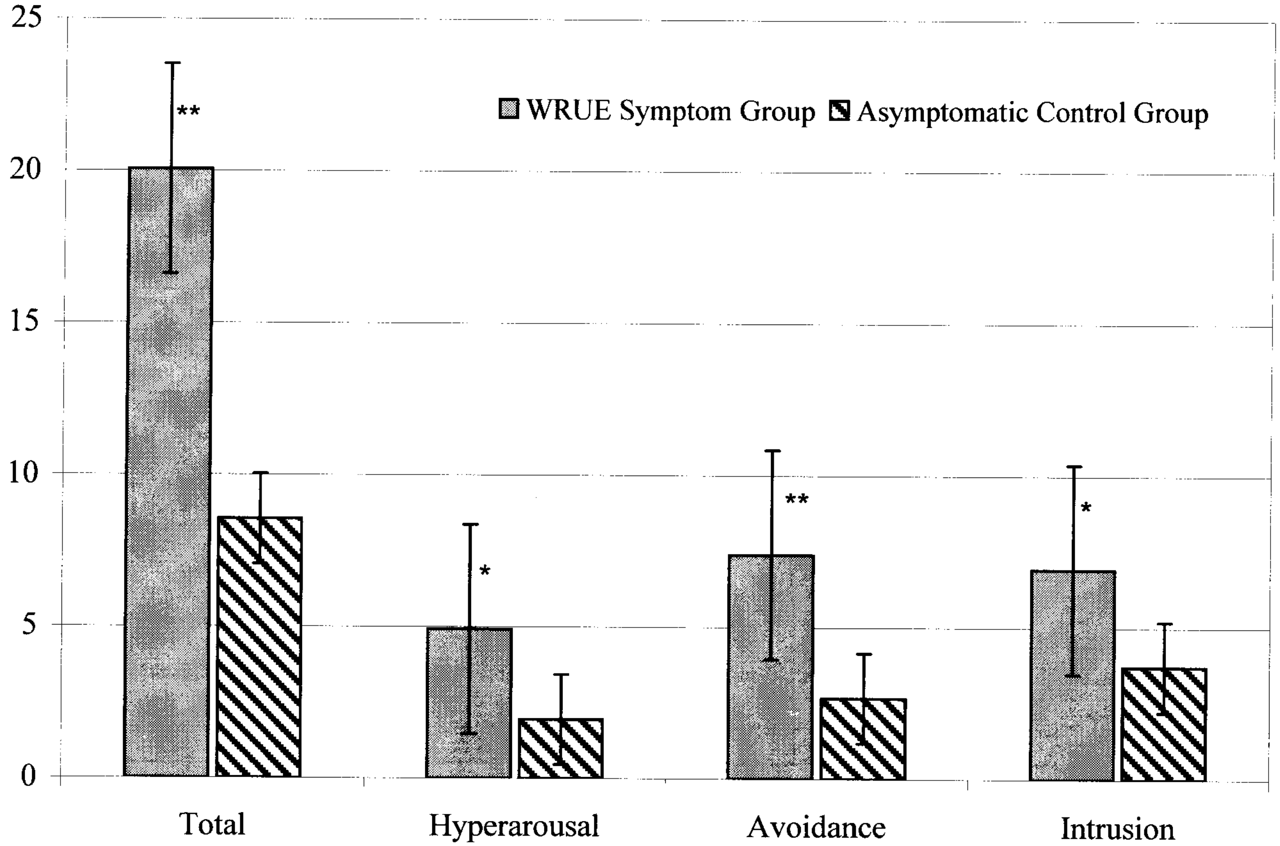
FIGURE 5
Timeline for Psychophysiological Assessment Protocol



* Self-report measures include:

- VAS Symptom Item
- VAS Stress Item

FIGURE 6
Impact of Events Scale – Revised (IES-R) Score for the Peak Job Stressor



*p < 0.05 **p < 0.001

FIGURE 7
Post-Stress Task Credibility Ratings

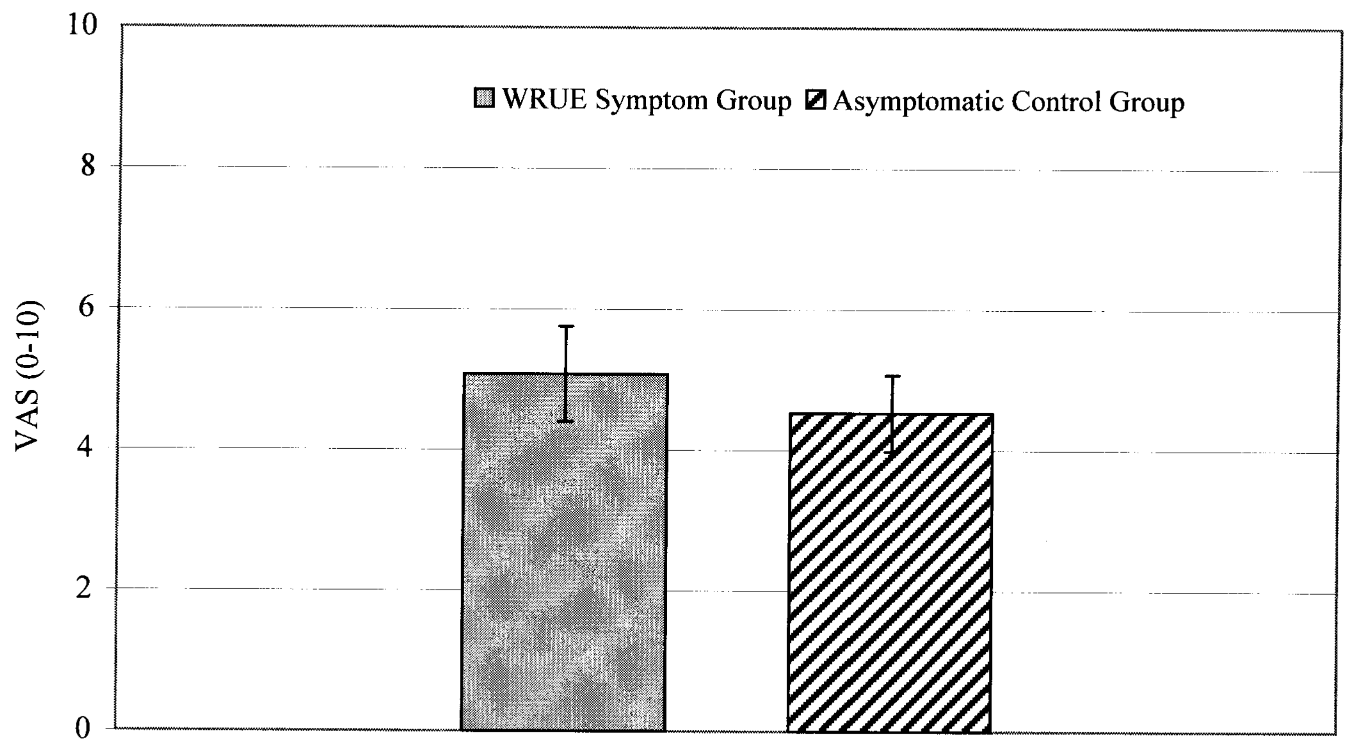


FIGURE 8
Visual Analog Scale Ratings for Distress (VAS, 0-10)

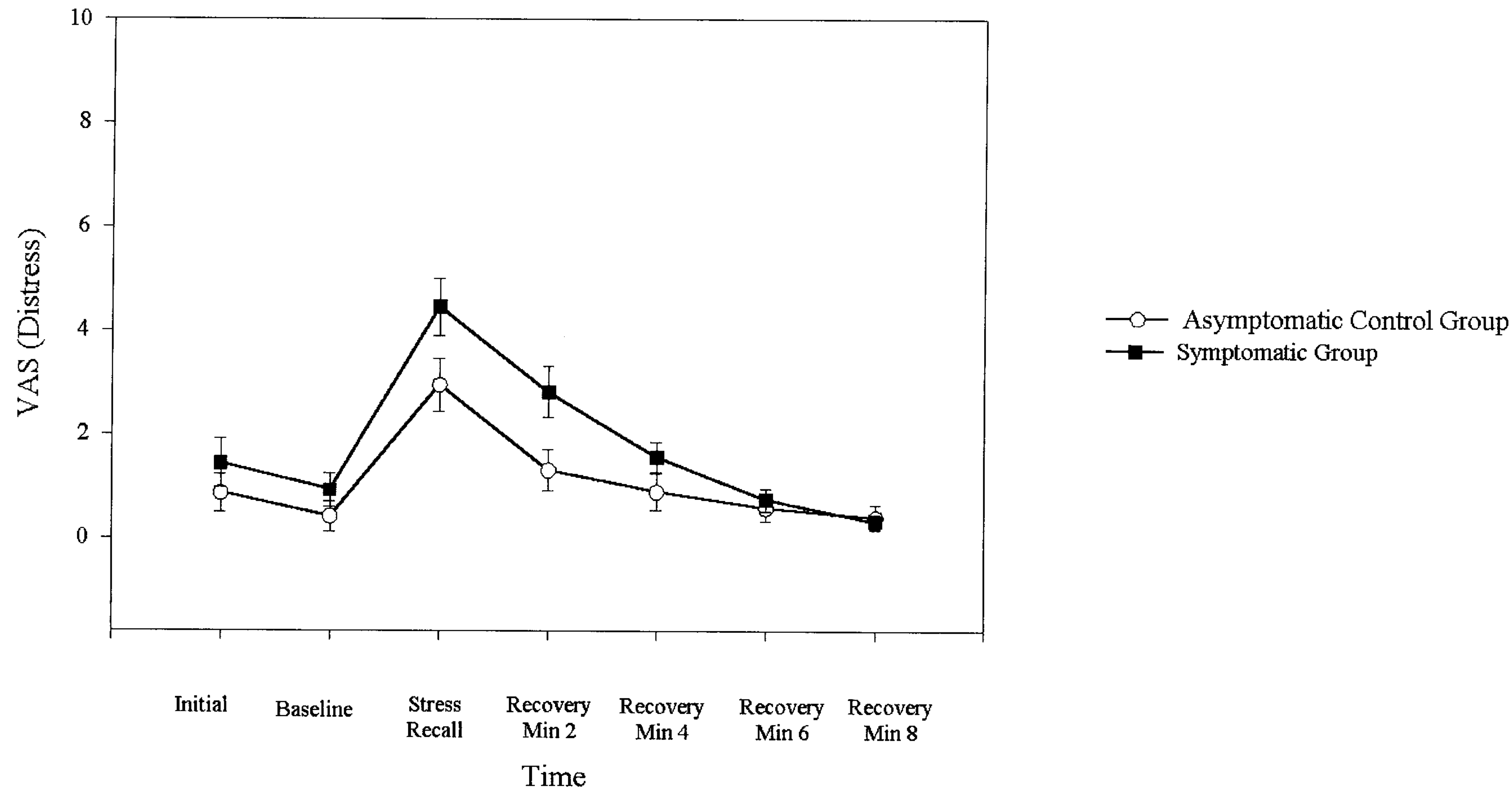


FIGURE 9
Visual Analog Scale Ratings for Symptoms (VAS, 0-10)

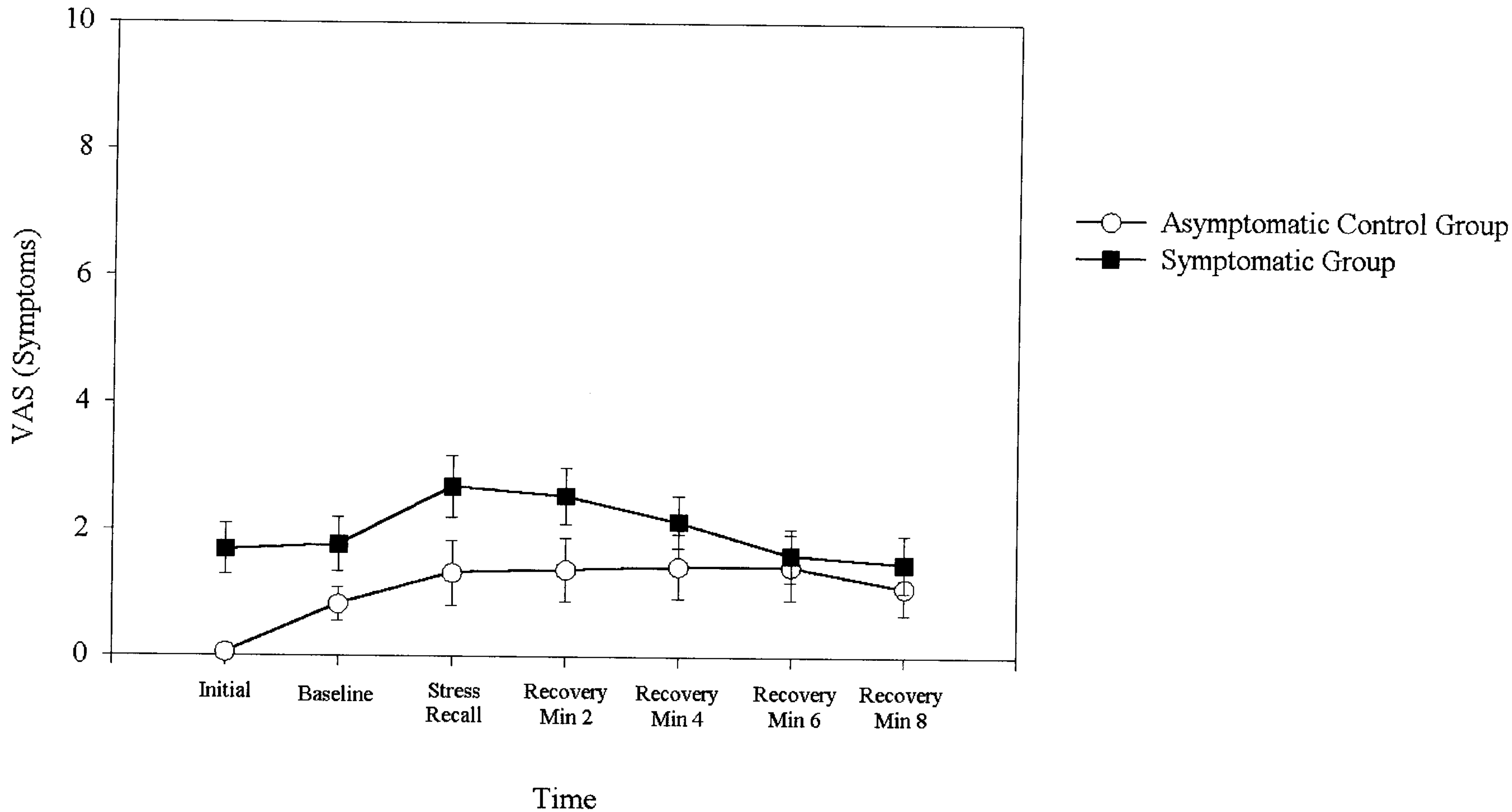


FIGURE 10
Heart Rate Response (Beats per Minute) to Job Stress Recall

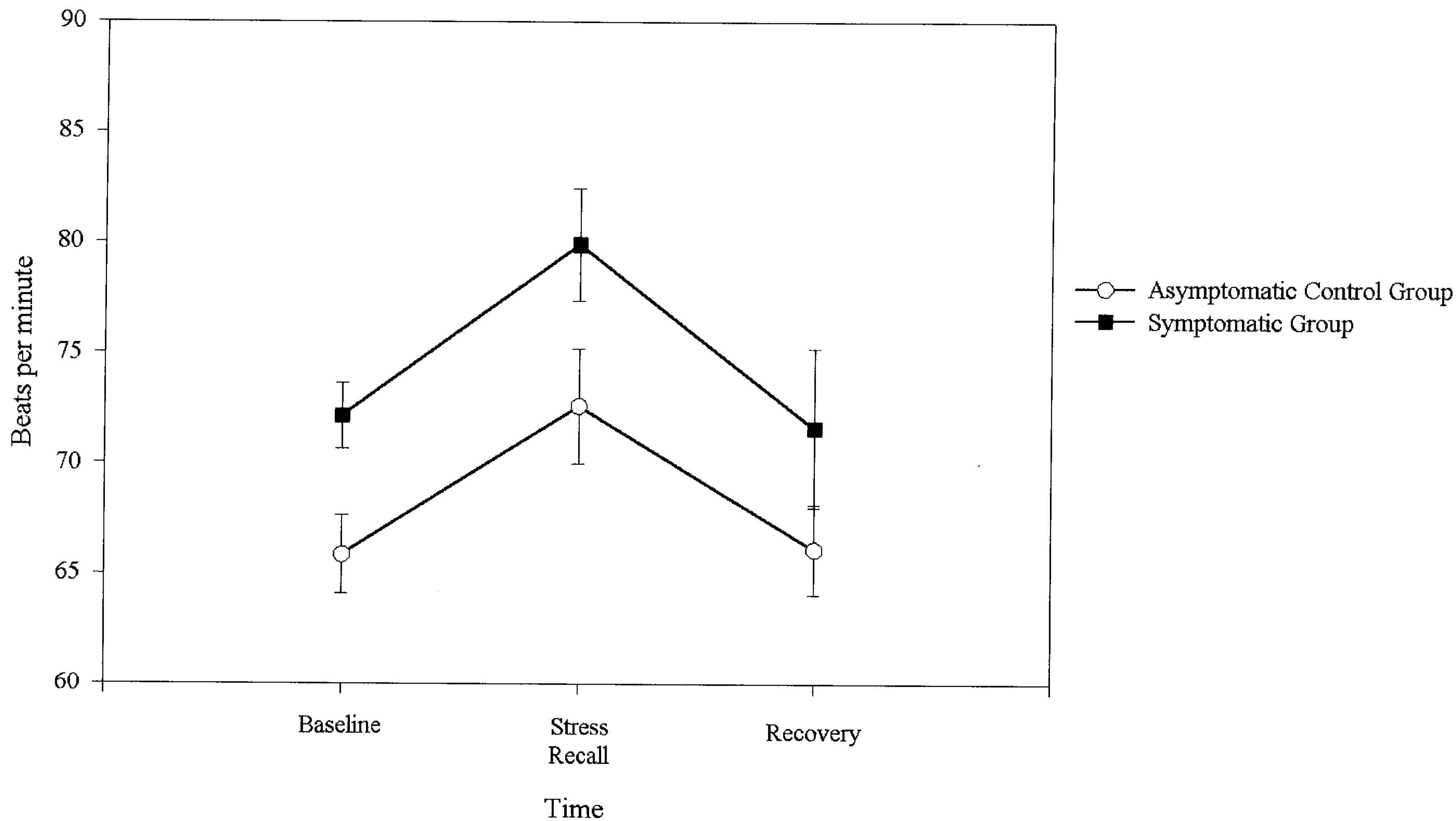


FIGURE 11
Salivary Cortisol Response (nmol/L) to Job Stress Recall

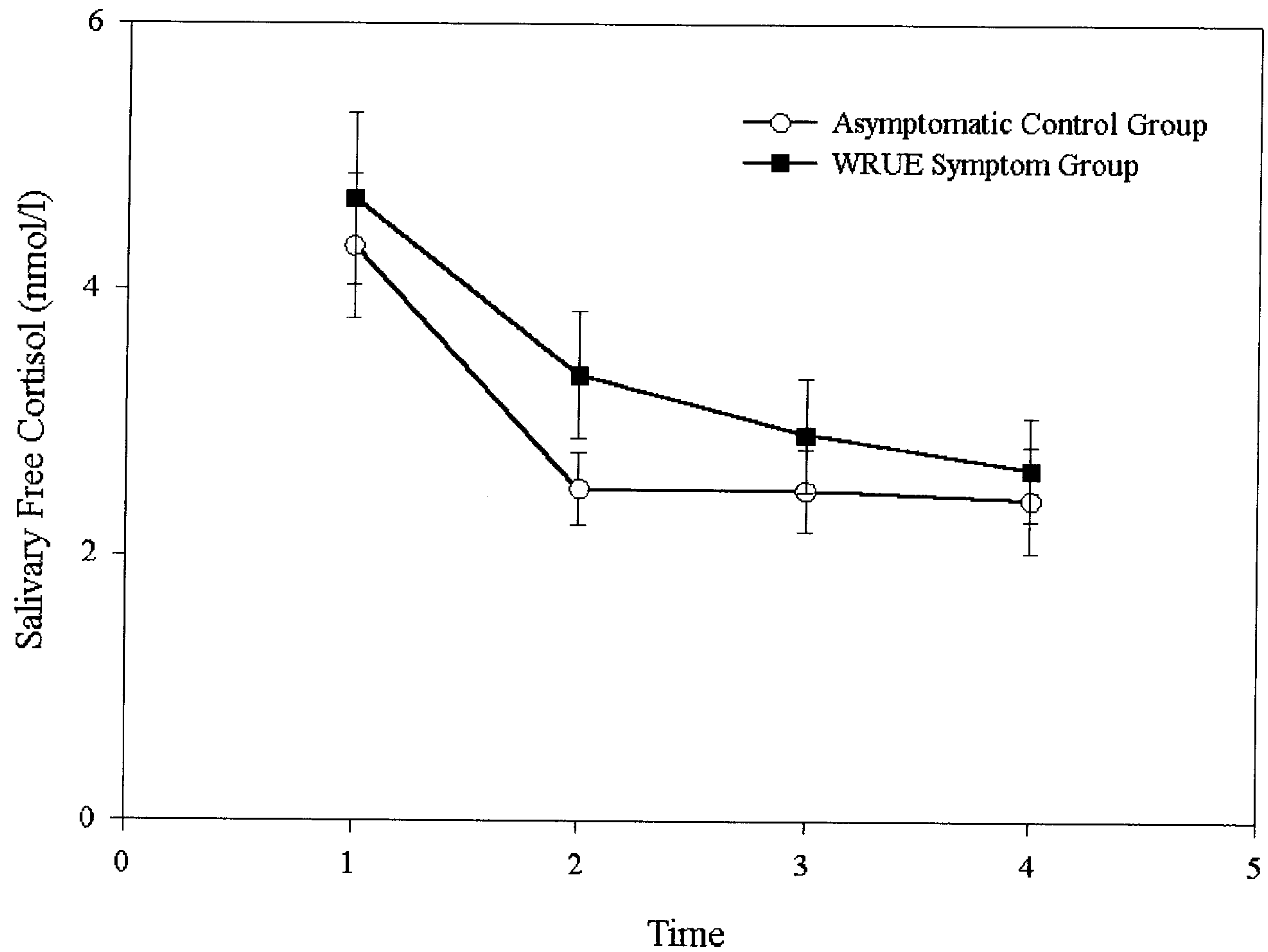


FIGURE 12
Forearm Flexor Response to Job Stress Recall

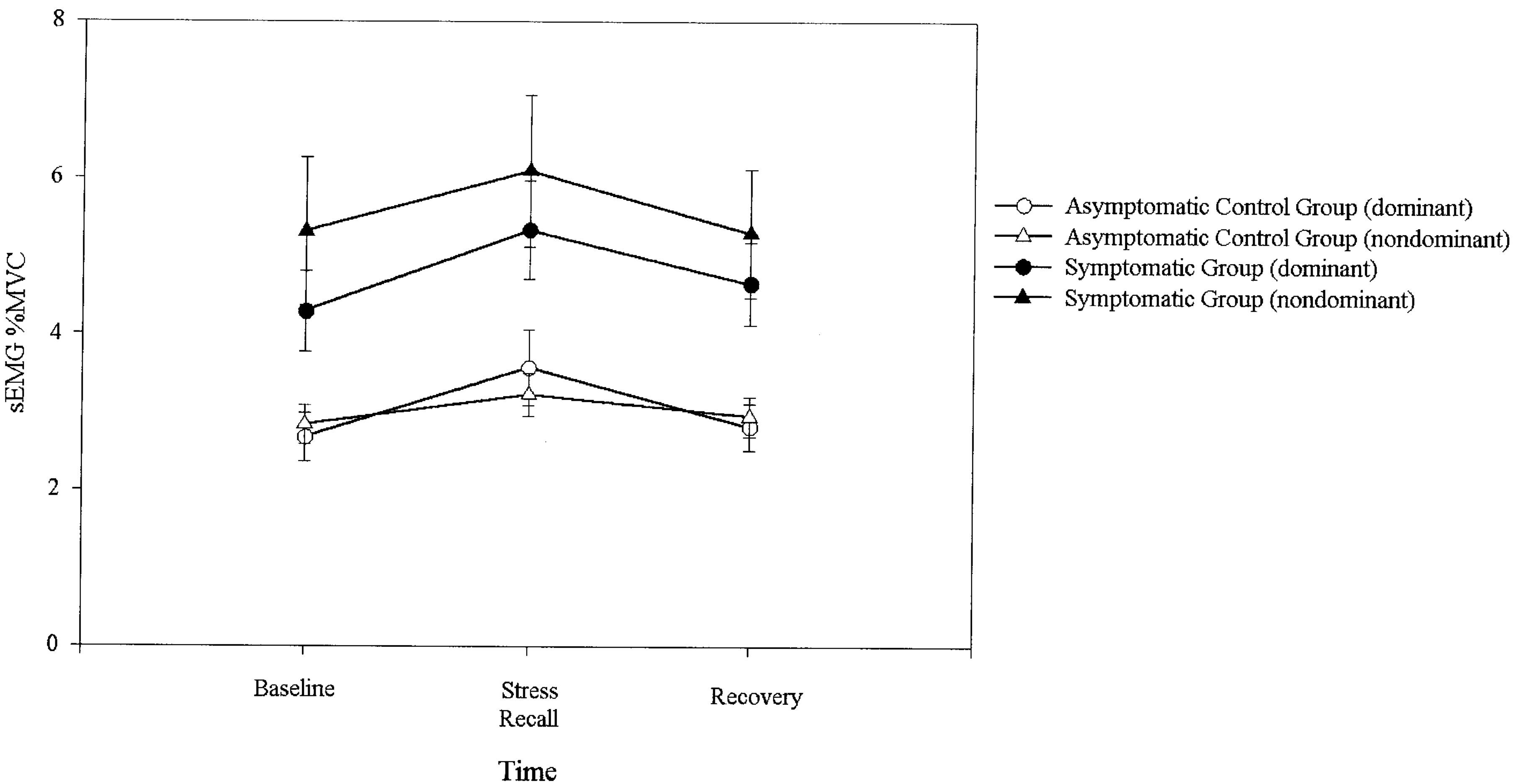
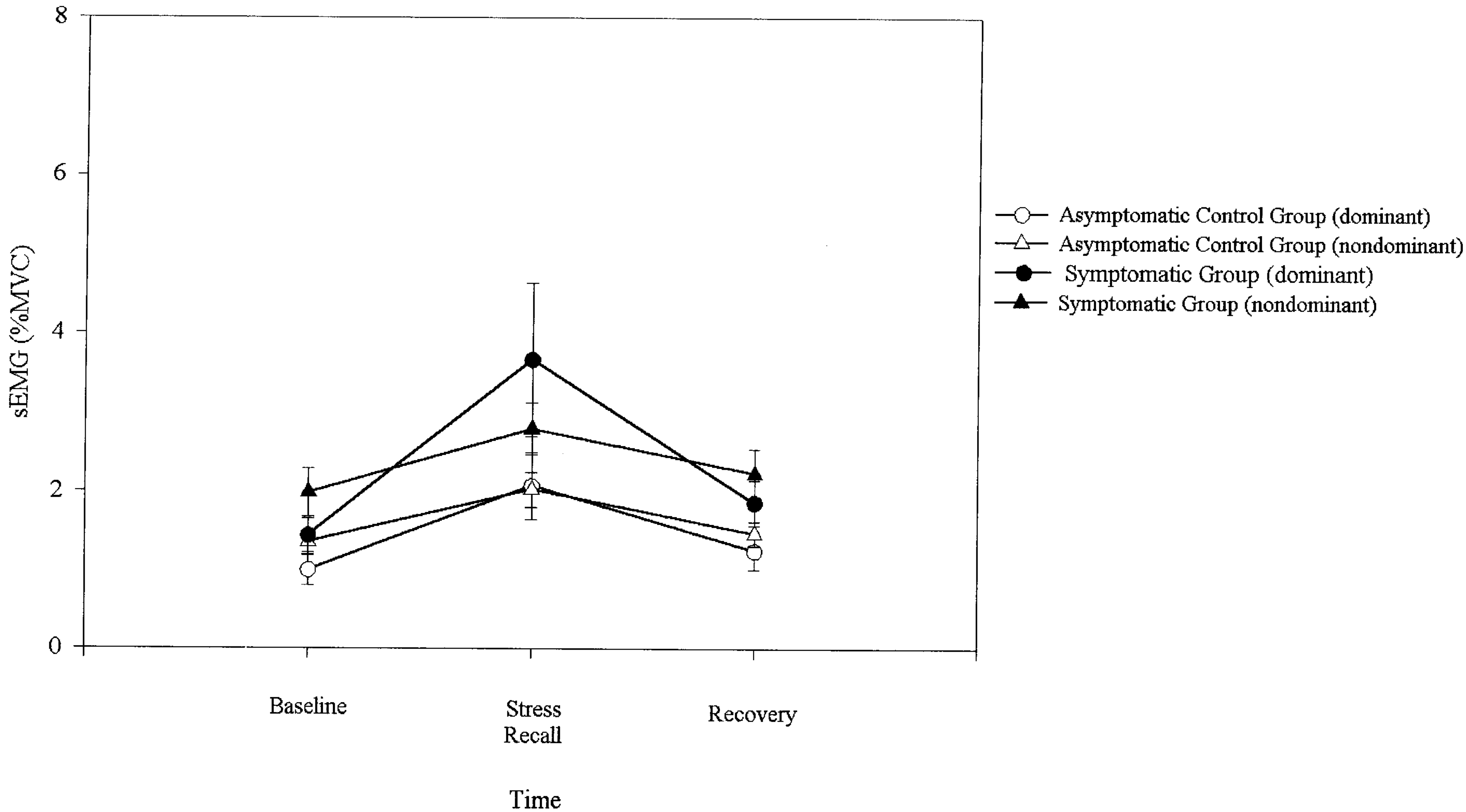


FIGURE 13
Forearm Extensor Response to Job Stress Recall



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APPENDIX A

UNIFORMED SERVICES UNIVERSITY OF THE HEALTH SCIENCES
4301 JONES BRIDGE ROAD
BETHESDA, MARYLAND 20814-4799

INFORMED CONSENT FORM
Research Study

Research Study Title: Job stress reactivity in carpal tunnel syndrome

Principal Investigator: Julie M. Storey, B.S. (with Michael Feuerstein, Ph.D.)
Department of Medical and Clinical Psychology

INTRODUCTION

You are invited to participate in a research study that examines work experiences and carpal tunnel syndrome. Before you decide to be a part of this research study, you need to understand the risks and benefits so that you can make an informed decision. This is known as informed consent.

This consent form explains the purpose of the study and all of the things that you will be asked to do if you agree to participate. Should you agree to participate in the study, you will be asked to sign this form indicating your agreement and that you understand what is involved. Your decision to take part in the study is voluntary. You may chose not to answer any of the questions you are asked, and you may choose to stop participating at any time.

STUDY DESCRIPTION

The purpose of this study is to find out how daily stress at work may contribute to pain in the wrist and hands. Approximately 50 female volunteers will participate in this study. This study requires you to make two visits to the Uniformed Service University and to complete a work diary for two weeks in between visits. The first visit will take about 1 $^{1}/_{2}$ hours of your time and the second visit will take approximately 2 hours of your time. If you are a federal worker, you will need to take approximately 3 $^{1}/_{2}$ hours of annual leave to participate in this research.

Physician Screen:

Prior to visiting the lab, you will be asked to meet briefly (15-20 minutes) with a physician who will ask you questions related to symptoms you may currently have in your hand and wrist. The physician will also perform three brief tests of symptoms in your hands. Two of these tests involve bending your hand at the wrist while you report any symptoms that you feel. The final test will evaluate the sense of touch in your fingertip by having you report when you can feel two distinct points that are in contact with your finger. These tests are very common physical examination procedures for carpal tunnel syndrome. You may feel some symptoms in your hands during this examination, but this will only last a short time.

Visit 1:

During the first visit, you will be given a survey about your health, medical history, job characteristics, job environment, and how you cope with your symptoms. You will also be

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interviewed and asked questions about your current and past levels of anxiety and worry. At the end of your first visit, we will measure how fast a nerve in your arm sends a signal to your fingers. This is called a nerve conduction test. To conduct this test, we will place a surface electrode on your elbow and index finger. Then, a low intensity, brief (less than 1 millisecond) electrical signal will be applied to the electrode placed on your elbow. You will probably feel a slight tingling sensation in your arm that may last for 1 to 3 seconds. The whole test will take about 2 minutes.

If any significant findings are identified during the behavioral screening, we will inform you. Also, if you agree, we will contact your physician and inform him/her of the finding(s).

Work diary:

After the first visit, you will be asked to keep a daily record of stressful work experiences for a period of two weeks. The amount of time required to complete this record will depend upon the number of events you experience. It will typically require between 5 and 10 minutes every day to complete.

Visit 2:

After you have kept this daily record for two weeks, you will return for your final visit. During this visit, you will be asked to recall and describe one of the stressful job experiences recorded in your diary while we measure your muscle response (from your upper back and forearm), skin conductance (sweat gland activity in the hand) level, and blood flow in your finger. Your recollection of this work event will be audiotaped for standardization purposes, but you will not be personally identified during the recording. At the completion of the study, all audiotapes will be reviewed by the principal investigator and then destroyed.

In order to measure your muscle response, small (4mm) sensors will be placed on the top and bottom surfaces of your left and right forearms and on your left and right shoulders. These sensors detect muscle tension only.

Your skin conductance level (sweat gland activity in your hand) will be measured by placing two small (11mm) sensors on the palm of your hand. These sensors detect sweat gland activity.

In order to measure blood flow, a small sensor will be placed on one of your index fingers. This sensor uses light to measure how much blood is flowing into your finger. This sensor produces and emits light.

Prior to recalling your stressful job experience, you will be asked to perform a handgrip test of your left and right forearm muscles. To do this, you will be asked to grip a device as tightly as you can for 3 seconds. You will do this two times for each arm.

You will also be asked to chew on a small cotton swab for 30-45 seconds 4 times during the experiment. These cotton swabs will be used to determine the level of a stress hormone your body is producing. These samples of your saliva will be sent to Pennsylvania State University to be analyzed. Immediately after they are analyzed, they will be destroyed. Visit 2 will last approximately 120 minutes (2 hours).

POSSIBLE BENEFITS

If you chose to participate in this study, you will receive $30 at the end of Visit 1 and an additional $70 after completing Visit 2, for a total of $100. You will only receive payments for the visits you complete. Additionally, you will receive a stress management and office ergonomics workbook. These materials describe simple techniques for improving your comfort at work. No other benefits are expected as a direct result of participating in this research study.

POSSIBLE RISKS

There is a possibility that you might experience slight, transient discomfort during the nerve conduction test that will be conducted during Visit 1. The electrical signal that is applied creates a brief (1-3 second) tingling sensation that you may feel inside your arm and/or hand. The device that will be used to conduct this test has been used in many job and research settings, and no instances of injury or prolonged discomfort have been observed.

During Visit 2, you will also be asked to remember and describe a stressful event at work. This may cause you to feel upset for a brief time. In our previous research experience with several hundred subjects, these feelings have been short-lived.

It is not known whether participation in this study might harm an unborn child. Therefore, you should avoid becoming pregnant during the course of the study.

RIGHT TO WITHDRAW FROM THE STUDY

You may decide to stop taking part in this study at any time. Your relation with the faculty, staff and administration at USUHS will not be changed in any way if you decide to end your participation in the study. However, you will only receive your payment for the portions of the study that you complete. Also, the investigators (Mrs. Storey or Dr. Feuerstein) may terminate the study at any time if you do not follow the research directions.

RECOURSE IN THE EVENT OF INJURY

This study should not entail any physical or mental risk beyond those described above. We do not expect complications to occur, but if, for any reason, you feel that continuing this study would constitute a hardship for you, we will immediately end your participation in the study.

In the event of a medical emergency while participating in this study, you will receive emergency treatment in the facility you are in or a nearby Department of Defense (military) medical facility (hospital or clinic). Emergency treatment/care will be provided even if you are not eligible to receive such care at a military medical facility. Care will be continued until the medical doctor treating you decides that you are out of immediate danger, If you are not entitled to care in a military facility, you may be transferred to a private civilian hospital. The attending doctor or member of the hospital staff will go over the transfer decision with you before it happens. The military will bill your health insurance for health care you receive that is not part of the study. If you are uninsured, you will not be personally billed for such care, and you WILL NOT be expected to pay for medical care at military hospitals.

In case you need additional care following discharge from the military hospital or clinic, a military health care professional will decide whether your need for care is directly related to being in this study. If your need for health care is related to the study, the military may offer you limited health care at its medical facilities. If you believe the government or one of the government's employees (such as a military doctor) has injured you, a claim for damages (money) against the federal government (including the military) may be filed under the Federal Torts Claim Act. If you would like to file a claim please contact the University's Office of General Counsel and request the filing forms.

If at any time you believe you have suffered an injury or illness as a result of participating in this research project, you should contact the Office of Research Administration at the Uniformed Services University of the Health Sciences, Bethesda, MD 20814 at (301) 295-3303. This office can review the matter with you, provide information about your rights as a research subject, and may be able to identify resources available to you. Information about judicial avenues of compensation is available from the University's General Counsel at (301) 295-3028. If necessary, Dr. Feuerstein can be reached at (301) 295-9677.

PRIVACY AND CONFIDENTIALITY

When you enter the study, you will be assigned a personal study ID number. All information that you provide as a part of this study will be confidential and will be protected to the fullest extent of the law. Information that you provide and other records related to this study will be kept private, accessible only to those persons directly involved in conducting this study, members of the Institutional Review Board at the Unformed Services University of the Health Sciences, and other Federal agencies who provide oversight for human use protection. All questionnaires and forms will be kept in a restricted access, locked cabinet while not in use. However, please be advised that under Federal Law, a military member's confidentiality cannot be strictly guaranteed.

To enhance your privacy of the answers that you provide, data from questionnaires will be entered into a database in which individual responses are not identified. After verification of the database information, the hard copy of the questionnaires containing identifiers will be shredded. Any reports on this study will only use the data in the database and will not use your name or identify you personally.

QUESTIONS

If you have any questions about this research study, you should contact Mrs. Storey at (301) 295-9660 at the Uniformed Services University of the Health Sciences, 4301 Jones Bridge Road, Bethesda, Maryland, 20814. If you have any questions about your rights as a research subject, you should call the Director of Research Programs in the Office of Research at the Uniformed Services University of the Health Sciences at (301) 295-3303. This person is your representative and has no connection to the doctors or personnel conducting this study.

SIGNATURES

By signing this form, I am agreeing that the study has been explained to me and that I understand the study. I am signing that I agree to take part in this study, but I may withdraw my consent to participate at any time. I will be given a copy of this consent form.

I AGREE TO PARTICIPATE IN THE FOLLOWING:

VISIT 1 (1 1/2 hours):
CARPAL TUNNEL SYNDROME PHYSICIAN SCREEN
QUESTIONNAIRES
SURFACE NERVE CONDUCTION TESTING

TWO-WEEK JOB STRESS DIARY (5-10 minutes/day)

VISIT 2 (2 hours):
HAND GRIP EVALUATUION
JOB STRESS RECALL TASK
SALIVA COLLECTIONS
MUSCLE TENSION MONITORING (FOREARMS AND UPPER BACK)
FINGER BLOOD FLOW MONITORING
SWEAT RESPONSE MONITORING (IN PALM OF HAND)

______________________________ ______________________________
Signature of Participant Date

______________________________ ______________________________
Signature of Witness Date

Investigator Statement

I certify that the research study has been explained to the above individual, by me or my research staff, and that the individual understands the nature and purpose, and the possible risks and benefits associated with taking part in this study. Any questions that have been raised have been answered.

______________________________ ______________________________
Signature of Investigator Date

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APPENDIX B

Stress Reactivity Study Subject Phone Screen

❒CASE ❒CONTROL
(Please check one)

Subject first phoned lab (date/time):____________________

Contact Record:

Date	Contact Type/Notes

Interviewer: ____________________ **Date:**__________

SUBJECT NAME:____________________ AGE:______ (21-50?) Y N
(N = DQ)

ADDRESS: ____________________

❒ HOME PH: __________ ❒ WORK PH: __________ ❒ EMAIL: __________
(Check the means by which the subject prefers to be contacted.)

APPROXIMATE HEIGHT: ________ inches

APPROXIMATE WEIGHT: ________lbs

APPROXIMATE BMI (from table): ________

Where respondent saw the advertisement for our study:____________________

1. Are you currently working full or part time and not self-employed?.. ❒Yes ❒No **(N = DQ)**
   What is your current job title?____________________
2. How many hours do you work in a typical work week?.. ______**hrs** **(<20 = DQ)**
3. How many hours do you work at a computer during a typical workday? ______**hrs** **(<4 = DQ)**
4. Have you experienced pain, numbness, weakness or tingling symptoms in your hands, wrists, elbows, forearms, neck or shoulders ***for at least a week or have occurred once per month for the past year?***

(circle all that apply)					**First noticed**	**Diagnosis/Date Diagnosed**	**How often?**
Shoulder	left	right	both	none			
Elbow	left	right	both	none			
Forearm	left	right	both	none			
Hand	left	right	both	none			
Wrist	left	right	both	none			
Neck	left	right	both	none			

❒Yes ❒No **(N = DQ for cases; Y=DQ for controls) For controls who answer "No", skip to Question #12)**

5. **On average**, how bad has this problem been over the past year? ❒No discomfort ❒ Mild ❒ Moderate ❒ Severe ❒Unbearable
   (NO DISCOMFORT OR MILD DISCOMFORT = DQ)
6. Did your symptoms develop since you began working in your current occupation?........................ ❒Yes ❒No **(N = DQ)**
   (Specify that "current occupation" = type of work e.g., data entry; not where or for whom they work)
7. Do you believe your symptoms are work-related?.. ❒Yes ❒No
8. *(If she has seen a physician)* Did your physician indicate your diagnosis was work-related?........... ❒Yes ❒No
9. Have you ever had an accident or sudden injury to your hand, wrist, forearm, elbow, or neck, such as a sports injury, fracture, or tendon tear, not related to your work?.. ❒Yes ❒No **(Y = DQ)**
   Site:________ Nature of injury:____________

10. Have you ever had surgery or has your physician ever <u>recommended</u> surgery for your symptoms?.... ❐Yes ❐No **(Y = DQ)**

11. Are you currently taking any medications for CTS symptoms, including over the counter medications?... ❐Yes ❐No
(If yes) Please specify type/dosage/frequency: ______________________________________
____
____

12. Are you currently taking any (other) medications on a regular basis, including over the counter medications?... ❐Yes ❐No
(If yes) Please specify type/dosage/frequency: ______________________________________
____
____
(DQ for hormone replacement therapy, steroidal anti-inflammatory drugs, & antihypertensives)

13. Have you ever been diagnosed with any of the following health problems? ❐Yes ❐No **(Y = DQ)**

❐Gout ❐Rheumatoid arthritis
❐Thyroid problems ❐Diabetes mellitus
❐Lupus ❐High blood pressure

14. Are you currently pregnant?... ❐Yes ❐No **(Y = DQ)**

15. Do you have regular menstrual cycles?... ❐Yes ❐No **(N = DQ)**

16. What was the date of the first day of your last menstrual cycle.................................. ____/____/2000

The next few questions ask for more details regarding your current job. Please indicate approximately how long you do this work on a <u>daily basis.</u>

17. Do you reach/hold your arms in front of or behind your body (e.g., using a keyboard, filing, handling parts, perform inspection tasks, pushing/pulling carts, etc.)? (Figure B).. ❐Never ❐0-2 hrs ❐2-4 hrs❐4-8 hrs

18. Do you perform a series of repetitive tasks/movements during the normal course of your work (e.g., using a keyboard, tightening fasteners, cutting meat, etc.)?.. ❐Never ❐0-2 hrs ❐2-4 hrs❐4-8 hrs

19. Are your wrists bent (up, down, to the thumb, or little finger side) while you work? (Figure E).. ❐Never ❐0-2 hrs ❐2-4 hrs❐4-8 hrs

20. Is your neck tipped forward or backward when you work? (Figure C)............ ❐Never ❐0-2 hrs ❐2-4 hrs❐4-8 hrs

21. Do you apply pressure or hold an item/material/tool (e.g., screwdriver, spray gun, mouse, etc.) in my hand for longer than 10 seconds at a time?................ ❐Never ❐0-2 hrs ❐2-4 hrs❐4-8 hrs

Figure B.

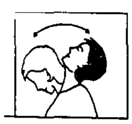

Figure C.

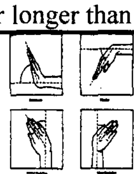

Figure E.

JRPD UE SCORE: ____________

ELIGIBLE/INELIGIBLE/DECLINED (circle one)

(If ineligible) Reason for ineligibility/declination: ______________________________________

(If eligible) Schedule date/time for Visit 1: ____/____/2000 ______ a.m./p.m. (Day 18, 19, 20, or 21)

Schedule date/time for Visit 2: ____/____/2000 ______ p.m. (Day 4, 5, 6, or 7)

APPENDIX C

6214284131

Subject ID #

Job Stress Study Questionnaire

Please print your responses in capital letters and avoid contact with the character dividers.

The following will serve as an example: ABCDEFGHIJKLM

First Name

Last Name

Gender

☐ Male ☐ Female

Number & Street Address

City

State

Zip Code -

Home Phone Number ( ) - -

Work Phone Number ( ) - -

Social Security Number - -

Date of Birth / / MM DD YY

Heaght in.

Weight lbs.

1. Education: What is the highest level of education that you have completed? (Place an "x" in one box)

- ☐ Less than High School
- ☐ High School Diploma/GED
- ☐ Some College
- ☐ 2-year Degree/A.A.
- ☐ Bachelor's Degree
- ☐ Some Graduate School
- ☐ Master's Degree
- ☐ Ph.D./M.D./Terminal Degree

2. Marital status: (Place an "x" in one box)

- ☐ Single
- ☐ Single but cohabitating
- ☐ Divorced
- ☐ Separated
- ☐ Widowed
- ☐ Married

3a. Race: (Place an "x" in one box)

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ White

3b. Ethnicity: (Place an "x" in one box)

- ☐ Hispanic or Latino
- ☐ Not Hispanic or Latino

4. Handedness:

(Place an "x" in one box)

- ☐ Right-handed
- ☐ Left-handed
- ☐ Both

5. What is your current job title?

6. Please check one of the categories below which most closely reflects your current job title.

- ☐ Managerial/ administrative occupation
- ☐ Professional/paraprofessional/ technical occupation
- ☐ Sales/sales-related occupation
- ☐ Clerical/administrative support occupation
- ☐ Service occupation
- ☐ Agricultural/ forestry/ fishing occupation
- ☐ Production/construction/maintenance/material handling occupation

7. How long have you held your current job?

years months

8. Is your primary job ...

- ☐ part-time **(20 or fewer hrs/wk)**
- ☐ full-time **(>20 hrs/wk)**

9. How long have you consistently (without breaks longer than one month) been working a similar number of hours per week in this type of job?

years months

1631284139

MEDICAL STATUS

10. Have you had any pain or discomfort that you believe to be related to your work? ☐ Yes ☐ No* *(If NO, skip to #16)

11. Has this problem been interfering with your ability to do your job? ☐ Yes ☐ No

12. Have you been maintaining your regular work schedule and number of hours? ☐ Yes ☐ No

13. Has your work decreased to a limited, alternate, or light duty status? ☐ Yes ☐ No

14. Have you missed work due to this problem? ☐ Yes ☐ No

14a. *If yes to #14,* how much work did you miss in the last month due to this problem? ☐☐ weeks ☐☐ days

15. Please rate the severity of your pain during the past week

No Pain ☐ 0 ☐ 5 ☐ 10 ☐ 15 ☐ 20 ☐ 25 ☐ 30 ☐ 35 ☐ 40 ☐ 45 ☐ 50 ☐ 55 ☐ 60 ☐ 65 ☐ 70 ☐ 75 ☐ 80 ☐ 85 ☐ 90 ☐ 95 ☐ 100 Severe pain

---

16. Do you smoke cigarettes or chew tobacco? ☐ Yes ☐ No (*If NO, skip to #23)

17. How soon after you wake up do you smoke your first cigarette?
☐ Within 5 minutes ☐ 6-30 minutes ☐ 31-60 mountes ☐ After 60 minutes

18. Do you find it difficult to refrain from smoking in places where it is forbidden? (for example, in church, at the library, in the movie theater, etc.) ☐ Yes ☐ No

19. Which cigarette would you hate most to give up?
☐ First one in the morning ☐ After dinner ☐ Last one in the evening ☐ Other

20. How many cigarettes per day do you smoke?
☐ 10 or less ☐ 11-20 ☐ 21-30 ☐ 31 or more

21. Do you smoke more frequently during the first hours after waking than during the rest of the day? ☐ Yes ☐ No

22. Do you smoke if you are so ill that you are in bed most of the day? ☐ Yes ☐ No

---

23. Do you take any **prescription** medications? ☐ Yes ☐ No* (*If NO, skip to #25)

If yes to #23, please list the type and the dosage in the spaces below:

Type of Medication	**Dosage** (how much and how often)
1.	1a.
2.	2a.
3.	3a.
4.	4a.
5.	5a.

---

24. Do you take any non-prescription medications? ☐ Yes ☐ No* * (If NO, skip to #23)

If yes to #24, please list the type and the dosage in the spaces below:

Type of Medication	**Dosage** (how much and how often)
1.	1a.
2.	2a.
3.	3a.
4.	4a.
5.	5a.

25. Have you been diagnosed with a specific disorder in your fingers, hands, arms, neck or shoulders?.......... ☐ Yes ☐ No
(*If NO, skip to #27)

26. If so, what was the diagnosis/diagnoses? (Please write in the spaces below):

1. ______

2. ______

3. ______

27. Have you ever been told by a doctor (physician) that you had tendonitis, tenosynovitis, carpal tunnel syndrome, thoracic outlet syndrome, or bursitis in any of these areas (Please check that all that apply)

Neck.........	☐ No	☐ Left	☐ Right	☐ Both	**Forearm......**	☐ No	☐ Left	☐ Right	☐ Both
Shoulder...	☐ No	☐ Left	☐ Right	☐ Both	**Hand/wrist..**	☐ No	☐ Left	☐ Right	☐ Both
Elbow........	☐ No	☐ Left	☐ Right	☐ Both					

28. Please check all of the following therapies that you have had for any type of pain or other problem in your hands, wrist, arms, shoulders, or neck. *(If you have never had any type of therapy for these problems, skip to item 32 on the next page)*

MEDICAL

Yes No
☐ ☐ Nonsteroidal anti-inflammatory drugs (e.g., Ibuprofen, Naproxen, Naprosyn)
☐ ☐ Oral steroids
☐ ☐ Local steroid injections
☐ ☐ Antidepressants
☐ ☐ Surgery: Problem ______ Type: ______
☐ ☐ Other (specify): ______

PHYSICAL THERAPY

Yes/No
☐ ☐ Splinting
☐ ☐ Muscle Re-education
☐ ☐ Transcutaneous nerve simulation
☐ ☐ Ultrasound
☐ ☐ Traction
☐ ☐ Collar
☐ ☐ Other (please specify) ______

PSYCHOLOGICAL

Yes/No
☐ ☐ Stress management
☐ ☐ Pain management
☐ ☐ Psychotherapy
☐ ☐ Hypnotherapy
☐ ☐ Biofeedback
☐ ☐ Other (specify) ______

29. Has your physician ever recommended surgery for work-related problems in any of the following areas?

Neck ☐ Yes ☐ No **Forearm** ☐ Yes ☐ No
Shoulder ☐ Yes ☐ No **Hand/wrist** ☐ Yes ☐ No
Elbow ☐ Yes ☐ No

30. Have you ever been told by a doctor that you had any of the following? (Please check all that apply)

	Yes	No		Yes	No
Diabetes	☐	☐	**Alcoholism**	☐	☐
Gout	☐	☐	**Thyroid Problems**	☐	☐
Lupus	☐	☐	**Rheumatoid Arthritis**	☐	☐

31. Have you ever had surgery for work-related problems in any of the following areas?

Neck ☐ Yes ☐ No **Forearm** ☐ Yes ☐ No
Shoulder ☐ Yes ☐ No **Hand/wrist** ☐ Yes ☐ No
Elbow ☐ Yes ☐ No

Instructions: Below you will find questions about your health in general. Please answer every question. Some questions may look like others, but each one is different. Please take the time to read and answer each question carfully by placing an "x" in the box that best represents your response.

32. In general, would you say your health is:

Excellent ☐ Very Good ☐ Good ☐ Fair ☐ Poor ☐

33. The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so,how much?

	Yes, limited a lot	Yes, limited a little	No, not limited at all
a. **Moderate activities,** such as moving a table, pushing a vacuum cleaner, bowling or playing golf	☐	☐	☐
b. Climbing **several** flights of stairs	☐	☐	☐

34. During the **past 4 weeks**, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a. **Accomplished less** than you would like	☐	☐	☐	☐	☐
b. Were limited in the **kind** of work or other activities	☐	☐	☐	☐	☐

35. During the **past 4 weeks**, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a. **Accomplished less** than you would like	☐	☐	☐	☐	☐
b. Were limited in the **kind** of work or other activities	☐	☐	☐	☐	☐

36. During the **past 4 weeks,** how much did pain interfere with your normal work (including both work outside the home and housework)?

☐ Not at all ☐ A little bit ☐ Moderately ☐ Quite a bit ☐ Extremely

37. These qustions are about how you feel and how things have been with you during the **past 4 weeks.** For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the **past 4 weeks** ...

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a. have you felt calm and peaceful?	☐	☐	☐	☐	☐
b. did you have a lot of energy?	☐	☐	☐	☐	☐
c. have you felt downhearted and depressed?	☐	☐	☐	☐	☐

38. During the **past 4 weeks,** how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?

☐ All of the time ☐ Most of the time ☐ Some of the time ☐ A little of the time ☐ None of the time

Instructions: Please indicate which of the following things you have difficulty in doing because of your symptoms. Place an "x" in the box that indicates how much difficulty you have with each activity.

	NO PROBLEM									MAJOR PROBLEM (Can't do it at all)
A. Sleeping	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	8 ☐	9 ☐	10 ☐
B. Writing	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	8 ☐	9 ☐	10 ☐
C. Opening jars	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	8 ☐	9 ☐	10 ☐
D. Picking up small objects with fingers	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	8 ☐	9 ☐	10 ☐
E. Driving a car more than 30 minutes	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	8 ☐	9 ☐	10 ☐
F. Opening a door	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	8 ☐	9 ☐	10 ☐
G. Carrying milk jug from the refrigerator	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	8 ☐	9 ☐	10 ☐
H. Washing dishes	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	8 ☐	9 ☐	10 ☐

Instructions: These questions are about your current job. The questions are intended to apply to all work environments. However, some words may not be quite suitable for your work environment. For example, the term supervisor is meant to refer to the boss, manager, department head, or the person or persons to whom an employee reports. For each question, please indicate how often these things happen. If the question is NOT APPLICABLE due to the nature of your work situation, please check NA.

	Never	Seldom	Sometimes	Fairly Often	Often	
1. Does your supervisor criticize you over minor things?	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	NA ☐
2. Do you have conflicts with your coworkers?	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	NA ☐
3. Do you have conflicts with your supervisor?	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	NA ☐
4. Is there constant pressure to keep working?	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	NA ☐
5. Does there seem to be a rush or urgency about everything?	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	NA ☐
6. Are there unpleasant physical conditions on your job, such as too much noise, dust, etc.?	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	NA ☐

Instructions: Individuals who experience pain develop a number of ways to cope, or deal with, their pain. These include saying things to themselves when they experience pain, or engaging in different activities. Below is a list of things that people have reported doing when they feel pain. For each activity, please indicate, using the scale below, how much you engage in that activity when you feel pain, where a 0 indicates you never do that when you are experiencing pain, a 3 indicates you sometimes do that when you are experiencing pain, and a 6 indicates you always do it when you are experiencing pain. Remember, you can use any point along the scale.

When I feel pain...	**Never do that**			**Sometimes do that**			**Always do that**
1. It's terrible, and I feel it's never going to get any better	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
2. It's awful, and I feel that it overwhelms me	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
3. I feel my life isn't worth living	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
4. I worry all the time about whether it will end	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
5. I feel I can't stand it anymore	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐
6. I feel like I can't go on	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐

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Instructions: The following questions refer to your symptoms for a typical twenty-four hour period during the past two weeks. Place an "x" in the box for one answer to each question.

1. How severe is the hand or wrist pain that you have at night?

- ☐ I do not have hand or wrist pain at night.
- ☐ Mild pain.
- ☐ Moderate pain.
- ☐ Severe pain.
- ☐ Very severe pain.

2. How often did hand or wrist pain wake you up during a typical night in the past two weeks?

- ☐ Never.
- ☐ Once.
- ☐ Two or three times.
- ☐ Four or five times.
- ☐ More than five times.

3. Do you typically have pain in your hand or wrist during the daytime?

- ☐ I never have pain during the day.
- ☐ I have mild pain during the day.
- ☐ I have moderate pain during the day.
- ☐ I have severe pain during the day.
- ☐ I have very severe pain during the day.

4. How often do you have hand or wrist pain during the daytime?

- ☐ Once or twice a day.
- ☐ Two to five time 5 a day.
- ☐ More than five times a day.
- ☐ The pain is constant.
- ☐ Never.

5. How long, on average, does an episode of pain last during the daytime?

- ☐ I never get pain during the day.
- ☐ Less than 10 minutes.
- ☐ 10 to 60 minutes.
- ☐ Greater than 60 minutes.
- ☐ The pain is constant throughout the day.

6. Do you have numbness (loss of sensation) in your hand?

- ☐ No.
- ☐ I have mild numbness.
- ☐ I have moderate numbness.
- ☐ I have severe numbness.
- ☐ I have very severe numbness.

7. Do you have weakness in your hand or wrist?

- ☐ No weakness.
- ☐ Mild weakness.
- ☐ Moderate weakness.
- ☐ Severe weakness.
- ☐ Very severe weakness.

8. Do you have tingling sensations in your hand?

- ☐ No tingling.
- ☐ Mild tingling.
- ☐ Moderate tingling.
- ☐ Severe tingling.
- ☐ Very severe tingling.

9. How severe is numbness (loss of sensation) or tingling at night?

- ☐ I have no numbness or tingling at night.
- ☐ Mild.
- ☐ Moderate.
- ☐ Severe.
- ☐ Very severe.

10. How often did hand numbness or tingling wake you up during a typical night in the past two weeks?

- ☐ Never.
- ☐ Once.
- ☐ Two or three times.
- ☐ Four or five times.
- ☐ More than five times.

11. Do you have difficulty with the grasping and use of small objects such as keys or pens?

- ☐ No difficulty.
- ☐ Mild difficulty.
- ☐ Moderate difficulty.
- ☐ Severe difficulty.
- ☐ Very severe difficulty.

Instructions: These questions ask you to rate the amount of time during the past four weeks that you had difficulty handling certain parts of your job. Please read and answer every question. Mark the "Does not apply to my job" box only if the question describes something that is not part of your current job. If you have more than one job, report on your main job only.

1.) In the past 4 weeks, how much of the time did your physical health make it difficult for you to do the following?	All of the time (100%)	Most of the time	Half of the time (50%)	Some of the time	None of the time (0%)	Does not apply to my job
a. Work the required number of hours	☐	☐	☐	☐	☐	☐
b. Get going easily at the beginning of the workday	☐	☐	☐	☐	☐	☐
c. Start on your job as soon as you arrived at work	☐	☐	☐	☐	☐	☐
d. Do your work without stopping to take breaks or rests	☐	☐	☐	☐	☐	☐
e. Stick to a routine or schedule	☐	☐	☐	☐	☐	☐

These questions ask about how things went at work overall.

2.) In the past 4 weeks, how much of the time did your physical health make it difficult for you to do the following?	All of the time (100%)	Most of the time	Half of the time (50%)	Some of the time	None of the time (0%)	Does not apply to my job
a. Handle your workload	☐	☐	☐	☐	☐	☐
b. Work fast enough	☐	☐	☐	☐	☐	☐
c. Finish work on time	☐	☐	☐	☐	☐	☐
d. Do your work without making mistakes	☐	☐	☐	☐	☐	☐
e. Satisfy the people who judge your work	☐	☐	☐	☐	☐	☐
f. Feel a sense of accomplishment in your work	☐	☐	☐	☐	☐	☐
g. Feel you've done what you are capable of doing	☐	☐	☐	☐	☐	☐

3.) In the past 4 weeks, how much of the time did your physical health make it difficult for you to do the following:	All of the time (100%)	Most of the time	Half of the time (50%)	Some of the time	None of the time (0%)	Does not apply to my job
a. Keep your mind on your work	☐	☐	☐	☐	☐	☐
b. Think clearly when working	☐	☐	☐	☐	☐	☐
c. Do work carefully	☐	☐	☐	☐	☐	☐
d. Concentrate on your work	☐	☐	☐	☐	☐	☐
e. Work without losing your train of thought	☐	☐	☐	☐	☐	☐
f. Easily read or use your eyes when working	☐	☐	☐	☐	☐	☐

In the past 4 weeks, how much of the time did your physical health make it difficult for you to do the following:	All of the time (100%)	Most of the time	Half of the time (50%)	Some of the time	None of the time (0%)	Does not apply to my job
a. Speak with people in-person, in meetings or on the phone..	☐	☐	☐	☐	☐	☐
b. Control your temper around people when working......	☐	☐	☐	☐	☐	☐
c. Help other people to get work done	☐	☐	☐	☐	☐	☐

33. In the past 4 weeks, how much of the time did your physical health make it difficult for you to do the following:	**All of the time (100%)**	**Most of the time**	**Half of the time (50%)**	**Some of the time**	**None of the time (0%)**	**Does not apply to my job**
a. Walk or around different work locations (for example, go to meetings..........	☐	☐	☐	☐	☐	☐
b. Lift, carry or move objects at work weighing more than 10 lbs..........	☐	☐	☐	☐	☐	☐
c. Sit, stand or stay in one position for longer than 15 minutes while working..........	☐	☐	☐	☐	☐	☐
d. Repeat the same motions over and over again while working..........	☐	☐	☐	☐	☐	☐
e. Bend, twist, or reach while working..........	☐	☐	☐	☐	☐	☐
f. Use hand-held tools or equipment (for example, a phone, pen, keyboard, computer mouse, drill, hairdryer, or sander)..........	☐	☐	☐	☐	☐	☐

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Continue the questionnaire on the next page.

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Instructions: Job stress can have serious effects on the lives of employees and their families. The impact of stressful job events is influenced by both the amount of stress associated with a particular event and the frequency of its occurrence. This survev will determine your perception of important sources of stress in your work. The survey lists 30 job-related events that many employees find stressful. First, you will be asked to rate the amount of stress associated with each event. On the following page, you will be asked to indicate the number of times within the last 6 months that you have experienced each event.

In making your ratings of the amount of stress for each stressor event, use all your knowledge and experience. Consider the amount of time and energy that you would need to cope with or adjust to the event. Base your ratings on your personal experience as well as what have seen to be the case for others. Rate the average amount of stress that you feel is associated with each event, rather than the extreme.

The first event, ASSIGNMENT OF DISAGREEABLE DUTIES, was rated by persons in a variety of occupations as producing an average amount of stress. This event has been given a rating of "5" and will be used as the standard for evaluating the other events. Compare each event with this standard. Then assign a number from "1" to "9" to indicate whether you judge the event to be less or more stressful than being assigned disagreeable duties.

STRESSFUL JOB-RELATED EVENTS	AMOUNT OF STRESS: Low				Moderate				High
1. Assignment of disagreeable duties	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
2. Working overtime	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
3. Lack of opportunity for advancement	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
4. Assignment of new or unfamiliar duties	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
5. Fellow workers not doing their job	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
6. Inadequate support by supervisor	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
7. Dealing with crisis situations	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
8. Lack of recognition for good work	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
9. Performing tasks not on job description	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
10. Inadequate or poor quality equipment	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
11. Assignment of increased responsibility	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
12. Periods of inactivity	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
13. Difficulty getting along with supervisor	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
14. Experiencing negative attitudes toward the organization	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
15. Insufficient personnel to handle an assignment	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
16. Making critical on-the-spot decisions	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
17. Personal insult from customer/consumer/colleague	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
18. Lack of participation in policy-making decisions	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
19. Inadequate salary	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
20. Competition for advancement	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
21. Poor or inadequate supervision	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
22. Noisy work area	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
23. Frequent interruptions	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
24. Frequent changes from boring to demanding activities	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
25. Excessive paperwork	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
26. Meeting deadlines	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
27. Insufficient personal time (e.g., coffee breaks, lunch)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
28. Covering work for another employee	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
29. Poorly motivated coworkers	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9
30. Conflicts with other departments	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9

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Instructions: For each of the job-related events listed, please indicate the approximate number of days during the past 6 months on which you have personally experienced this event. Place an “x” in the box to the left of the “0” if the event did not occur; place an “x” in the box to the left of the "9+" for each event that you experienced personally on 9 or more days during the past 6 months.

STRESSFUL JOB-RELATED EVENTS	Number of Days on Which the Event Occurred During the Past 6 Months									
	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
1. Assignment of disagreeable duties	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
2. Working overtime	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
3. Lack of opportunity for advancement	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
4. Assignment of new or unfamiliar duties	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
5. Fellow workers not doing their job	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
6. Inadequate support by supervisor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
7. Dealing with crisis situations	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
8. Lack of recognition for good work	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
9. Performing tasks not on job description	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
10. Inadequate or poor quality equipment	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
11. Assignment of increased responsibility	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
12. Periods of inactivity	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
13. Difficulty getting along with supervisor	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
14. Experiencing negative attitudes toward the organization	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
15. Insufficient personnel to handle an assignment	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
16. Making critical on-the-spot decisions	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
17. Personal insult from customer/consumer/colleague	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
18. Lack of participation in policy-making decisions	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
19. Inadequate salary	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
20. Competition for advancement	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
21. Poor or inadequate supervision	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
22. Noisy work area	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
23. Frequent interruptions	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
24. Frequent changes from boring to demanding activities	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
25. Excessive paperwork	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
26. Meeting deadlines	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
27. Insufficient personal time (e.g., coffee breaks, lunch)	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
28. Covering work for another employee	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
29. Poorly motivated coworkers	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+
30. Conflicts with other departments	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7	☐ 8	☐ 9+

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Instructions: Indicate on average, how long you do this work on a daily (every day or weekly) basis

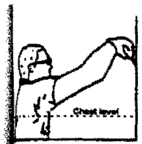


Figure A.

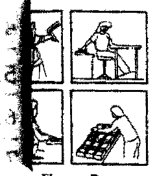


Figure B.

Figure C.

Figure D.

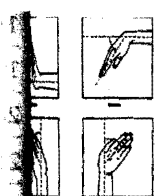


Figure E.

Figure F.

Task	More than 4 hrs / day	2 - 4 hrs / day	Less than 2 hrs / day	Less than 5 hrs / week	Never
1. I work with my hands at or above chest level. (Figure A)	○	○	○	○	○
2. To get to or do my work, I must lay on my back or side and work with my arms up.	○	○	○	○	○
3. I must hold or carry materials (or large stacks of files) during the course of my work.	○	○	○	○	○
4. I force or yank components of work objects in order to complete a task.	○	○	○	○	○
5. I reach/hold my arms in front of or behind my body (e.g., using keyboard, filing, handling parts, perform inspection tasks, pushing/pulling carts, etc). (Figure B)	○	○	○	○	○
6. My neck is tipped forward or backward when I work. (Figure C)	○	○	○	○	○
7. I cradle a phone or other device between my neck and shoulder. (Figure D)	○	○	○	○	○
8. My wrists are bent (up, down, to the thumb, or little finger side) while I work. (Figure E)	○	○	○	○	○
9. I apply pressure or hold an item/material/tool (e.g., screwdriver, spray gun, mouse, etc. in my hand for longer than 10 seconds at a time).	○	○	○	○	○
10. My work requires me to use my hands in a way that is similar to wringing out clothes. (Figure F).	○	○	○	○	○
11. I perform a series of repetitive tasks/movements during the normal course of my work (e.g. using keyboard, tightening fasteners, cutting meat, etc).	○	○	○	○	○
12. The work surface (e.g., desk, bench, etc.) or tool(s) that I use presses into my palm(s), wrist(s), or against the sides of my fingers leaving red marks on or beneath the skin.	○	○	○	○	○
13. I use my hand/palm like a hammer to do aspects of my work.	○	○	○	○	○
14. My hands and fingers are cold when I work.	○	○	○	○	○
15. I work at a fast pace to keep up with machine production quota or performance incentive.	○	○	○	○	○
16. The tool(s) that I use vibrates and/or jerks my hand(s)/arm(s).	○	○	○	○	○
17. My work requires that I repeatedly throw or toss items.	○	○	○	○	○
18. My work requires me to twist my forearms, such as turning a screwdriver.	○	○	○	○	○

Instructions: Indicate on average, how long you do this work on a daily (every day or weekly) basis

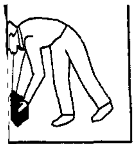


Figure G.

Figure H.

Figure I.

Figure J.

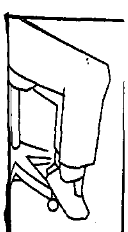


Figure K

Task	More than 4 hrs / day	2-4 hrs / day	Less than 2 hrs / day	Less than 5 hrs / week	Never
19. I wear gloves that are bulky, or reduce my ability to grip.	○	○	○	○	○
20. I squeeze or pinch work objects with a force similar to that which is required to open a lid on a new jar.	○	○	○	○	○
21. I grip work objects or tools as if I am gripping tightly onto a pencil.	○	○	○	○	○
22. When I lift, move components, or do other aspects of my work, my hands are lower than my knees. (Figure G)	○	○	○	○	○
23. I lean forward continually when I work (e.g., when sitting, when standing, when pushing carts, etc).	○	○	○	○	○
24. The personal protective equipment or clothing that I wear limits or restricts my movement.	○	○	○	○	○
25. I repeatedly bend my back (e.g., forward, backward, to the side, or twist) in the course of my work.	○	○	○	○	○
26. When I lift, my body is twisted and/or I lift quickly. (Figure H)	○	○	○	○	○
27. I can feel vibration through the surface that I stand on, or through my seat.	○	○	○	○	○
28. I lift and/or carry items with one hand (Figure I)	○	○	○	○	○
29. I lift or handle bulky items.	○	○	○	○	○
30. I lift materials that weigh more than 25 pounds.	○	○	○	○	○
31. My work requires that I kneel or squat. (Figure J)	○	○	○	○	○
32. I must constantly move or apply pressure with one or both feet (e.g. using foot pedals. driving, etc).	○	○	○	○	○
33. When I'm sitting, I cannot rest both feet flat on the floor. (Figure K)	○	○	○	○	○
34. I stand on hard surfaces.	○	○	○	○	○
35. I can see glare on my computer screen or work surface.	○	○	○	○	○
36. It is difficult to hear a person on the phone or to concentrate because of other activity, voices, or noise in/near my work area.	○	○	○	○	○
37. I must look at the monitor screen constantly so that I do not miss important information (e.g. radar scope).	○	○	○	○	○
38. It is difficult to see what I am working with (monitor, paper, parts, etc).	○	○	○	○	○

WORKSITE ASSESSMENT

1. How long have you worked at your present work tasks?........ [ ][ ] yrs [ ][ ] mos

2. When did you start to use a visual display unit (i.e., computer monitor)........ [ ][ ] mm / [ ][ ] yy

3. When did you start to use a mouse?........ [ ][ ] mm / [ ][ ] yy

4. Average work hours per week:........ [ ][ ][ ] hrs/week

5. Average percent of work tasks from total work time:

a.) Desk work .... [ ][ ][ ] %

b.) VDU work (work at a computer monitor) .... [ ][ ][ ] %

c.) Laptop work (work on a computer laptop) .... [ ][ ][ ] %

d.) Meetings/seminars .... [ ][ ][ ] %

e.) Discussions with co-workers .... [ ][ ][ ] %

f.) Phone-calls .... [ ][ ][ ] %

e.) Other (please specify) [ ] [ ][ ][ ] %

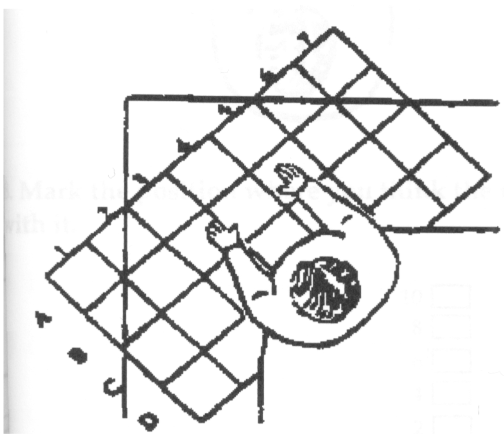
h.) Other (please specify) [ ] [ ][ ][ ] %

100 %

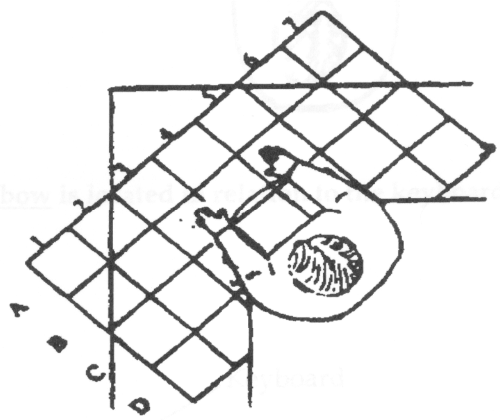
POSITION OF MOUSE AT PRIMARY COMPUTER WORKSTATION

6. Go to the picture of the workstation below (a - d) which is the most relevant when you are working with a MOUSE. Put one cross in the square where you most often have the MOUSE located when you work with it.

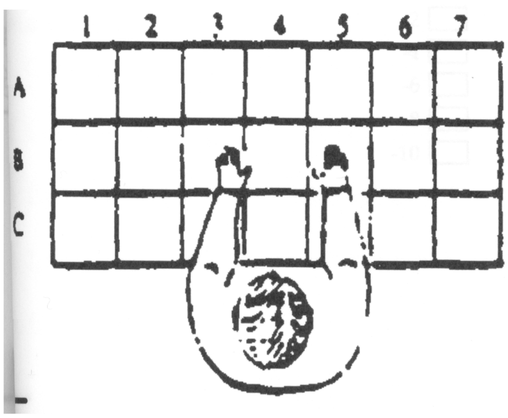
a.) Corner table without extendible/ adjustable surface



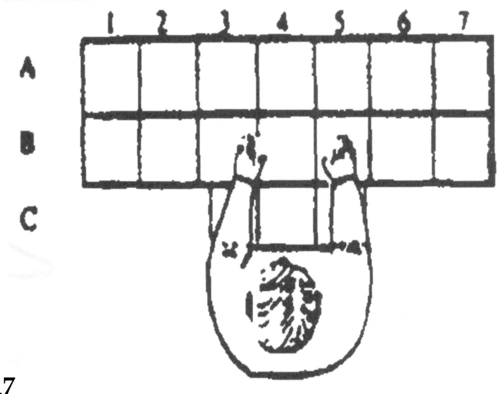
b.). Corner table with extendible/adjustable surface



c.). Straight table without extendible/adjustable surface



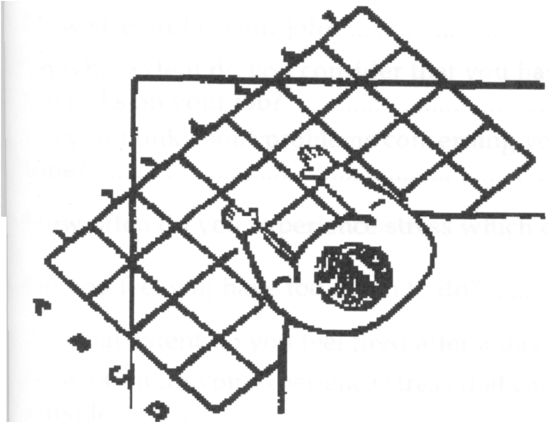
d.). Straight table with extendible/adjustable surface



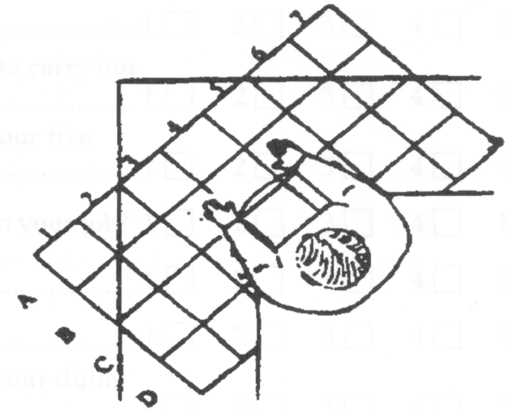
POSITION OF KEYBOARD AT PRIMARY COMPUTER WORKSTATION

7. Go to the picture of the workstation below (a - d) which is the most relevant when you are working with the KEYBOARD. Put one cross in the square where you most often have the KEYBOARD located when you work with it.

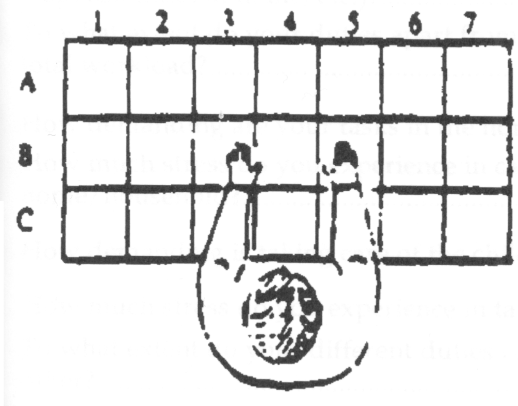
a.) Corner table without extendible/adjustable surface



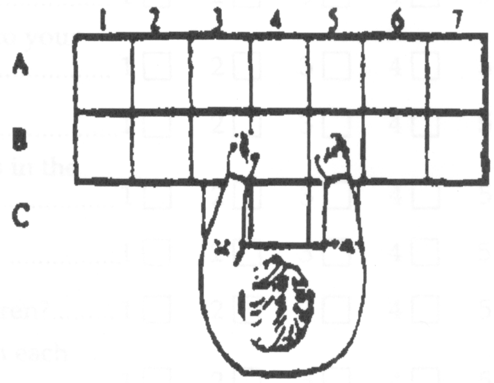
b.) Corner table with extendible/adjustable surface



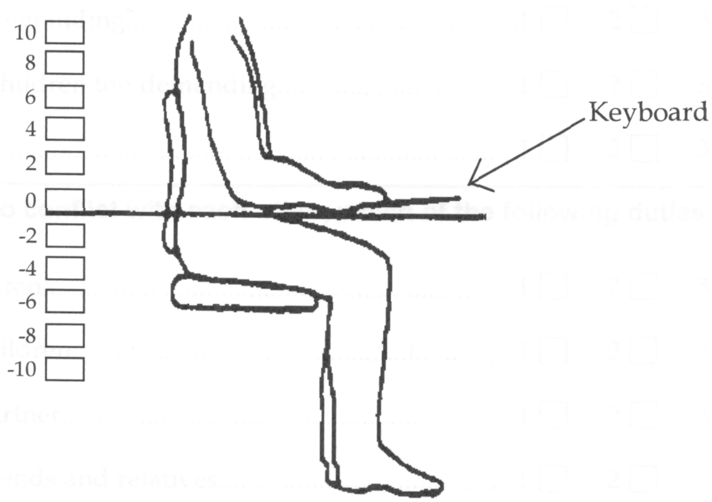
c.). Straight table **without** extendible/adjustable surface



d.) Straight table **with** extendible/adjustable surface



8. Mark the position where you think the underside of your elbow is located in relation to the keyboard when working with it.



Instructions: The following questions relate to your "total workload" which is the combined load of paid work and upaid duties Unpaid duties include household responsibilities, childcare, and any other tasks you perform outside of your paid work. Please mark your response to each question by placing an "X" in the appropriate box.

	Not at all						Very much
1. How demanding is your job?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
2. How stressful is your job?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
3. To what extent do you consider that you have sufficient time to carry out the tasks on your job?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
4. Do you think about problems concerning your work during your free time?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
5. How often do you experience stress which can be attributed to your job?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
6. Do you feel you have too much to do?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
7. To what extent do you feel tired after a day at work?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
8. How often do you experience stress that can be attributed to your duties outside your job?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
9. All in all, how demanding are your duties?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
10. In general, how stressful do you find your total work load (job, responsibilities at home, etc.)?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
11. To what extent do your duties apart from your job contribute to your total workload?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
12. How demanding are your tasks in the home/household?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
13. How much stress do you experience in carrying out your tasks in the home/household?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
14. How demanding is taking care of the children?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
15. How much stress do you experience in taking care of the children?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
16. To what extent do your different duties come into conflict with each other?	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

To what extent do the following factors contribute to your experiencing a conflict between your different duties:

17. Job too demanding	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
18. Home/household work too demanding	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
19. Care and supervision of the children too demanding	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
20. Other duties too demanding	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

Then different duties come into conflict with each other, which of the following duties are generally allocated less time than usual:

21. Care and supervision of children	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
22. Leisure time together with children	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
23. Leisure time together with partner	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
24. Leisure time together with friends and relatives	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐
25. Own leisure time	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐

Instructions: Below is a series of statements a person might use to describe his/her attitudes, opinions, interests, and other characteristics. Each statement is followed by two choices, True and False. Read the statement and decide which choice best describes you. Please answer every statement, even if you are not completely sure of the answer. Read each statement carefully, but don't spend too much time deciding on the answer.

1. Sometimes I feel and experience things as I did when I was a child .... True ☐ False ☐
2. I can be greatly moved by eloquent or poetic language .... True ☐ False ☐
3. While watching a movie, a T.V. show, or a play, I may become so involved that I forget about myself and my surroundings and experience the story as if it were real and as if I were taking part in it .... True ☐ False ☐
4. If I stare at a picture and then look away from it, I can sometimes "see" an image of the picture, almost as if I were still looking at it .... True ☐ False ☐
5. Sometimes, I feel as if my mind could envelop the whole world .... True ☐ False ☐
6. I like to watch cloud shapes change in the sky .... True ☐ False ☐
7. If I wish, I can imagine (or daydream) some things so vividly that they hold my attention as a good movie or story does .... True ☐ False ☐
8. I think I really know what some people mean when they talk about mystical experiences .... True ☐ False ☐
9. I sometimes "step outside" my usual self and experience an entirely different state .... True ☐ False ☐
10. Textures - such as wool, sand, wood - sometimes remind me of colors or music .... True ☐ False ☐
11. Sometimes I experience things as if they were doubly real .... True ☐ False ☐
12. When I listen to music, I can get so caught up in it that I don't notice anything else .... True ☐ False ☐
13. If I wish, I can imagine that my body is so heavy that I could not move it if I wanted to .... True ☐ False ☐
14. I can often somehow sense the presence of another person before I actually see or hear him/her .... True ☐ False ☐
15. The crackle and flames of a wood fire stimulate my imagination .... True ☐ False ☐
16. It is sometimes possible for me to be completely immersed in nature or in art and to feel as if my whole state of consciousness has somehow been temporarily altered .... True ☐ False ☐
17. Different colors have distinctive and special meanings for me .... True ☐ False ☐
18. I am able to wander off in to my own thoughts while doing a routine task and actually forget that I am doing the task, and then find a few minutes later that I have completed it .... True ☐ False ☐
19. I can sometimes recollect certain past experiences in my life with such clarity and vividness that it is like living them again or almost so .... True ☐ False ☐
20. Things that might seem meaningless to others often make sense to me .... True ☐ False ☐
21. While acting in a play, I think I could really feel the emotions of the character and "become" her/him for the time being, forgetting both myself and the audience .... True ☐ False ☐
22. My thoughts often don't occur as words but as visual images .... True ☐ False ☐
23. I often take delight in small things (like the five-pointed star shape that appears when you cut an apple across the core or the colors in soap bubbles) .... True ☐ False ☐
24. When listening to organ music or other powerful music, I sometimes feel as if I am being lifted into the air........ True ☐ False ☐
25. Sometimes I can change noise into music by the way I listen to it .... True ☐ False ☐
26. Some of my most vivid memories are called up by scents and smells .... True ☐ False ☐
27. Some music reminds me of pictures or changing color patterns .... True ☐ False ☐
28. I often know what someone is going to say before he or she says it .... True ☐ False ☐
29. I often have "physical memories;" for example, after I've been swimming I may still feel as if I'm in the water .... True ☐ False ☐

30. The sound of a voice can be so fascinating to me that I can just go on listening to it ....True ☐ False ☐

31. At times. I somehow feel the presence of someone who is not physically there .... True ☐ False ☐

32. Sometimes thoughts and images come to me without the slightest effort on my part .... True ☐ False ☐

33. I find that different odors have different colors .... True ☐ False ☐

34 . I can be deeply moved by a sunset .... True ☐ False ☐

End of Questionnaire

Thank you.

APPENDIX D

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Job Events Diary
Page 1

Today's Date: ____ / ____ / ____

Subject ID # [ ][ ][ ]

Step 1: Think back over your work day. For each of the job-related events highlighted below, indicate the approximate number of times during the workday you experienced this event. Use any point along the scale, where "0" means the event did not happen during your workday, and "5+" means the event happende five or more times.

JOB-RELATED EVENTS	# of Times the Event Occurred Today	JOB-RELATED EVENTS	# of Times the Event Occurred Today
1. Assignment of disagreeable duties	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	16. Making critical on-the-spot decisions	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
2. Working overtime	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	17. Personal insult from customer/ consumer/colleague	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
3. Lack of opportunity for advancement	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	18. Lack of participation in policy-making decisions	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
4. Assignment of new or unfamiliar duties	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	19. Inadequate salary	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
5. Fellow workers not doing their job	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	20. Competition for advancement	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
6. Inadequate support by supervisor	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	21. Poor or inadequate supervision	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
7. Dealing with crisis situations	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	22. Noisy work area	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
8. Lack of recognition for good work	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	23. Frequent interruptions	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
9. Performing tasks not on job description	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	24. Frequent changes from boring to demanding activities	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
10. Inadequate or poor quality equipment	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	25. Excessive paperwork	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
11. Assignment of increased responsibility	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	26. Meeting deadlines	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
12. Periods of inactivity	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	27. Insufficient personal time (e.g., coffee breaks, lunch, etc.)	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
13. Difficulty getting along with supervisor	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	28. Covering work for another employee	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
14. Experiencing negative attitudes toward the organization	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	29. Poorly motivated coworkers	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+
15. Insufficient personnel to handle an assignment	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+	30. Conflicts with other departments	☐0 ☐1 ☐2 ☐3 ☐4 ☐5+

Step 2: Compare your responses above with the list of events you were given during your first visit to the lab. For each event on the list that you indicated occurred during your workday, fill out the worksheet entitled "Job Events Diary: Page 2." If an event occured more than once during your day, you need only complete Page 2 for the **MOST** stressful occurrence of that event. AT THE MOST, you should only complete **three** Page 2's.

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JOB EVENTS DIARY: Page 2

Subject ID # ☐☐☐

Today's Date: ___ / ___ / ___ **TIME:** ___ : ___ ☐ a.m. ☐ p.m.

PART I: Please fill in the item number and description of this event/situation from the Page 1.

Item #: ☐☐ Item Description: ______________________

PART II: Please elaborate on the details of the identified event/situation.

What is your relationship to the person(s) involved? (Please PRINT your responses)

What did you do to resolve the situation?

What was the outcome of the situation?

PART III: How stressful was this event/situation overall? (Please place an "x" in the box which best describes your response)

Not at all stressful ☐ 0 ☐ ☐ 1 ☐ ☐ 2 ☐ ☐ 3 ☐ ☐ 4 ☐ ☐ 5 ☐ ☐ 6 ☐ ☐ 7 ☐ ☐ 8 ☐ ☐ 9 ☐ ☐ 10 Extremely stressful

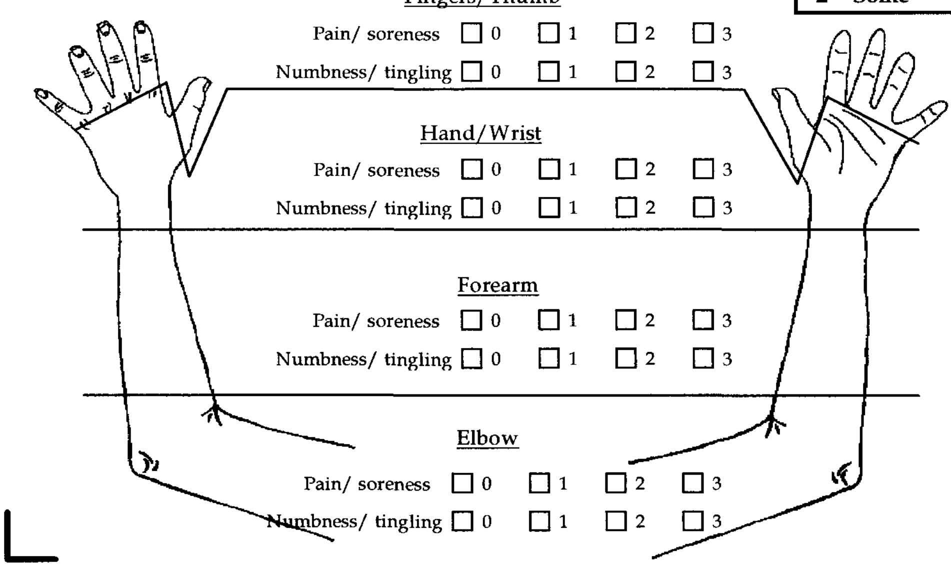
PART IV: Below is a list of words that describe feelings people have. Please read each one and then place an "x" in once box which best describes how you felt regarding the situation/event described in Part II

	NOT AT ALL	A LITTLE	MODERATELY	QUITE A BIT	EXTREMELY
Tense........	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Angry.......	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Relaxed....	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Peeved......	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Uneasy......	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Grouchy...	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Restless....	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Spiteful....	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Nervous...	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Annoyed...	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Anxious....	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

	NOT AT ALL	A LITTLE	MODERATELY	QUITE A BIT	EXTREMELY
Resentful..........	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Panicky.............	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Bitter.................	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
On edge...........	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Ready to fight..	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Shaky................	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Rebellious........	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Deceived...........	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Furious............	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Bad-tempered..	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
Depressed/blue..	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

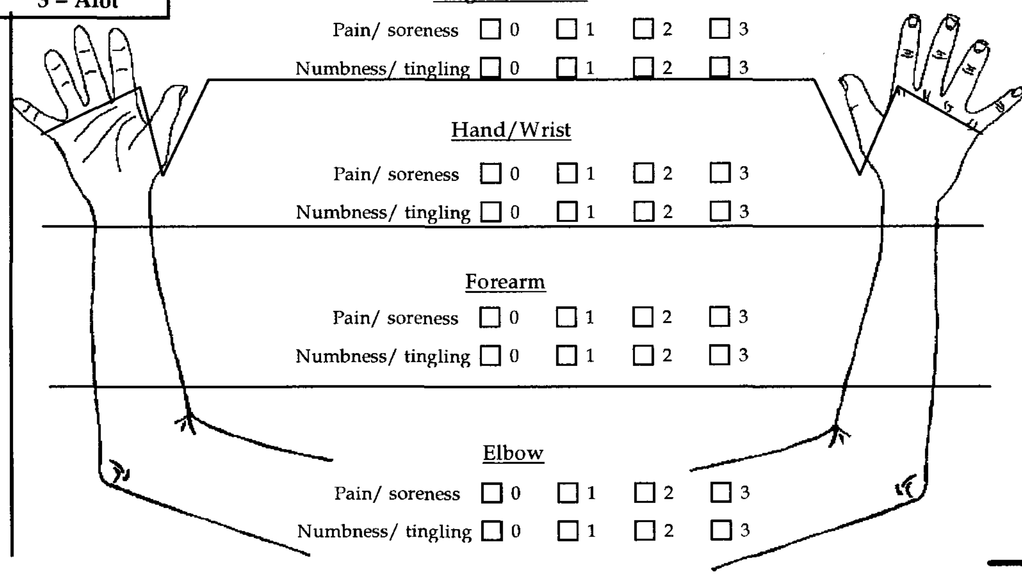
0 = Not at all 1 = A little
2 = Some 3 = Alot

LEFT ARM



Fingers/Thumb				
Pain/ soreness	☐ 0	☐ 1	☐ 2	☐ 3
Numbness/ tingling	☐ 0	☐ 1	☐ 2	☐ 3
Hand/Wrist				
Pain/ soreness	☐ 0	☐ 1	☐ 2	☐ 3
Numbness/ tingling	☐ 0	☐ 1	☐ 2	☐ 3
Forearm				
Pain/ soreness	☐ 0	☐ 1	☐ 2	☐ 3
Numbness/ tingling	☐ 0	☐ 1	☐ 2	☐ 3
Elbow				
Pain/ soreness	☐ 0	☐ 1	☐ 2	☐ 3
Numbness/ tingling	☐ 0	☐ 1	☐ 2	☐ 3

RIGHT ARM



Fingers/Thumb				
Pain/ soreness	☐ 0	☐ 1	☐ 2	☐ 3
Numbness/ tingling	☐ 0	☐ 1	☐ 2	☐ 3
Hand/Wrist				
Pain/ soreness	☐ 0	☐ 1	☐ 2	☐ 3
Numbness/ tingling	☐ 0	☐ 1	☐ 2	☐ 3
Forearm				
Pain/ soreness	☐ 0	☐ 1	☐ 2	☐ 3
Numbness/ tingling	☐ 0	☐ 1	☐ 2	☐ 3
Elbow				
Pain/ soreness	☐ 0	☐ 1	☐ 2	☐ 3
Numbness/ tingling	☐ 0	☐ 1	☐ 2	☐ 3

APPENDIX E

Instructions for the Stress Recall Interview

The stress recall interview is designed to elicit physiological responses by discussing an emotionally arousing topic with a stranger. The main goal of the interview is to help the participant who is being interviewed re-experience stressful emotions, behaviors and thoughts by reconstructing a distressing event in detail. Seemingly trivial features of the situation (e.g., the physical environment, others present, facial expressions, time of day, etc.) help trigger the re-experiencing of troubling thoughts and emotions. At all times, the focus is on thoughts and emotions. Situational details are important only to the extent that they help the participant recover past feelings.

The underlying idea is that stressful emotions are triggered and organized by cognitive appraisals. These appraisals involve the perception that an important self-goal or need is threatened. Stressful emotions are reactivated in the present by activating this appraisal, or "core thought." The goal of the interview is to elicit critical, stress-inducing thoughts and their associated emotions. There is a flow to the interview that goes more or less like this:

- Describe specific situation
- Describe associated emotions
- Identify core thoughts that activate these stressful emotions

At all times, the focus is on getting the participant to re-experience stressful emotions and the core thoughts that activate them. This should not be construed as a rigid, lock-step sequence. Successful interviewing involves an ability to shift flexibly from one level to another, while steadily pursing the core stress-arousing thought.

I. THE INTERVIEW: DESCRIBING THE SITUATION

The first 4 minutes of the interview should primarily be the subject relaying the details of the event. The following outline provides a line of questioning to facilitate this process if the subject has difficulty elaborating on the event. This outline should be considered flexible; the point is to quickly engage the participant in the process of re-experiencing troubling thoughts and emotions.

- Tell me about this event
- Where did this happen?
- Who was there and what else was happening?
- Why was this stressful for you?
- How long has this been a problem?
- Has this sort of thing happened before?
- How often does this problem bother you?

II. THE INTERVIEW: DESCRIBING EMOTIONS

After the 4-minute recall, you will help the participant focus on feelings aroused during the problem situation.

The interviewer first asks the participant how she felt during the situation. What emotion(s) were felt at the time? If the participant uses a word like "scared" or "mad," what exactly do they mean? What does it mean for this participant to feel "scared" or "mad?" This is known as elaboration.

Elaboration is an interviewing skill that requires practice. As used here, the term, "elaboration," means getting the participant to expand and clarify a thought or feeling. Most of the interview time is devoted to helping participants elaborate stressful emotions and thoughts. Some participants elaborate spontaneously and easily. In most cases, however, the interviewer must provide continued encouragement, prompting, and reinforcement. Below are examples of interviewer statements that encourage, prompt, and reinforce elaboration of feelings. Interviewers should commit these statements to memory.

Elaboration of a feeling statement (e.g., "I felt mad.")

- How did that feel?
- Was that all you felt? Did you feel anything else?
- Tell me what that was like for you – when you felt "mad."
- What were you like when you felt that way?
- How did you look to others when you were feeling "mad?"
- What did other people see when you were feeling that way?
- How did you act when you felt "mad?"
- What did you do in this situation?
- How did other people react? How did you feel about how they reacted?

III. THE INTERVIEW: IDENTIFYING CORE THOUGHTS

Once the subject has reported a feeling/feelings in the situation, the next goal is to find out what thoughts triggered or were associated with the emotion. Participants may find it easier to describe their stressful thoughts (i.e., what went through their minds) than their emotions.

Below are examples of interviewer statements that encourage, prompt, and reinforce elaboration of core thoughts. Interviewers should commit these statements to memory.

Elaboration of the stressful thoughts behind the emotion (e.g., "He was making me angry.")

- What was going through your head when you were feeling angry?
- What went through your mind when he said/did that?
- What did you say to yourself when that happened?
- Was there anything you wanted to say but didn't?
- What did you really want to say?
- What do you wish you had said?
- When you think about this situation now, what goes through your mind?
- Why do these thoughts come to mind?
- How do these thoughts make you feel now?

IV. THE INTERVIEW: RE-EXPERIENCING THE SITUATION

The third step is to play back the situation again, encouraging the participant to get in touch with thoughts and feelings they might not have mentioned the first time and to talk about the situation's impact. The purpose of this step is to make sure the participant has had a chance to get in touch with their most stressful thoughts and feelings. The interviewer tries to get the participant to "pull it all together" as in a scene from a movie.

This works best if the interviewer tries to picture the situation as if it were a film on TV. Where is this happening? Who is there? What do they look like? How are they acting? Often, recalling minor visual details like these will help trigger thoughts or feelings the participant had not mentioned previously. The interviewer tries to draw these thoughts and feelings out. The interviewer should try to come across as a sympathetic friend who is making a sincere effort to understand how the participant really felt. The interviewer is asking for the participant's "help" in an effort to understand what it was like. The following line of questioning is recommended:

OK, I want to be sure I really understand what this was like for you. Could you take me through the situation again?

I'd like you to take a moment to imagine the situation now. Put yourself back on the scene and imagine it all happening again. Picture the place where you were. Picture the other people who were there and how they looked and acted.

OK, now help me picture this.

Where is this happening?

Who is there?

How do they look? What do their faces look like? What do their voices sound like?

What do you say to them? What do you want to say?

Why is this important?

What happens next?

How does this make you feel physically?

How do you feel about the way they are acting/reacting?

Drawing a "blank."

Sometimes participants seem unable to recall what they thought or felt in a stressful situation. If the participant has difficulty reporting distressing thoughts and feelings, the interviewer can ask:

- Why don't you want this situation to happen again?
- Why would it be stressful for you if this problem happened again? What would be bad about it?
- Why does this problem bother you? What comes to mind when you think about it?

Some interviewing "Don'ts"

In addition to knowing what to ask, the interviewer must learn what NOT to ask. Following are several **DON'TS** that can impede elaboration.

1. **Avoid asking leading questions.** Avoid questions like "Did that feel bad?", "Did that make you angry?" Such queries put words into the participant's mouth. The goal is to get them to report their own words.
2. **Avoid closed-ended questions.** These are questions that can be answered with a simple "yes" or "no." For example, "Did that hurt?" "Yes." End of story. Instead ask, "How did that feel?" Open-ended questions (often beginning with "how" or "why") encourage the participant to elaborate on their thoughts and feelings.
3. **Avoid facial expressions that might exert undue influence (e.g., frowns).**
4. **Avoid talking too much.** The interviewer's job is to get the participant to do the talking. If the participant remains quiet, the interview will not function as a social stressor. Novice interviewers tend to do too much talking, summarizing, and questioning. When allowed to talk without interruptions, participants frequently will provide enough information to make interviewer questions unnecessary.
5. **Avoid interrupting the participant unless absolutely necessary.** Interruptions break the participant's flow of thought and feeling, and prevent them from re-experiencing the problem situation.
6. **Avoid sounding mechanical.** Memorize and rehearse the interview questions to a point where you are able to sound relaxed and natural when you question the participant. The participant should feel as if she/he is having a conversation with a sympathetic, concerned friend.

Enhancing Interviewing Skills

Interviewing becomes easier with practice. Mastery can be facilitated by listening regularly to audiotapes of one's interviews. This experience can be humbling, but it is one of the best ways to improve. While listening, the following questions should be uppermost in one's mind:

1. **Am I talking too much?** The more the interviewer speaks, the less the participant does, and the interview's efficacy as a stressor is reduced. Can you find ways to communicate that allow you to speak less frequently or more succinctly?

2. **Am I interrupting?** Inexperienced interviewers tend to interrupt with questions or elaborations before the participant has finished speaking. This is detrimental because it disrupts the participant's flow of thought and feeling, it dampens emotion, and it often deflects the focus of attention onto issues of secondary importance. Interruptions should be rare, occurring only when the participant is wandering off track or when time pressures force the interviewer to move to the next phase of the interview.
3. **Are my comments facilitative?** Interviewers should ask themselves if their questions or comments led participants to elaborate their emotions and thoughts more fully and intensely. If they did not, could the comment have been phrased in a more facilitative way? Was the comment really necessary?
4. **Am I getting at the participant's core thoughts and feelings?** On reviewing the tape, you may notice you were missing clues to important thoughts or feelings that were at the root of the participant's stress. How might you have explored these more effectively?

APPENDIX F

1.) How DISTRESSED do you feel right now?

0 ——————————————————————————— 10

Not at all distressed | Extremely distressed

2.) To what degree do you feel PAIN, SORENESS, NUMBNESS, or TINGLING right now?

0 ——————————————————————————— 10

No pain, Soreness, Numbness, or Tingling | Extreme Pain, Soreness, Numbness, or Tingling

How similar to the actual experience did you feel during this discussion?

0 |——————————————————| 10

Not at all like the original experience

Exactly like the original experience

APPENDIX G

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Subject ID# | | |

IES-R

INSTRUCTIONS: The following is a list of difficulties people sometimes have after stressful life events. Please read each item and then indicate how distressing each difficulty has been for you during the past 7 days with respect to the stressful event identified. How much were you distressed or bothered by these difficulties?

	Not at all	A little bit	Moderately	Quite a bit	Extremely
1. Any reminder brought back feelings about it	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
2. I had trouble staying asleep	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
3. Other things kept making me think about it	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
4. I felt irritable and angry	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
5. I avoided letting myself get upset when I thought about it or was reminded of it	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
6. I thought about it when I didn't mean to	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
7. I felt as if it hadn't happened or wasn't real	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
8. I stayed away from reminders about it	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
9. Pictures about it popped into my mind	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
10. I was jumpy and easily startled	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
11. I tried not to think about it	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
12. I was aware that I still had a lot of feelings about it, but I didn't deal with them	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
13. My feelings about it were kind of numb	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
14. I found myself acting or feeling like I was back at that time	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
15. I had trouble falling asleep	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
16. I had waves of strong feelings about it	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
17. I tried to remove it from my memory	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
18. I had trouble concentrating	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
19. Reminders of it caused me to have physical reactions, such as sweating, trouble breathing, nausea, or a pounding heart	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
20. I had dreams about it	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
21. I felt watchful and on guard	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐
22. I tried not to talk about it	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐