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Occupational and Bio \psychosocial Risk Factors for Carpal Tunnel Syndrome: A Case-Control Study

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OCCUPATIONAL AND BIOPSYCHOSOCIAL RISK FACTORS FOR CARPAL TUNNEL SYNDROME: A CASE-CONTROL STUDY

by

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ABSTRACT

Occupational and Biopsychosocial Risk Factors for Carpal

Tunnel Syndrome: A Case-Control Study

by

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The present study was designed to assess the risk factors associated with carpal tunnel syndrome (CTS). Toward this end, a wide range of putative occupational, biological, and psychosocial correlates of CTS was investigated using a case-control methodology. Cases were 87 patients from an orthopedic clinic with clinical symptoms and electrodiagnostic testing results suggestive of CTS. Controls were 74 gender-matched patients from the same orthopedic clinic, without clinical symptoms of CTS and normal electrodiagnostic testing results. Participants completed a self-report questionnaire that included eight potential occupational correlates (i.e., repetition, force, vibration, typing, lifting heavy loads, and standing on feet), 10 potential personological correlates (i.e., obesity, advocational exercise levels, diabetes, thyroid problems, arthritis, gynecological surgery, and menstrual complications), and 11 potential psychosocial correlates (i.e., depression, anxiety, somatization, health locus of control, job satisfaction, and physical and mental health indices). Results of multiple logistic regression analyses revealed that occupational repetition, vigorous exercise, physical activities with wrist strain, physical health, and job satisfaction were significant predictors of CTS. In addition, obesity was a borderline significant predictor of CTS. Plausible explanations for the current findings, along with implications, are discussed.

(219 pages)

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Jason Talley Goodson

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION AND PROBLEM STATEMENT

Carpal tunnel syndrome (CTS) is a common condition that annually affects 3.1% of the population (National Health Interview Survey [NHIS], Work Loss Data Institute, 2001). The lifetime risk of developing CTS has been estimated to be a high as 10% (Spinner, Bachman, & Amadio, 1989). According to Leigh and Miller (1998), CTS is among the four most frequent causes of workers' compensation disability coverage (both permanent and temporary status). In a study conducted by the National Institute for Occupational Safety and Health, the estimated prevalence of CTS was 1.5% (2.65 million) of the US population (Tanaka et al., 1994).

In addition to high prevalence rates, several investigators have reported an increasing incidence of CTS. For instance, Stevens, Sun, Beard, O'Fallon, and Kurland (1988) conducted a 20-year study and documented a trend towards increasing CTS incidence rates, with age-adjusted rates of 88 and 125 per 100,000 persons during the first and last 5-year periods of the study. Franklin, Haug, Heyer, Checkoway, and Peck (1991) found an increased trend in CTS workers' compensation claims in Washington State between the years of 1984 and 1988. In their study, the incidence rate of these claims increased from 1.78 per 1,000 full time employees (FTE) in 1984, to 2.00 per 1,000 FTE in 1988. Furthermore, the Bureau of Labor Statistics reported that the incidence of CTS increased by 3% from 1992 to 1994 (U.S. Department of Labor, 1997).

The results of these studies are echoed in concerns of numerous medical researchers who claim that CTS rates are on the rise. For instance, Winn, Morrissey, and Huechtker (2000) noted that CTS is increasing in both frequency and economic impact. Jarvik and Yuen (2001) reported that "since the 1980s there has been a dramatic increase in the diagnosis of carpal tunnel syndrome" (p. 241). Likewise, Olney (2001) indicated that the incidence of CTS has been increasing over the past 20 years. Bell and Crumpton (1997) stated that CTS was the "largest problem facing ergonomists and the medical community" and was "developing in epidemic proportions" (p. 790).

In addition to the high occurrence rates, CTS is associated with considerable medical costs. Szabo (1998) noted that the nonmedical costs of CTS workers' compensation coverage settlement cases averaged $10,000 per hand, with the total cost (i.e., worker compensation and medical costs) ranging from $20,000 to $100,000 per case. Likewise, Palazzo (1994) reported that a surgical workers compensation case may cost between $25,000 and $100,000 per hand. Independent of workers' compensation costs, CTS results in medical costs that exceed $1 billion per year (Patterson & Simmons, 2002). Furthermore, carpal tunnel release is the most commonly performed hand operation, with more than 200,000 procedures carried out each year (Patterson & Simmons).

Given the prevalence, increasing incidence, and high costs associated with CTS, it is advantageous to identify biopsychosocial risk factors for the syndrome. Identification of such risk factors may lead to appropriate primary prevention programs for CTS and corresponding reductions in incidence and costs. However, there exists considerable debate in the CTS literature regarding which risk factors are associated with the onset of the syndrome. Many researchers believe CTS is a "cumulative trauma disorder," or "repetitive strain injury" and substantial evidence has been accumulated to support the hypothesis that occupational risk factors (e.g., repetitive/forceful movements of the hand, vibration, wrist extension/flexion) are associated with CTS onset. For instance, Silverstein, Fine, and Armstrong (1987) conducted a cross-sectional study of 652 active workers and found significantly higher mean levels of CTS in workers who performed jobs requiring high levels of force and repetition (as opposed to workers with jobs requiring low levels of force and repetition). Similarly, Cannon, Bernacki, and Walter (1981) carried out a case-control study of workers at an aircraft engine manufacturing company. Results of their study indicated that employees who used vibrating tools and performed repetitive motion tasks had statistically significant higher rates of CTS than employees without such exposure. The results of these studies have been used to support the premise that CTS is primarily an occupation-related disorder.

In contrast, other investigators concluded that personological (i.e., medical and personal) variables are primary risk factors for CTS. For example, Nathan and Keniston (1993) carried out a cross-sectional study of six different populations and used stepwise regression techniques to predict CTS risk. Results consistently indicated that individual factors such as body mass index (BMI), age, wrist size, and exercise explained a greater proportion of the variance associated with CTS risk than did occupational factors. Likewise, Cosegrove, Chase, Mast, and Reeves (2002) carried out a prospective study of workers' compensation claimants among railroad workers. Results of this study indicated that no association existed between job type and elevated CTS risk. However, mean wrist index (i.e., wrist depth/wrist width), age, and BMI were all found to be significant predictors of CTS. These studies serve to highlight the disagreement surrounding the putative risk factors associated with CTS.

Adding further impetus for the personological view of CTS are findings from recent studies that indicate that psychosocial variables may also increase risk for CTS. For example, Leclerc et al. (1998) reported that individuals who endorsed psychological problems had a significantly elevated odds ratio for CTS (*OR* = 2.34). Similarly, Roquelaure, Mariel, Dano, Fanello, and Penneau-Fontbonne (2001) found the presence of psychological distress was associated with significantly elevated odds ratios for CTS (*OR* = 4.3). Although findings from these studies show that psychological factors might be associated with CTS, it remains unclear which specific psychological constructs may increase risk. This lack of clarity is, in part, due to past reliance on global, nonspecific measures of psychological impairment (e.g., psychological distress/problems) as opposed to measures of more specific constructs (e.g., depression, anxiety, somatization). Furthermore, results from other studies have not supported the notion of psychological variables as risk factors for CTS. For example, Ferry, Hannaford, Warskj, Lewis, and Croft (2000) found that nonpsychotic psychiatric illness was not a risk factor for CTS. Likewise, Blanc, Faucett, Kennedy, Cisternas, and Yelin (1996) found the presence of a psychiatric condition was not associated with CTS. Given the preliminary and conflicting nature of the findings from these studies, future research is needed to determine which, if any, psychological constructs increase risk for CTS.

The desired outcome of identifying risk factors of any disease state is prevention. Similarly with CTS, valid risk factor identification is an essential step towards the design of effective primary prevention programs. Given the prevalence, increasing incidence, and high medical costs associated with CTS, effective prevention programs are needed. The design and implementation of such programs could result in substantial decreases in medical costs and lost work days related to CTS. However, for prevention programs to be effective, they must modify valid risk factors. Yet, as illustrated above, consensus has not been reached regarding which factors constitute primary risk for CTS onset. This lack of consensus takes on added meaning in light of findings that past prevention programs have yet to justify their design and implementation. In a critical review of literature, Rosenbaum and Ochoa (2002) concluded that none of the ergonomic or prevention programs have shown efficacy in reducing CTS risk. This underscores the need to base prevention strategies on empirically supported risk factors as opposed to putative risk factors.

The investigator had two primary purposes for the present study. First, the investigator hoped to add clarity to the current risk factor literature by identifying valid occupational and personological risk factors associated with CTS. Second, the investigator sought to extend the current research literature by delineating which, if any, psychosocial constructs increase risk for CTS. The investigator used a case-control methodology and assessed participants with and without CTS on a number of potential risk factors. The overarching hypothesis was that CTS is a multiply determined syndrome and highest risk would result from the combined effect of occupational, personological, and psychosocial risk factors.

CHAPTER II

REVIEW OF LITERATURE

General Overview of Carpal Tunnel Syndrome

The review of literature will be presented in three sections. The first section will provide a general overview of CTS. Following the general overview will be a discussion of risk factor classification guidelines for epidemiological research. Lastly, the CTS risk factor literature will be reviewed.

The general overview of CTS will cover the following areas: (a) the anatomy of the carpal tunnel, (b) the symptoms of CTS, and (c) the diagnosis of CTS. The purpose for the review of the anatomy of the carpal tunnel is to familiarize the reader with the biomechanics underlying CTS. This will serve to provide an understanding of how exposure to certain factors may cause damage to the median nerve within the carpal tunnel and increase risk for CTS. The purpose for reviewing the symptoms and diagnosis of CTS is to demonstrate the rationale for the case definition used in the present study.

The Anatomy of the Carpal Tunnel

The carpal canal is an open-ended, fibrosseus canal in the wrist, through which pass the median nerve, nine flexor tendons of the fingers and their sheaths (Viikari-Juntura & Silverstein 1999). The floor (i.e., dorsal and lateral sides) of the tunnel is formed by the eight carpal bones. The transverse carpal ligament forms the roof (i.e., volar side) of the canal and completes the oval-shaped tunnel (Cantatore, Dell'Accio, & Lapadula, 1997; Rosenbaum & Ochoa, 2002). The fibrosseus nature of the canal makes it a rigid structure (Viikari-Juntura & Silverstein). Further, although the carpal canal is an anatomically open-ended compartment, pressure does not freely transfer in and out of the canal, which causes it to function as a closed structure (Cantatore et al.; Viikari-Juntura & Silverstein). This leaves the carpal canal susceptible to high levels of pressure, which can result in ischemia (low oxygen usually due to obstruction of arterial blood flow) induced damage to the median nerve and subsequent CTS symptoms (Cantatore et al.). In addition, high levels of carpal canal pressure may result in irritation and swelling of the flexor tendons and/or palmar bowing of the transverse carpal ligament, both of which may cause compression of the median nerve and symptoms of CTS (Jarvik & Yuen, 2001; Jeng, Radwin, & Rodriquez, 1994). Pressure induced damage may lead to demyelination (loss of myelin with preservation of the axons or fiber tracts; Rosenbaum & Ochoa) and eventually complete axonal loss can occur (Jarvik & Yuen).

Symptoms of Carpal Tunnel Syndrome

The typical clinical picture of CTS is pain and paresthesia of the hand in the median nerve innervated digits (thumb, index finger, middle finger, and half of the ring finger; Cantatore et al., 1997; Rosenbaum & Ochoa, 2002; Szabo, 1998). It is also common for patients to complain of pain that radiates into the forearm, upper arm, and even into the shoulder (Jarvik & Yuen, 2001). Pain and paresthesia are typically worse at night, and CTS patients often report nighttime pain episodes that awaken them from sleep (Jarvik & Yuen; Padua, Padua, LoMonaco, Romanini, & Tonali, 1998). Patients with CTS may obtain relief from pain and numbness by shaking the hand, which is referred to as the "flick test," and is itself a valid and reliable clinical sign of CTS (Phillups, 1984). Carpal tunnel-related paresthesias are frequently accompanied by sensory deficits in the median nerve innervated regions of the hand (e.g., reduced two-point discrimination, reduced perception of pin prick; Rosenbaum & Ochoa). Additional symptoms reported by patients include weakness or clumsiness of the hand, history of dropping objects from hands, weak grip, dry skin, and swelling or color changes in the hand (American Academy of Neurology, American Association of Electrodiagnostic Medicine, and American Academy of Physical Medicine and Rehabilitation, [AAM,AAEM,AAPMR] 1993). Finally, in severe CTS, weakness and even wasting of the thumb muscles is not uncommon (Cantatore et al.).

Diagnosis of Carpal Tunnel Syndrome

Before a discussion of the diagnosis of CTS is undertaken, it is important to differentiate between the terms *sensitivity* and *specificity*. Sensitivity refers to the ability of a test to accurately identify those who truly have a particular syndrome. Specificity refers to the ability of a test to accurately identify those who do not have a particular syndrome. Thus, the sensitivity for a CTS test would be the number of individuals positively diagnosed with CTS divided by the total number of CTS cases. The specificity of a CTS test would be the number of individuals with a negative CTS test result, divided by the total number of negative CTS cases. These terms become important when considering the findings from a group of expert CTS research physicians who met to determine consensus guidelines for CTS (Rempell, Evanoff, et al., 1998). The group's first conclusion was that there is no diagnostic gold standard for CTS. As such, it is advantageous to review diagnostic protocols and identify those that have evidence to support their use.

Clinical symptoms of Carpal Tunnel Syndrome. The Quality Standards Subcommittee of the American Academy of Neurology (QSS AAM) met in 1993 and reviewed the CTS literature for the past 10 years (QSS AAM). With respect to diagnosis based on clinical symptoms, the subcommittee concluded that the likelihood of CTS increases with the following number of standard symptoms: (a) dull, aching discomfort in the hand, forearm, or upper arm; (b) parasthesia in the hand; (c) weakness or clumsiness of the hand; (d) dry skin, swelling, or color changes in the hand; (e) occurrence of any of these symptoms in the median distribution; (f) symptoms provoked by sleep; (g) symptoms provoked by sustained hand or arm positions; (h) symptoms provoked by repetitive action of the hand or wrist; (i) symptoms mitigated by changes in hand posture; and (j) symptoms mitigated by shaking the hand (p. 2406). Similar diagnostic protocols have been put forth by Rempell, Evanoff, et al. (1998) and Padua et al. (1998).

Investigators studying the diagnostic accuracy of clinical symptom assessments have obtained sensitivity values ranging from .12 - .41 and specificity values ranging from .76 - .99 (Franzblau et al., 1994; Rempell, Evanoff, et al., 1998). The low sensitivity values suggested that sole reliance on clinical symptoms as a case definition for CTS may be less than optimal for research trials.

Electrodiagnostic testing in carpal tunnel syndrome. Electrodiagnostic (EDX) testing for CTS consists of nerve conduction studies in which the median nerve is stimulated and the latency of the conduction impulse across the carpal tunnel is recorded. Median nerve latencies are either compared to latencies of other nerves in the hand, or with published normative values. Conduction slowing of the median nerve suggests nerve damage, and is reflective of CTS (Jarvik & Yuen, 2001). In addition, the degree of slowing is thought to reveal the severity of median nerve damage, with mild slowing suggestive of early CTS and severe slowing (or absence of conduction value) suggestive of advanced CTS (Jarvik & Yuen). Electrodiagnostic testing may involve assessment of both sensory and motor nerve fibers. Sensory nerve conduction studies are considered to be more sensitive, however, motor conduction studies are useful in assessing the severity of CTS (Cantatore et al., 1997).

Electrodiagnostic testing is widely accepted as the most accurate single method for diagnosing CTS (Arons & Hasbani, 1997; Jablecki, Andary, So, & Williams, 1993; Katz, Larsen, Fossel, & Laing, 1991). The AAN, AAEM, and AAPMR (1993) issued a summary statement that EDX studies "have been found to be highly sensitive and specific for the diagnosis of CTS."

Specifically, the QSSAAM reviewed 165 research articles and reported sensitivity values ranging from 49 - 85% and specificity values greater than 95%. Likewise, Rempell and the group of CTS expert medical researchers (Rempell, Evanoff, et al., 1998) concluded that "electrodiagnostic study findings are considered to be the most accurate single test" (p. 1148).

AAN, AAEM, and AAPMR (1993) issued the following standards and guidelines for performing EDX testing. Standard 1: Sensory conduction studies across the wrist of the median nerve and, if results are abnormal, of one other sensory nerve in the symptomatic limb; Standard 2: If the initial median sensory nerve conduction study across the wrist has a conduction distance greater than 8 cm and the results are normal, additional studies as follows: (a) Median sensory conduction across the wrist over a short (7 to 8 cm) conduction distance, or (b) comparison of median sensory conduction across the wrist with radial or ulnar sensory conduction across the wrist in the same limb. Guideline: Motor conduction studies of the median nerve recording from the thenar muscle and of one other nerve in the symptomatic limb, to include measurement of distal latency.

Jarvik and Yuen (2001) described commonly used nerve conduction studies that would meet the AAN, AAEM, and AAPMR (1993) standards and guidelines. Procedures for Standard 1 testing would involve stimulation of the median and ulnar nerves at the wrist and recording the latencies at the ring finger. The authors noted that because the ulnar nerve does not cross the carpal tunnel, comparison of the two nerves gives information regarding median nerve damage within the carpal tunnel. Differences in peak latencies of 0.4 ms or greater are considered abnormal. The sensitivity and specificity of this test is reported to be 82 - 95%, respectively (Jarvik & Yuen). Procedures for Standard 2 testing would involve stimulation of the median and ulnar sensory nerves at the palm and recording the latencies at the wrist 7 or 8 cm apart. Differences in peak latencies of 0.4 ms or greater are considered abnormal. The reported sensitivity for this test is 66%

and the specificity 95% (Jarvik & Yuen). The most sensitive motor conduction test that would meet the first AAN, AAEM, and AAPMR guideline is stimulation of the median and ulnar motor nerves at the wrist and recording the latencies at the abductor pollicis brevis (Jarvik & Yuen). This test typically is positive in moderate or severe CTS cases. Differences in peak latencies of 1.2 ms or greater are considered abnormal (Cosegrove et al., 2002). The sensitivity of this test is approximately 67%, with the specificity 97% (Jarvik & Yuen).

Despite these high values, Rempell, Evanoff, et al. (1998) indicated that when assessing populations of healthy workers, the sole reliance on EDX testing may not be appropriate. More specifically, the authors noted that the use of EDX testing with healthy populations may result in a high number of false positives. For instance, Nathan, Takigawa, Keniston, Meadows, and Lockwood (1994) reported on a study of Japanese furniture workers and found that while 18% of the workers had abnormal EDX results, only 2% reported clinical symptoms of CTS. Likewise, Pritchard, Keenan, Croft, and Silman (1998) estimated that 10 - 18% of the general population exhibited abnormal slowing of the median nerve at the carpal canal; although only one fifth of those individuals reported symptoms of CTS. Hence, while the use of EDX testing has been associated with high predictive values among "high risk" populations (e.g., participants referred to electrodiagnostic centers, etc.), specificity values may be attenuated when assessing "healthy populations" (Rempell, Evanoff, et al.).

Additional guidelines. According the Rempell et al. (1998) group, the optimal case definition (i.e., that with the highest predictive value) is one that includes the assessment of both clinical symptoms and EDX testing. However, the authors noted that specific sensitivity and specificity values were not possible to report, as EDX testing alone is typically used as the comparative "gold standard." In addition, the Rempell group provided guidelines for when EDX testing is unavailable and when symptom reports are inconsistent with EDX study results. When

EDX testing is unavailable, the group suggested that, "combination of symptom characteristics and physical exam findings provide the greatest diagnostic information." (p. 1448). The sensitivity values for this diagnostic procedure ranged from .07 - .41 and the specificity values ranged from .76 - .99. With respect to conflicting results, the group concluded that without the presence of clinical symptoms, the likelihood of CTS was low, regardless of EDX findings. When symptoms are present, however, and EDX testing results are negative, the group was not able to reach a consensus.

In summary, the literature suggests that EDX testing is the most accurate single test for CTS. Moreover, inclusion of symptom reports with EDX testing results in further diagnostic accuracy. On the other hand, sole reliance on EDX testing in epidemiological research may result in a high number of false positives if healthy study participants are used. Finally, when EDX testing is not available, the most appropriate method for diagnosing CTS is thought to be the combination of symptom reports and physical examinations.

Risk Factor Classification Typology

This section of the literature review will discuss risk factor classification strategies in epidemiological research. Following, the author will review the CTS risk factor literature from the conceptual framework of a risk factor typology.

Kraemer, Kazdin, Offord, Kessler, Jensen, and Kupfer (1997) defined a risk factor as

> a measurable characterization of each subject in a special population that precedes the outcome of interest and which can be used to divide the population into 2 groups (the high risk and the low risk groups that comprise the total population). (p. 338)

Accordingly, risk factors for CTS would be those variables that have been shown to *precede* and *increase* the risk for CTS. Given the emphasis on precedence, only variables identified through longitudinal or prospective studies would be appropriately labeled as risk factors. In contrast, variables identified through cross-sectional studies (e.g., correlational, case-control, etc.) would not meet risk factor criteria as it remains unclear if such factors are antecedents, correlates, or consequences of the outcome in question. Instead, such variables are assigned "preliminary status" until precedence is established through prospective research designs. As such, the status of a particular risk factor should be directly related to the methodologies used to establish its relationship with a particular outcome. Unfortunately, past CTS research has failed to differentiate between risk factors that have been shown to precede and increase risk for CTS and correlates identified through cross-sectional research. Instead, all variables that have been found to be associated with CTS have been indiscriminately classified as risk factors, irrespective of the methodology used to establish the association.

Kraemer et al. (1997) proposed a risk factor typology that classifies different types of risk factor-disease relationships based on the design used to establish the relationship. At the first level of the typology are *correlates*. *Correlates* are variables identified through cross-sectional research designs (e.g., correlational, population-based epidemiological, family studies, etc.). The term *correlate* is thought to be an appropriate label for such variables as it does not connote precedence. Exceptions to this preliminary status are *fixed markers,* which are variables that remain relatively immutable (e.g., race, sex, etc.) and/or can be shown to precede disease onset (e.g., documentation in medical records, birth records, etc.). At the next level of the typology are *risk factors*. As previously indicated, the term *risk factor* is justified only when it can be shown that the variable precedes and increases disease onset through prospective research designs. Kazdin, Kraemer, Kessler, Kupfer, and Offord (1997) identified several types of *risk factors*. *Variable markers* are risk factors that can be shown to change within participants (e.g., weight, age, etc.) or change through interventions (e.g., medication, therapy, etc). *Variable markers* may be established through longitudinal studies and prospective randomized clinical trials. *Causal risk factors* are variables for which it can be shown that manipulation changes the risk of a particular outcome. *Causal risk factors* are established through prospective randomized clinical trials. Lastly, as alluded to above, *fixed markers,* are variables that cannot be demonstrated to change and may be established through cross-sectional or longitudinal research studies.

Differentiating between established risk factors and preliminary correlates may have implications for prevention programs. As suggested by Coie et al. (1993), the goal of prevention science is "prevent or moderate human dysfunction" (p. 1013). As such, successful prevention programs should seek to intervene with variables that have been shown to elevate risk for future dysfunction (as opposed to variables that are concomitants or consequences of the dysfunction). Likewise, to successfully mitigate dysfunction, prevention strategies should focus on variables that are modifiable through intervention. To identify modifiable risk factors, it is first necessary to appropriately classify putative risk factors according to their established relationship with the dysfunction. A risk factor typology that differentiates between correlates, fixed markers, variable markers, and causal risk factors may serve as a useful guide for developing future prevention strategies.

With these considerations, the following section will review the CTS risk factor literature and classify the numerous putative risk factors according to the typology suggested by Kraemer et al (1997) and Kazdin et al. (1997). For each risk factor, longitudinal studies will first be discussed followed by cross-sectional studies.

Review of Carpal Tunnel Syndrome Risk Factor Literature

To obtain the articles for the current review, the author searched Medline and Psychinfo databases for research studies that had investigated risk factors and CTS. Additionally, bibliographies from preliminary studies were scrutinized for relevant studies. In total, 66 studies were located and included in the current review. The findings from these articles will be presented in three sections: (a) occupational risk factors for CTS, (b) personological risk factors for CTS, and (c) psychosocial risk factors for CTS. The organization of the review into these three categories was based on several considerations. First, as previously indicated, debate exists as to whether CTS is primarily an occupational syndrome or more associated with personological risk factors (Bekkelund, Pierre-Jerome, Tobergsen, Ingebrigsten, 2001; Cosegrove et al., 2002; Nathan, Keniston, Myers, & Meadows, 1992a; Silverstein, Lawrence, & Armstrong, 1987; Solomon, Katz, Bohn, Mogun, & Avorn 1999; Werner, Franzblau, Albers, & Armstrong, 1997a). Given this debate, much of the risk factor research literature is organized according to occupational and personological findings. The specific occupational and personological factors included were those variables that have received the most empirical attention. It was speculated that more frequently studied variables would allow for stronger conclusions regarding their empirical status, thereby enhancing the accuracy of their placement in the risk factor typology. A distinct category for psychosocial variables was included in hopes of clarifying which, if any, psychosocial variables may be associated with CTS. That is, the small number of studies that have investigated psychosocial variables have reported conflicting results and used nondistinct measures of psychosocial dysfunction, leaving it difficult to draw any meaningful conclusions. As such, the findings from psychosocial variables were reviewed separately to allow for closer inspection for trends in the findings from these studies.

For each of the factors included in the review, the findings from longitudinal studies will first be discussed, followed by the findings from cross-sectional studies. The review will also include discussions regarding the methods used to diagnose CTS and the measures used to assess exposure to the risk factor. Accordingly, the results of studies will be inspected for differential trends in findings based on diagnostic protocols and/or risk factor measurements. Furthermore, based on studies that reported odds ratios, a mean odds ratio for each factor will be reported. Lastly, each factor will be assigned a final classification status in the CTS risk factor typology.

The characteristics for each of the studies are provided in the Table of Literature Review Study Characteristics located in Appendix A. The first column of the table provides the study number for each of the 66 studies. Studies number 1 - 6 are the longitudinal/prospective studies. Given the small number of studies (and their emphasis in the risk factor classification taxonomy), the findings from longitudinal studies will be discussed in more detail. Study numbers 7-66 are the cross-sectional studies. To avoid repeated and lengthy listings of authors and study years, the cross-sectional studies will be referenced by their study number only. A summary of the literature review findings is provided in Table 1.

Occupational Risk Factors

In this section, occupational risk factors for CTS will be reviewed. The review will cover the following risk factors: (a) repetition of the hand and/or wrist, (b) force; (c) combined repetition-force, and (d) vibration.

Repetition. Considerable research has been conducted investigating repetitive physical work as a risk factor for CTS. While the majority of research has been cross-sectional in nature, four longitudinal studies were located for the present review (Nathan, Keniston, Myers, & Meadows, 1992b; Roquelaure, et al., 2001; Werner, Franzblaue, Albers, Buchele, & Armstrong, 1997b). Overall, the results of these studies are not consistent with the hypothesis that occupational repetition is a risk factor for CTS. Specifically, only one study found occupational reptition to be predictive of CTS, while three studies reported no increased risk. The duration

Table 1

Literature Review Summary

Study variable	Summary of longitudinal studies	Summaary of cross-sectional studies	Mean odds ratio	Final classification in the CTS risk factor typology
Occupational repetition	1 supporting study; 3 nonsupporting studies	16 supporting studies; 5 nonsupporting studies	3.38	Correlate
Occupational force	1 supporting study; 3 nonsupporting studies	5 supporting studies; 6 nonsupporting studies	--	Not included in risk factor typology
Combined repetition and force	2 nonsupporting studies	6 supporting studies; 5 nonsupporting studies	6.3	Correlate
Vibration	No studies	7 supporting studies; 1 nonsupporting study	3.46	Correlate
Female gender	1 supporting study; 4 nonsupporting studies	17 supporting studies; 1 nonsupporting study	1.94	Fixed marker
Gynecological surgery	No studies	4 supporting studies; 2 nonsupporting studies	3.24	Correlate
Oral contraceptive use	No studies	1 supporting study; 6 nonsupporting studies	--	Not included in risk factor typology
Hormonal menstrual problems/disorders	No studies	3 supporting studies; 2 nonsupporting studies	1.8	Correlate
Age	3 supporting studies; 2 nonsupporting studies	18 supporting studies; 7 nonsupporting studies	--	Variable marker

(*table continues*)

Study variable	Summary of longitudinal studies	Summaary of cross-sectional studies	Mean odds ratio	Final classification in the CTS risk factor typology
Obesity	3 supporting studies; 1 nonsupporting studies	15 supporting studies; 3 nonsupporting studies	3.25	Variable marker
Caucasian ethnicity	2 nonsupporting studies	3 supporting studies; 3 nonsupporting studies	--	Not included in risk factor typology
Diabetes Mellitus	2 nonsupporting studies	8 supporting studies; 6 nonsupporting studies	2.21	Correlate
Thyroid dysfunction	2 nonsupporting studies	3 supporting studies; 7 nonsupporting studies	--	Not included in risk factor typology
Advocatinal exercise levels	1 supporting study	1 supporting study	--	Classification pending further replication
Psychological dysfunction	1 supporting study; 1 nonsupporting study	2 supporting studies; 2 nonsupporting studies	3.32	Correlate
Job satisfaction	1 supporting study	2 nonsupporting studies	--	Classification pending further studies

of follow up of these studies spanned from 1-5 years, with the longer studies not supporting repetition as a risk factor.

In the one supporting study, Werner et al. (1997a) conducted a prospective case-control study of workers from several different industrial sites. Workers with abnormal EDX testing results but no clinical symptoms of CTS ("asymptomatic cases") were compared to workers with normal EDX testing results. Workers were followed for 1-2 years (range 10 months - 24 months). Repetition ratings were based on a rating scale of 1-10, with higher numbers suggestive of higher levels of repetition. Results of the study indicated that each unit increase in repetition was associated with an odds ratio of 1.35.

In contrast, Nathan et al. (1992a) carried out a 5-year longitudinal study of 316 industrial workers from 1984-1989. Exposure to occupational repetition was assessed using the Occupational Hand Use Rating Scale (OHU). The OHU is a 5-item self-report measure developed by Nathan, Keniston, Meadows, and Lockwood (1984), which categorizes individuals into one of the following five groups: (a) very light resistance/low levels of repetition, (b) light resistance/very high levels of repetition, (c) moderate resistance/moderately high levels of repetition, (d) heavy resistance/moderate repetition, and (e) very high resistance/high levels of repetition. Results of a stepwise regression analysis indicated that occupational repetition levels at 1984 were not significant predictors of CTS onset in 1989. In a similar study, Nathan et al. (1992b) reported on a 5-year longitudinal study involving 429 industrial workers. Occupational repetition was again assessed using the OHU. As with the first study, the results of a stepwise regression analysis suggested that occupational repetition ratings in 1984 were not significantly predictive of CTS onset in 1989. Finally, Roquelaure et al. (2001) carried out a prospective study of footwear factory workers. Following baseline assessment for CTS, 162 workers were followed for 1 year and reassessed for CTS. Occupational repetition was assessed both via self-report and workstation analyses. Workstation analyses defined work as repetitive if work cycles were less than 30 seconds and/or greater than one half of the workers' cycle was spent repeating the same motions. Results of the study indicated that occupational repetition was not predictive of CTS at follow-up.

Twenty-one cross-sectional studies have looked at the connection between occupational repetition and CTS. The characteristics of these studies are provided in Appendix A. Of the 21 studies, 16 found positive associations between repetition and CTS (21, 28, 34, 38, 40, 43, 44, 45, 46, 47, 49, 50, 51, 52, 55, 56), while five found no connection (23, 25, 27, 35, 48). The most common methodologies were standard cross-sectional designs, which accounted for 13 of the 21 studies. Of the remaining five studies, three used case-control designs (24, 46, 47, 51, 56, 51) and three were national survey studies (38, 50, 58). The number of study participants in the 21 studies ranged from 83 to 44, 232, with a median of 404.

Several different protocols were used in the 21 studies to diagnose CTS. As illustrated in Appendix A, nine studies used a stringent case definition requiring both clinical symptoms and EDX testing (21, 23, 28, 35, 43, 45, 46, 47, 55), three studies used EDX testing only (25, 27, 48), three relied on participants self-report (38, 40, 50), two used diagnostic codes in medical databases (34, 51), four required the presence of clinical symptoms and/or signs (44, 48, 49, 52), and one used carpal tunnel release surgery records as a proxy diagnosis (56). Consideration of differential study results by diagnostic protocol reveals a trend towards positive findings with studies that used appropriately stringent case definition. Specifically, seven of the nine studies that required both clinical symptoms and EDX testing reported positive findings (21, 28, 43, 45, 46, 47, 55). In contrast, all three studies that relied solely on EDX testing results reported negative findings (25, 27, 48). This latter trend towards negative findings may be, in part, explained by potential selection biases associated with the reliance on EDX testing only to diagnose CTS. As previously indicated, the (sole) use of EDX testing in epidemiological research may result in a high number of false positives (Nathan et al., 1992a; Pritchard et al., 1998; Rempell, Evanoff, et al., 1998). A high number of false positives may, in turn, restrict the detection of significant differences between cases and controls. On the other hand, studies that use case definitions with greater diagnostic accuracy (i.e., clinical symptoms and EDX testing) may be more likely to detect significant between group differences.

Exposure to occupational repetition was measured in numerous different ways in the 21 studies. Overall the measurement of repetition lacked standardization and appropriate psychometric validation. That is, the majority of researchers devised idiosyncratic methods to measure repetition, thereby limiting the extent to which repetition ratings may generalize beyond individual studies. Exceptions were found in six studies that used standardized and psychometrically valid measures of occupational repetition (21, 25, 27, 35, 48, 49). Three of those studies used the OHU, which is a self-administered questionnaire with adequate reliability and validity (25, 27, 48). The remaining three studies measured occupational repetition via the "Silverstein criteria" (21, 35, 49). The Silverstein criteria was developed by Silverstein and colleagues using written job analyses, videotaped job analyses, transcriptions of job descriptions, and electromyographic assessment of job performance. Based on these analyses, various jobs were classified into the following four categories: (a) low force-low repetition , (b) low force-high repetition, (d) high force-low repetition, and (d) high force-high repetition. Accordingly, study participants are classified into each category based on their job type (Silverstein et al., 1987). Silverstein and colleagues reported adequate reliability and validity with the use this method.

None of the remaining 15 studies used standardized measures of repetition. The most common practice was to have occupational physicians/hygienists rate the repetitiveness of jobs (repetitive vs. nonrepetitive or Likert rating scales) and then assigned study participants repetition ratings according to their job type (23, 43, 44, 45, 52, 55). In addition, four studies used self-report questionnaires and/or interviews to assess repetition (34, 46, 47, 51, 56), three used a one-item self-report dichotomous assessment of repetition (38, 40, 50), and one used a questionnaire along with selected biomechanical analyses of workstations (28). No trend for differential study results by method of repetition assessment was evident.

Twelve of the 18 cross-sectional studies reported odds ratio for repetition (21, 34, 38, 40, 44, 45, 47, 49, 50, 51, 55, 56). Based on these studies, the mean odds ratio (*OR*) for repetition was 3.38, indicating that the magnitude of association between occupational repetition and CTS is large.

Comparison of the results from the longitudinal and cross-sectional studies reveals noteworthy differences. In particular, the majority of longitudinal studies found no relationship between repetition and CTS, while the preponderance of cross-sectional studies reported positive associations. Several factors may account for this discrepancy. First, the cross-sectional studies possessed considerably larger sample sizes than did the longitudinal studies. Specifically, the mean sample size of the four longitudinal studies was 175, while the mean sample size of the 21 cross-sectional studies was 6,373. As such, the cross-sectional studies likely possessed considerably greater statistical power to detect significant between group differences. It seems worth noting, however, that greater power to detect between group differences should be considered along with the meaningfulness of the differences detected. This was stressed by Kraemer et al. (1997) when the authors stated "given a large enough sample size, virtually every factor could be demonstrated to be a risk factor for every outcome that follows" (p. 338). Thus, while heightened statistical power increases the detection of significant between group differences, this does insure that such differences are meaningful. Second, cross-sectional studies investigating repetition and CTS may be susceptible to certain biases that increase the likelihood of positive findings. For instance, Szabo (1998) noted that cross-sectional studies that compare populations of "high risk" and "low risk" workers (a common methodology of the cross-sectional studies in the present review) may report spuriously elevated rates of CTS among the high risk workers. The reason being that low risk workers may be less sensitive to occupational stressors (as compared to high risk workers) and therefore less likely to recall and report symptoms of CTS. Szabo further noted that the classification of job exposure in the majority of cross-sectional studies has not been blind to the health status of participants. As a result, when classifying the job exposures of known CTS participants, researchers may be more likely to notice repetitive aspects of work (i.e., confirmation bias). Adding to these biases, Kraemer and colleagues suggested that concomitants or consequences tend to be much more highly correlated with outcomes than actual risk factors. When considered together, the high correlations found in the cross-sectional studies may suggest that repetition is a correlate or consequence of CTS (as opposed to a risk factor that precedes onset), that increases in awareness (both among participants and researchers) following the emergence symptoms. Finally, longitudinal studies may fail to detect risk factors that have strong, but short-term effects on CTS development (Leclerc, Landre, Chastang, Niedhamer, & Roquelaure, 2001). Specifically, longitudinal studies with follow-up periods lasting longer than the noticeable effects of a certain risk factor may fail to detect the contribution of that risk factor. This may be particularly relevant in longitudinal studies investigating CTS as lag times between risk factor exposures and CTS onset is unknown (Leclerc et al.). Furthermore, as risk factor exposures tend to vary *within* longitudinal trials, the timing of follow-up measurement becomes an important consideration (Jacobi, Hayward, de Zwaan, Kraemer, & Agras, 2004). Again, this may be particularly relevant to longitudinal studies investigating CTS as none of the studies obtained interval measurements (i.e., measurements of risk factor exposure between baseline and follow-up).

In summary, occupational repetition is well documented to be associated with CTS in cross-sectional research. Furthermore, the magnitude of association between repetition and CTS would be considered large. However, findings from longitudinal and prospective designs have not supported the hypothesis that repetition is a risk factor for CTS. Furthermore, the measurement of repetition is plagued by lack of standardization and use of assessment tools without psychometric validation. As such, results of the current review suggest that occupational repetition is best classified as a correlate of CTS.

Force. Four longitudinal studies assessing occupational force as a risk factor for CTS were included in the present review (Leclerc et al., 2001; Nathan et al., 1992a, 1992b; Roquelaure et al., 2001). As with repetition, the majority of these studies did not support the hypothesis that force is a risk factor for CTS. Specifically, only one of the four studies (Leclerc et al.) found occupational force to be predictive of future CTS. The span of follow-up ranged from 1 - 5 years, with longer follow-up durations not being predictive of CTS incidence.

The single supporting study was a prospective study of 598 industrial workers with a follow-up period of 3 years (Leclerc et al., 2001). Diagnosis of CTS was based on medical examinations or diagnoses in charts. Measurements of force were obtained from self-report questionnaires regarding the working conditions of study participants. The questionnaire inquired into the frequency of nine forceful movements (e.g., "tighten with force," "work with force," "press with hand," etc.). Results of the study indicated that males who worked at jobs requiring them to "tighten with force" and "hold in position," had significantly elevated odds ratios for CTS (4.09 and 3.59, respectively). In females, however, no relationship between occupational force and CTS was found.

In contrast, the remaining three studies did not find occupational force to be a risk factor for CTS. Roquelaure et al. (2001) conducted a prospective study of 162 footwear workers with a follow-up period of 1 year. Diagnosis of CTS was based on the presence the clinical symptoms and/or signs and lack of confounding diagnoses. Exposure to force was assessed using a self-report questionnaire and analyses of work stations. Results of the study indicated that force was not significantly associated with CTS at follow-up. In addition, Nathan et al. (1992a) and Nathan et al. (1992b) carried out two longitudinal studies that both found occupational force to be unrelated to CTS at follow-up.

Eleven cross-sectional studies were located that investigated the relationship between occupational force and CTS (14, 21, 25, 27, 35, 42, 47, 49, 55, 56, 62). As shown in Appendix A, five of the 11 studies found force to be significantly associated with CTS (14, 21, 42, 56, 62), while 6 found no association (25, 27, 35, 47, 49, 55). The majority of studies used standard cross-sectional designs (14, 21, 25, 27, 35, 42, 49, 55, 62), with the exception of two case-control methodologies (47, 56). The number of participants in the 11 studies ranged from 36 to 4,137, with a mean of 633.8.

With respect to diagnosis of CTS, only four of the 11 studies used a stringent case-definition, requiring both clinical symptoms and EDX testing (21, 35, 47, 55). Two studies used carpal tunnel release surgery as a proxy diagnosis (14, 56), three used only abnormal EDX testing results (25, 27, 42), one required only clinical symptoms and/or signs (49), and one used clinical signs and/or symptoms, or carpal tunnel release surgery (62). No trend for differential study results by diagnostic protocol was evident.

Several different methods for measuring exposure to occupational force were used in the 11 studies. Appendix A illustrates that only five of the 11 studies used psychometrically validated assessments of force (21, 25, 27, 35, 49). Of the remaining studies, two classified participants by occupation type (14, 62), one used results of interviews to assign ratings of force (47), one used an interview and job evaluation checklist (42), one used rating scales and video-taped analyses of work stations (55), and one used a self-report questionnaire (56). The lack of standardized and psychometrically valid measurements of force leaves it difficult to generalize findings beyond individual studies.

Odds ratios between force and CTS were reported in only three studies (1, 21, 56). Based on these studies, the mean OR for force was 3.3. While this is considered a large association, it is tempered by the small number of studies from which it was derived, as well as the overall equivocal results of the 11 studies.

In summary, longitudinal studies have not supported the hypothesis that occupational force is a risk factor for CTS. Furthermore, results from cross-sectional studies have been equivocal. Moreover, the majority of studies used individualized methods to measure force, which limits the generalization of study findings. As such, results of the present review do not support the inclusion of force in the CTS risk factor typology.

Combined repetition and force. Despite considerable research investigating the relationship between combined repetition and force and CTS, only two longitudinal studies were located for the present review. Both studies were 5-year longitudinal trials conducted by Nathan and colleagues (Nathan et al., 1992a, 1992b), which reported no relationship between repetitive and forceful work and CTS development.

In contrast, 11 cross-sectional studies assessing repetition and force were located in the present review (7, 25, 26, 27, 35, 39, 41, 42, 49, 53, 54). Inspection of Appendix A reveals that six of the 11 studies found positive associations between repetitive-forceful work and CTS (7, 41, 42, 49, 53, 54), while five reported null findings (25, 26, 27, 35, 39). With the exception of one case-control methodology (54), all the studies used standard cross-sectional designs. The number of study participants ranged from 33 to 4137, with a mean of 738.18.

The stringency of diagnostic protocols varied considerably across studies. Specifically, three of the 11 studies used a case-definition that required both clinical signs and abnormal EDX testing results (35, 42, 54). In addition, one study required both clinical symptoms and EDX testing or carpal tunnel release surgery (53). Of the remaining studies, six relied only on EDX testing (7, 25, 26, 27, 39, 41), and one used clinical symptoms and/or signs (49). Consideration of differential study results by diagnostic protocol reveals a slight trend towards positive findings with studies that used stringent case definitions (3 to 1). In contrast, results from studies that used only EDX testing were equivocal.

The measurement of repetition and force exposure lacked standardization and appropriate psychometric validation. Only four of the 11 studies used a validated assessment (25, 27, 35, 49), while the remaining seven studies used individualized methods (7, 26, 39, 41, 42; 53, 54) to combined repetition and force. Three rated participants according to job types (26, 39, 41), one used an occupational physician to classify exposure ratings (7), one used observations and interviews with workers (42), one used self-report questionnaire, job station analyses, and neurophysiologic examinations (53), and one used a self-report questionnaire (54). Again, the lack of standardized and psychometrically valid assessments of repetitive and forceful work merit caution in generalizing the study findings.

Four studies reported odds ratios between repetitive and forceful work and CTS (41, 49, 53, 54). Based on these studies, the *OR* for repetitive and forceful work is 6.3, which is considered a large association.

The results of studies investigating combined repetition and force consistently differed between longitudinal and cross-sectional studies. Specifically, the two longitudinal studies found no relationship between repetitive and forceful work and CTS, while the majority of cross-sectional studies reported positive associations. Possible explanations for this difference are similar to those suggested for repetition, including: (a) larger sample sizes (greater statistical power) in cross-sectional studies, (b) susceptibility of cross-sectional studies to recall and classification biases, and (c) potential discrepancies between the duration of follow-up in longitudinal studies and the length of risk factor effects.

In summary, data is lacking from longitudinal studies to support repetitive and forceful work as a risk factor for CTS. Furthermore, the measurement of repetition and force lacks standardization and psychometric validation. On the other hand, results from cross-sectional studies are fairly consistent with the hypothesis that repetitive and forceful work is associated with CTS. Furthermore, a slight trend towards positive findings in studies that used stringent case definitions seemed evident, and the mean magnitude of association was large ($OR = 6.3$). As such, the present review classifies combined repetition and force as a correlate of CTS.

Vibration. Exposure to vibration is a commonly cited risk factor for CTS. Unfortunately, no longitudinal studies investigating vibration as a risk factor for CTS were located. Cross-sectional research, however, has consistently found positive associations between vibration and CTS. Specifically, eight studies were located for the present review (19, 34, 40, 47, 50, 51, 55, 60) and seven reported positive findings (19, 34, 40, 47, 50, 51, 60). With respect to methodologies, three studies used case-control designs (34, 47, 51), two were national survey studies (40, 50), two were standard cross-sectional designs (19, 55), and one was an epidemiological and clinical study (60). The number of study participants spanned from 96 to 44, 233, with the median being 271.

Several different protocols were used to diagnose CTS. Three of the eight studies used a stringent case-definition, requiring the presence of both clinical symptoms and EDX testing (19, 47, 55). Of the remaining studies, two relied on diagnoses in medical charts (34, 51), two asked participants if they had been diagnosed with CTS by a health care provider (40, 50), and one used clinical symptoms and/or signs diagnose CTS (60).

The primary method for assessing exposure to vibration was self-report use of hand -held vibratory tools while at work (19, 34, 40, 47, 50, 51). Exceptions were found in two studies, one that used occupational physicians to rate vibration exposure (55), and one that directly measured vibration exposure via acceleration recordings from chain saws (60). Five of the eight studies reported *OR* for vibrations exposures (34, 40, 47, 50, 51). The mean *OR* from these five studies was 3.46, which is considered large.

In summary, data from longitudinal research on vibration and CTS is lacking. However, results from cross-sectional studies have consistently supported the notion that exposure to vibration is associated with CTS. The mean *OR* reported for vibration was large (3.46), and may be considered fairly representative as the majority of studies reported odds ratios. Thus, the present review classifies occupational vibration as a correlate of CTS.

Occupational Risk Factor Conclusions

The present section reviewed the occupational factors associated with CTS. It was suggested that repetition, combined repetition and force, and vibration are correlates of CTS, while force is lacking empirical support for inclusion in the risk factor taxonomy. The present section also revealed that measures of occupational exposure are lacking in standardization and psychometric validation. Thus, the reliability and validity of the measures used to assess occupational exposure remain questionable, which renders generalizations beyond individual studies tenuous. It was also suggested that occupational studies have used numerous different protocols for diagnosing CTS. As sensitivity and specificity values vary between protocols, the studies reviewed were likely quite different with respect to their abilities to detect true differences between groups. Indeed, slight trends towards positive findings were revealed in studies that used more stringent case definitions (repetition and combined repetition and force). The following section will review the personological factors implicated in CTS.

Personological Risk Factors

Research findings have implicated several personological risk factors with CTS. Variables such as female gender, age, and obesity have well-established relationships with CTS. Other personological variables (e.g., exercise, gynecological surgery, diabetes mellitus, etc.) have been researched less systematically, but the results from existing studies suggested that a relationship may exist.

Female gender. Female gender is a widely accepted risk factor for CTS. In fact, it has been common for carpal tunnel researchers to conduct case-control studies that match participants on gender. For the present review, five longitudinal studies investigating female gender as a risk factor for CTS were located. Four studies did not find female gender to be predictive of CTS, while one study reported positive findings.

In the sole supporting longitudinal study, Gorsche et al. (1999) conducted a prospective incidence study of 421 industrial workers with negative EDX testing results at baseline. After a follow-up period of 1 year, female gender was associated with an *OR* of 1.8. In contrast, Leclerc et al. (2001) conducted a 3-year prospective study that did not find increased incidence rates for females. Likewise, Roquelaure et al. (2001) found no increased incidence of CTS in females after a 1-year follow-up period. Finally, in the two longitudinal studies conducted by Nathan and colleagues (Nathan et al., 1992a, 1992b), female gender was not predictive of CTS onset after 5-year follow-up periods.

The results of cross-sectional research have consistently found female gender to be associated with CTS. The present review located 18 cross-sectional studies, 17 of which found a positive association with CTS (11, 12, 14, 15, 33, 36, 38, 40, 45, 50, 53, 58, 61, 63, 64, 65, 66). With respect to the methodologies used in the 18 studies, three were standard cross-sectional designs (11, 31, 63,), three were national survey studies (40, 50, 58), two were population-based incidence studies (15, 66), one was a national prevalence study (38), two were retrospective cohort studies (53, 61), two were retrospective patient studies (33, 36), one was a retrospective study (65), one was a patient study (14), one was a case-control study (12), and one was an epidemiological study (64). The number of study participants spanned from 96 to 44,233, with the median number of study participants being 2,630.

Several different diagnostic protocols were used across the 18 studies. Five used a stringent case definition that required both clinical symptoms and EDX testing (11, 36, 45, 53, 63). Of the remaining studies, four used diagnostic codes located in databases (15, 33, 64, 66), three used participants' self-report of being diagnosed by a health care provider (40, 50, 58), two used "clinical diagnoses" (12, 14), one used EDX testing alone (31), one used self-reported CTS (38), one used clinical symptoms and/or signs (65), and one required two out of three criteria to be present (symptoms, signs, or EDX testing) (61). No trend for differential findings by diagnostic protocol were evident. A total of six studies reported odds ratios for female gender and CTS (11, 40, 45, 50, 53, 58), with the mean *OR* being 1.94.

In summary, longitudinal studies did not support female gender as a risk factor for CTS, while cross-sectional research consistently found a positive association between female gender and CTS. However, as gender is a relatively immutable characteristic, it is most appropriately categorized as a fixed marker of CTS.

Female-related complications. The three most common female-related complications studied with CTS have been gynecological surgery, oral contraceptive use, and menstrual-hormonal problems. No longitudinal studies investigating any of the female-related complications were located for the present review.

Gynecological surgery was investigated in six cross-sectional studies (16, 33, 34, 46, 49, 57). As illustrated in Appendix A, four of the six studies found gynecological surgery to be associated with CTS (16, 33, 34, 46), while two found no such association (49, 57). In addition, three studies reported odds ratios for gynecological surgery (16, 34, 46), with the mean *OR* from these studies being 3.24. Based on these studies, gynecological surgery is classified as a correlate of CTS.

The present review also found seven cross-section studies that had looked at the relationship between oral contraceptive use and CTS (13, 34, 43, 44, 46, 49, 52). Six of the seven studies found no relationship between oral contraceptive use and CTS (34, 43, 44, 46, 49, 52), while one found a positive association (13). As such, the present review did not support the inclusion of oral contraceptive use in the CTS risk factor typology.

Five cross-sectional studies investigating hormonal/menstrual problems/disorders (which includes hormonal replacement therapy) were located (8, 12, 13, 44, 57). As shown in Appendix A, three studies found a positive association with CTS (12, 13, 57), while two found no association (8, 44). One study reported an odds ratio (12), which was 1.8. Based on these studies, hormonal/ menstrual problems/disorder is currently classified as a correlate of CTS.

Age. Increasing age is another commonly cited risk factor for CTS. As with gender, CTS researchers have frequently conducted case-control studies that match participants on age. Five longitudinal studies were located that investigated age as a risk factor for CTS. Findings from three of the five studies supported the hypothesis that increasing age is a risk factor for CTS. In particular, Leclerc et al. (2001) conducted a 3-year prospective study that found an *OR* of 1.25 for individuals between the ages of 30 - 39. In addition, Nathan and colleagues (Nathan et al., 1992a, 1992b) carried out two longitudinal studies (5-year duration) that both found increasing age to be associated with increased rates of CTS.

In contrast, Werner et al. (1997a) conducted prospective study of 108 industrial workers with a follow-up period of 1 - 2 years. Study results did not find increased age to be associated with increased CTS rates. Likewise, Roquelaure et al. (2001) carried out a prospective study of 162 footwear factory workers with a follow-up period of 1 year. Results of the study did not find the increase of 1 year in age to be associated with increased rates of CTS.

It seems noteworthy that the studies with longer follow-up periods reported positive associations between increasing age rates and CTS, while the two studies that reported negative findings had brief follow-up periods (i.e., 1 year and 1 - 2 years). More specifically, it may be unlikely that the deleterious health-related effects of aging would manifest within the span of 1 - 2 years.

Cross-sectional research has consistently found age to be associated with increased rates of CTS. Twenty-five cross-sectional studies investigating the relationship between age and CTS were located for the present review. Eighteen of the 25 studies reported positive associations (11, 13, 14, 15, 24, 25, 26, 31, 35, 36, 38, 40, 44, 48, 50, 53, 58, 66), while seven studies found no significant relationships (7, 29, 32, 34, 37, 39, 45). Regarding the methodologies, 10 of the studies used standard cross-sectional designs (7, 11, 25, 26, 31, 35, 37, 39, 44, 48), two were epidemiological studies (13, 45), three were patient studies (14, 29, 36), two were population-based incidence studies (15, 66), three were case-control studies (24, 32, 34), three were national survey studies (40, 50, 58), one was a national prevalence study (38), and one was a retrospective cohort study (53). The number of study participants spanned from 63 to 44,233, with the median being 563.5.

Several different protocols for diagnosing CTS were used in the 25 studies. Five used a stringent case-definition, requiring both clinical symptoms and EDX testing abnormalities (11, 24, 35, 45, 36). Of the remaining studies, eight used EDX testing only (7, 25, 26, 29, 31, 37, 39, 48,), three used diagnoses found in medical charts of databases (15, 34, 66), three asked participants if they had received a diagnosis of CTS by a health care provider (40, 50, 58), two studies used a record of carpal tunnel surgery as a proxy diagnosis (14, 32), one used participants self-report (38), one used clinical symptoms only (44), one used a clinical diagnosis (13), and one used clinical symptoms/signs or past CTS surgery (53). Inspection for trends in study results revealed a higher ratio of positive findings in studies that used a more stringent case definition (4:1). In contrast, when EDX testing alone was used the ratio of positive to negative findings was 1 to 4.

Odds ratios were reported for various age intervals across studies. As such, the calculation of a single *OR* for age was not possible. However, the study results did suggest that odds ratios increased with age. For instance, the *OR* for individuals 30 - 39 years of age was reported to be 1.25 (1), while the *OR* for individuals age 45 - 66 was reported to be 2.0. Consistent with this trend, another study reported an *OR* increase of 3.3 for each 10 years.

In summary, considerable research has been accumulated to support the hypothesis that increasing age is associated with CTS. Increased risk seems to begin in the 30s steadily increase over the next three decades. Of particular importance for the present review, the findings from longitudinal studies were consistent with those from cross-sectional studies. As a result of this consistency, age is given definitive status in the risk factor typology and classified as a variable marker.

Obesity. Considerable research has linked obesity to increased rates of CTS. The most common method for assessing obesity has been assessed through calculations of the Body Mass Index (BMI). Consistent with the National Center for Health Statistics and Center for Disease Control and Prevention classifications (Flegal, Carroll, Kuezmarski, & Johnson, 1998), BMI values from 25 - 29 are typically considered overweight, and BMI values of 30 and greater are considered obese.

Four longitudinal studies have investigated obesity as a risk factor for CTS. Three of the four studies supported the hypothesis that obesity increases risk for CTS. Specifically, Leclerc et al. (2001) conducted a 3-year prospective study of 598 industrial workers and reported that obese female participants were significantly more likely to develop CTS over the study period (*OR* =2.38). Likewise, Roquelaure et al. (2001) reported an *OR* of 4.4 for obese participants after a 1-year prospective trial. In addition, Nathan et al. (1992b) conducted a 5-year longitudinal study that found obesity was a significant predictor of future CTS. In contrast, Werner et al. (1997a) conducted a 1-2 year prospective study and found no association between obesity and CTS.

Seventeen cross-sectional studies examining obesity were located for the present review. Of those 17 studies, 14 found positive correlations between obesity and CTS (8, 11, 13, 24, 25, 31, 32, 35, 36, 52, 53, 56, 57, 60), while three reported null findings (34, 46, 55). With respect to the methodologies, six studies used standard cross-sectional designs (11, 25, 31, 35, 52, 55), six were case-control studies (8, 24, 32, 34, 46, 56), two were epidemiological studies (13, 57), one was a retrospective patient study (36), one was a retrospective cohort study (53), one was a national survey study (50), and one was an epidemiological and clinical study (60). The number of study participants ranged from 96 to 4, 137, with the mean number of participants being 947.

The protocols used to diagnose CTS varied considerably across studies. Six studies used a stringent protocol for diagnosing CTS (symptoms and EDX), while an additional study required either clinical symptoms and EDX or history of past surgery (53). Three studies used a history of CTS surgery as a proxy diagnosis for CTS (32, 56,57), two studies used EDX testing only (25, 31), two studies used diagnoses found in medical charts or databases (8, 34), two studies relied on clinical symptoms/signs (52, 60), one study used clinical diagnosis for CTS (13), and one study used participants self-report of being diagnosed with CTS by a health care provider (50). In addition, 10 studies reported odds ratios for obesity and CTS (1, 4, 8, 11, 24, 31, 32, 50, 52, 53). Based on these studies, the mean *OR* for obesity was 3.25, which is considered large.

In summary, research has repeatedly found positive associations between obesity and CTS. Additionally, the magnitude of association between obesity and CTS is large. Moreover, as seen with age, findings were consistent across longitudinal and cross-sectional studies. As such, obesity is given definitive status in the risk factor typology and classified as a variable marker.

As such, the results of the present review suggest that obesity is appropriately classified as a variable marker of CTS.

Ethnicity. Findings from several studies have suggested that Caucasians may be at higher risk for developing CTS. Two longitudinal studies were located that investigated ethnicity as a risk factor for CTS. Findings from both studies were not consistent with the hypothesis that Caucasian ethnicity were more likely to develop CTS. Specifically, Gorsche et al. (1999) conducted a 1-year prospective study that found no connection between ethnicity and CTS. Similarly, Nathan et al. (1992a) carried out a 5-year longitudinal study that found ethnicity not to be predictive of CTS development.

In addition, six cross-sectional studies have investigated associations between ethnicity and CTS. Overall, results of the studies were equivocal. In particular, three studies reported positive correlations between Caucasian ethnicity and CTS (40, 50, 58), two studies reported null findings

(13, 55), and one study found non-White ethnic status to be associated with CTS (38). As such, the present review does not support the inclusion of ethnicity in the CTS risk factor typology.

Diabetes Mellitus. Diabetes has been studied as a risk factor for CTS in two longitudinal studies, both of which found no connection between diabetes and CTS. In particular, Gorsche et al. (1999) and Roquelaure et al. (2001) conducted 1-year prospective trials and reported that individuals with diabetes were not more likely to develop CTS.

Fourteen cross-sectional studies investigating diabetes and CTS were located for the present review. Of those 14 studies, eight reported positive associations between diabetes and CTS (12, 19, 20, 32, 33, 43, 57, 61), while six reported null findings (8, 34, 46, 51, 52, 55). With respect to the methodologies, six studies used case-control designs (8, 12, 32, 34, 46, 51), one was a retrospective patient study (33), one was a retrospective cohort study (61), one was an epidemiological study (57), and the remaining five were standard cross-sectional designs (12, 19, 20, 43, 52, 55). The number of study participants ranged from 99 to 4,244 with a mean of 942.2.

The 14 studies used seven different protocols for diagnosing CTS. The most common protocol was an appropriately stringent case definition requiring both symptoms and EDX testing (19, 20, 43, 46, 55). In the remaining studies, four used diagnoses found in databases and medical charts (8, 33, 34, 51), two relied on carpal tunnel surgery records as a proxy diagnosis (32, 57), one study used clinical symptoms (52), one used a clinical diagnosis (12), and one required that two of three criteria be met (clinical symptoms, signs or CTS surgery; 61). No differential results by diagnostic protocol were evident. Finally, two studies reported odds ratios between diabetes and CTS (12, 32). The mean *OR* from these studies was 2.21, which is considered moderate in magnitude.

The results studies investigating diabetes consistently differed between longitudinal and cross-sectional studies. Specifically, the two longitudinal studies found no association between diabetes and CTS, while the majority of cross-sectional studies reported positive associations. This difference may be the results of differences in sample sizes, which were considerably larger in cross-sectional studies. As such, cross-sectional studies may have possessed greater statistical power to detect significant between group differences.

In summary, evidence from longitudinal studies is lacking to suggest that diabetes is a risk factor for CTS. However, ample cross-sectional data exist to support the classification of diabetes as a correlate of CTS.

Thyroid dysfunction. Thyroid dysfunction is another medical variable that has been associated with CTS. Two longitudinal studies have investigated the relationship between thyroid dysfunction and CTS. Results from both studies were not consistent with the premise that thyroid dysfunction is a risk factor for CTS. In particular, Gorsche et al. (1999) and Roquelaure et al. (2001) conducted 1-year prospective trials that found no association between thyroid dysfunction and CTS development.

Ten cross-sectional studies investigated thyroid dysfunction and CTS. Overall, the results of these studies suggested that thyroid dysfunction was not significantly associated with CTS. Specifically, seven of the ten studies reported null findings (43, 46, 51, 52, 55, 57, 61), while only three found positive correlations (12, 17, 32). As such, the present review does not support the inclusion of thyroid dysfunction in the CTS risk factor typology.

Arthritic diseases. The link between arthritic diseases and CTS has been studied in one prospective trial. Gorsche et al. (1999) conducted a 1-year prospective trial found no connection arthritic diseases and CTS development.

Seven cross-sectional studies have investigated CTS and arthritic diseases (8, 12, 13, 33, 43, 46, 61), with four of those studies reporting significant associations (8, 12, 33, 61). Two of these studies (8, 61) found a history of osteoarthritis was associated with significantly elevated rates of CTS. One study found significant connection between inflammatory arthritis and CTS (12), and one study found a history of rheumatoid arthritis to be associated with CTS (33). The number of study participants ranged from 125 to 4, 244 with mean of 1,280.57.

With respect to methodology, three of the seven studies used case-control methodologies (8, 12, 46), while the remaining four used retrospective, epidemiological, and cross-sectional designs (13, 33, 52, 61). Of the seven studies, only one used an appropriately stringent diagnostic protocol (46). The most common protocols used were clinical diagnoses (12, 13) and diagnoses in medical charts or databases (8, 33).

In summary, longitudinal data do not exist to support the hypothesis that arthritic diseases are risk factors for CTS. However, ample cross-sectional evidence has been accumulated to support the classification of arthritic diseases as a correlate of CTS.

Advocational exercise. Two studies have investigated the effects of advocational exercise levels on CTS. The first study was a 5-year longitudinal study conducted by Nathan et al. (1992b). Study results suggested that higher levels of advocational exercise significantly reduced the risk for developing CTS. The second study was cross-sectional and found increased levels of advocational exercise to be negatively correlated with CTS (25). In summary, while evidence does exist to support a connection between advocational exercise and CTS, further replication is needed before it is included in the risk factor typology.

Personological Risk Factor Conclusions

The present section reviewed several different personological risk factors for CTS. Based on the studies reviewed, female gender was classified as a fixed marker, while age and obesity were classified as variable markers of CTS. Furthermore, gynecological surgery, menstrual problems and/or disorders, diabetes, and arthritic diseases were classified as correlates of CTS. Supporting evidence was lacking to include oral contraceptive use, ethnicity, and thyroid dysfunction in the risk factor typology. Finally, advocational exercise may be connected to CTS but additional research is needed before being included in the typology. As seen with the occupational factors, studies investigating personological risk factors used a wide range of protocols to diagnose CTS. In studies that investigated age, a slight trend towards positive findings was evident in studies that used more stringent case definitions. The next section will review the psychosocial risk factors for CTS.

Psychosocial Risk Factors

As previously alluded to, limited research has been conducted investigating associations between psychosocial factors and CTS. Furthermore, the results of these studies have not been consistent. In this section these studies, as well as any conclusions that can be drawn from them, will be discussed.

Psychological risk factors. Several different types psychological risk factors have been studies with CTS, including: (a) somatic and depressive symptoms, (b) psychological distress, (c) psychological problems, (d) nonpsychotic psychiatric illness, (e) neurosis, and (f) Axis I and II disorders.

As illustrated in Appendix A, two longitudinal studies have investigated psychological risk factors and CTS. Leclerc et al. (2001) conducted a 3-year prospective study that found the presence of "somatic and depressive symptoms" were not associated with the development of CTS. In this study, somatic and depressive symptoms were measured using a list of questions constructed by the authors, which upon close inspection, do not seem specific to the constructs assessed (e.g., somatic symptoms: "Do you often have personal worries that get you down physically?"). The second longitudinal study was the 1-year prospective trial carried out by

Roquelaure et al. (2001). The authors investigated "psychological distress" using the General Health Questionnaire (a psychometrically valid assessment). Results of the study indicated that the presence of psychological distress was associated with a significantly elevated *OR* for CTS (4.3).

In addition, four cross-sectional studies were located for the present review. As shown in Appendix A, the results of these four studies were mixed, with two studies reporting positive findings (10, 52), and two finding no connection (8, 13). Of the two studies that reported positive findings, one found psychological problems to be associated with CTS (10), and one found CTS patients had higher rates of anxiety disorders (both current and lifetime) than a comparison group of low back pain patients (10). The methodologies of all four studies varied slightly with one using a case control design (8), one a cohort study design (10), one was an epidemiological study (13), and one used a standard cross-sectional design (52). The number of study participants ranged from 94 to 2,528 with a mean of 1,073.5.

As seen in previous sections, the protocols used to diagnose CTS varied across studies. Two studies relied on clinical diagnoses (10, 13), one used medical codes in a database (8), and one used clinical symptoms only (52). With respect to the measurement of the psychological risk factors, two studies relied on data base records, with one study coding for nonpsychotic psychiatric illness (8), and one coding for neurosis (13). In the remaining studies, one used the Structured Clinical Interview for Diagnosing DSM-III-R axis I and II (*Diagnostic and Statistical Manual of Mental Disorders*, American Psychological Association, 1987) disorders and one used the Langer's screening questionnaire to measure psychological problems (52). Inspection of study results by method of measurement reveals that both studies that used psychometrically validated measures found positive results (10, 52), while the database studies reported negative findings. This pattern was also evident in the longitudinal studies.

Two studies calculated odds ratios as a measure of effect between the psychological risk factors and CTS (2, 52). Based on these studies, the mean *OR* for psychological distress is 3.32, which is considered large.

In summary, findings from both longitudinal and cross-sectional research are mixed. However, there seems to be a trend towards positive findings with the use of psychometrically valid assessments, such that all three studies that used valid measures reported positive findings. Furthermore, the mean *OR* reported for psychological risk factors was large (3.2). As such, evidence does exist to support the hypothesis that psychological factors may be associated with CTS; and, therefore, psychological factors (i.e., psychological dysfunction) are appropriately classified as correlates of CTS. However, it remains unclear which specific psychological variables are associated with CTS. That is, while one study found a connection with anxiety disorders, the remaining studies measured nonspecific psychological constructs (i.e., psychological distress, psychological problems). Additional research is needed to clarify which specific psychological constructs are associated with CTS.

Job satisfaction. As with the psychological risk factors, relatively few studies have investigated job-related psychosocial variables associated with CTS. The job-related psychosocial factor most commonly studied has been job satisfaction. One longitudinal study was located that investigated job satisfaction and CTS. Leclerc et al. (2001) carried out a 3-year prospective trial investigating job satisfaction as a risk factor for CTS. Job satisfaction was measured with a list of questions put together by the authors for the purposes of the study. Results of the study indicated that low levels of job satisfaction were related to CTS in females (*OR* = 1.79). In addition, two cross-sectional studies have looked at job satisfaction (51, 52). Results of both studies suggested that low levels of job satisfaction were unrelated to CTS. With respect to the methodologies, one study used a case-control design (51), and one used a standard cross-sectional design (52). The number of participants in the studies was 417 and 1,547, with a mean of 982. Both studies used less stringent diagnostic protocols (i.e., diagnostic codes in databases [51] and clinical symptoms [52]).

In summary, minimal longitudinal evidence exists to support job satisfaction as a risk factor for CTS. The results of cross-sectional studies do not support a connection between job satisfaction and CTS, although this connection remains tentative as it is based only on two studies. As such, confirming evidence is needed from both longitudinal studies and cross-sectional replication studies before including job satisfaction in the CTS risk factor typology.

Limited inferences can be drawn regarding the potential psychosocial risk factors for CTS. Psychological dysfunction seems to be associated with CTS (especially when assessed with psychometrically valid measures). Additional research is needed to elucidate which specific psychological constructs are associated with CTS. Job satisfaction may be associated with CTS, but this speculation remains tentative pending further replication.

Literature Review Conclusions

The present review examined the occupational, personological, and psychosocial variables implicated as risk factors for CTS. The review sought to classify the numerous putative risk factors for CTS into a risk factor typology. Results of the review suggested that three personological variables meet risk factor criteria. In particular, age and obesity were classified as variable markers of CTS, and female gender was classified as a fixed marker. The remaining factors were given either preliminary status (i.e., correlates) or not included in the typology. Those variables classified as correlates were repetition, combined repetition and force, vibration, gynecological surgery, menstrual-hormonal problems and/or disorders, diabetes, arthritic diseases, and psychological factors. Variables not included in the risk factor typology were force, ethnicity, oral contraceptive use, and thyroid dysfunction. It was also suggested that advocational exercise and job-related psychosocial risk factors may be associated with CTS, but further replication is needed before their inclusion in the typology. The present review also highlighted the need for future research to delineate which psychological constructs are associated with CTS. That is, the broad nature of the psychological factors heretofore studied (e.g., psychological problems) limits the empirical and clinical utility of the research findings. The present review revealed additional limitations in the existing research. Specifically, it was repeatedly noted that much of the research has failed to use standardized, psychometrically valid measurements of risk factor exposure. Lastly, the stringency of the protocols used to diagnose CTS differed considerably across studies, resulting in differential abilities to detect true differences between groups. The following section will integrate the findings from the present literature review according to the biopsychosocial model.

Biopsychosocial Model of Carpal Tunnel Syndrome Risk

Based on the findings from the present literature review, a biopsychosocial model of risk for carpal tunnel syndrome will be proposed. The biopsychosocial model proposes that a wide array of interrelated biological, psychological, and social factors are important in any given state of health or illness (Engel, 1977). This stands in contrast to the medical or biomedical model that suggested all health-related symptoms can be explained by aberrant somatic processes (Mechanic, 1968). To the author's knowledge, this is the first attempt at integrating the various CTS risk factors into a unifying biopsychosocial model of risk. As such, it is expected that future research will build upon and refine the present model. The proposed model will be illustrated in Figure 1 with a graphical display of the interrelating risk factors provided. Following the graphical display, a hypothetical case example will be used to articulate the speculated pathways of risk.

Hypothetical Case Example: Anna O

As previously stated, a case example will be used to integrate the various risk factors for CTS. The case example will be a hypothetical individual (Anna O.) seeking a medical evaluation due to pain and parasthesia of the hands. Discussion of the case will begin by reviewing the factors that increased the individual's risk for CTS. In addition, plausible explanations will be provided for each factor reviewed. Following discussion of individual factors and plausible explanations, possible interactions between individual factors will be proposed.

Review of personological, psychosocial, and occupational factors. Anna O. is a 48-year-old postmenopausal woman complaining of pain and parasthesia of the hands. She is a single mother of five and works full time as a cleaner in a large industrial warehouse. The results of a physical evaluation (including a review of CTS symptoms, administration of provocative signs, and administration of EDX testing) suggested that Anna has severe CTS (bilateral).

A review of Anna's medical history revealed several health-related conditions that likely increased her risk of developing CTS. For instance, in her early 40s, Anna developed both type II diabetes and rheumatoid arthritis. In addition, Anna recently underwent gynecological surgery (bilateral oopherectomy) following several years of painful and irregular menstruation. These adverse health conditions, coupled with poor health habits (i.e., sedentary lifestyle without exercise), have resulted in considerable weight gain eventuating in obesity (i.e., BMI = 32).

A review of Anna's psychosocial history also revealed several possible risk factors for CTS. For example, Anna has a history of generalized anxiety and major depressive disorders. Furthermore, Anna rated her job satisfaction as poor, describing herself as a "disgruntled employee."

In addition, scrutiny of Anna's occupational history revealed several factors that also may have increased her risk for CTS. First, Anna is required to perform repetitive work tasks such as

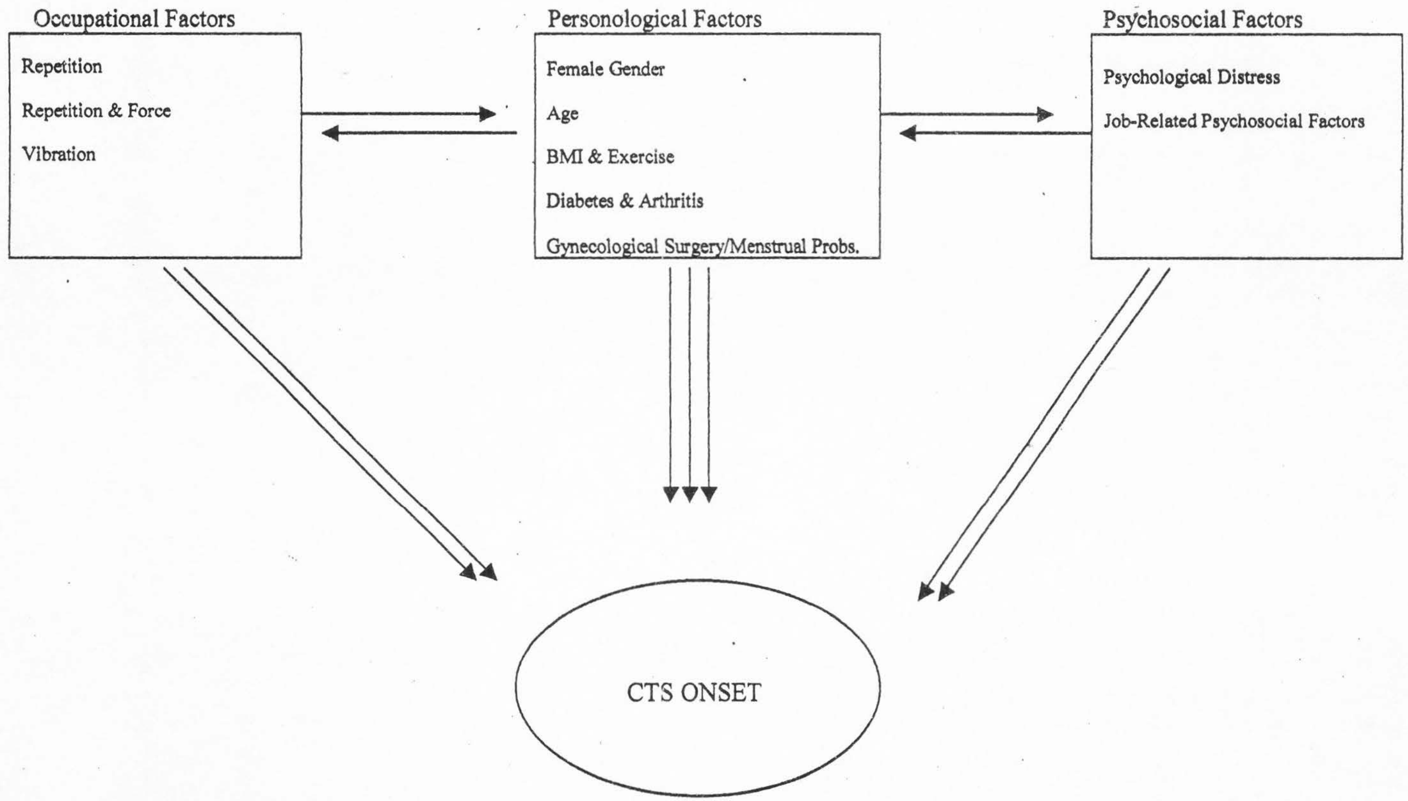

Figure 1. Biopsychosocial model of CTS risk.

sweeping with a manual broom and stacking warehouse materials. Further, Anna is required to clean the warehouse floor using a vibrating buffer machine. This not only exposes Anna to vibration, but also requires repetitive and forceful hand/wrist movements (i.e., flexion and extension of the hand at the wrist).

Plausible explanations for correlates/risk factors. The first category of risk reviewed in Anna's history were personological factors such as gender, age, medical conditions (i.e., diabetes, rheumatoid arthritis, and obesity) and lifestyle habits (i.e., lack of exercise). Beginning with Anna's gender, as a female she has been exposed to a host of conditions that may have increased her risk for CTS. In particular, associations between female-related conditions and CTS have been found with pregnancy, lactation, oral contraceptive use, menopause, gynecological surgery, and hormonal/menstrual problems (Cantatore et al., 1997). Thus, through exposure to one or all of these conditions, Anna's risk for CTS may have been elevated. In addition, Anna's age (48 years) is likely a contributing factor in the onset of her CTS symptoms. Specifically, risk for developing CTS has been shown peak in the 40s and 50s. These age-related increases in CTS rates may be due the biological processes of aging and/or increasing length of exposure years (Tanaka et al., 1995). Disease conditions and health complications may have also contributed to Anna's symptoms. Diabetes, for instance, has been speculated to aggravate median nerve ischemia through hypoxia-related damages associated with peripheral neuropathy (Stevens, Beard, O'Fallon, & Kurtland, 1992). With respect to rheumatoid arthritis, the disease has been suggested to cause compression-related damages to the median nerve due to inflammation of the synovial sheaths (Solomon et al., 1999). Moreover, gynecological surgery (e.g., bilateral oopherectomy) has been proposed to increase risk for CTS due to oestrogen withdrawal and subsequent increases in noradrenaline and dopamine activity. The vasodialatory effects associated with chronic elevations in noradrenaline and dopamine have been speculated to cause damage the functioning of the median nerve (Pascual et al., 1991). In regards to menstrual problems, hormonal fluctuation and fluid retention have been speculated to adversely effect the functioning of the median nerve (Ferry et al., 2000). Obesity may elevate CTS risk through increased deposits of fatty tissues in the carpal canal, causing compression-related damage to the median nerve. Lastly, lack of exercise has been speculated to increase CTS risk through decreases in overall levels of health, which, in turn, may be closely related to the health of the median nerve (Nathan & Keniston, 1993).

The second category of risk reviewed in Anna's history were psychosocial dysfunctions, such as psychological disturbances (i.e., generalized anxiety disorder and major depressive disorder) and low job satisfaction. Beginning with generalized anxiety disorder, symptoms of anxiety may have increased Anna's risk for CTS through chronic elevations in muscular tension (via an anxiety-muscle tension feedback loop). Chronic muscular tension may, in turn, increase neuromuscular fatigue, thereby increasing the likelihood of median nerve damage or injury (Mathis, Gatchel, Polatin, Boulas, & Kinney, 1994). With respect to major depressive disorder, chronic symptoms of depression have been associated with elevated levels of peripheral catecholamines and cortisol (Turner, 1997). Elevations in peripheral catecolamine and cortisol activity may result in vasodilatory effects that have been speculated to adversely effect the median nerve. Lastly, Anna's low level of job satisfaction may have elevated her risk by inducing apathy towards engaging protective anthropomorphic movements. Poor occupational health may have, in turn, increased the likelihood of injury and/or damage to the median nerve (Bongers, de Winter, Kompier, & Hildebrandt, 1993).

The third category of risk reviewed in Anna's history was occupational factors such as repetition, vibration, and combined repetition and force. With respect to repetition, Anna's exposure may have increased her risk for CTS through elevating pressure levels within the carpal canal causing compression-induced damage to the median nerve (Cantatore et al., 1997). In addition, Anna's exposure to vibration may have elevated her risk for CTS by causing repeated microtrauma to the median nerve and/or swelling of the synovial sheaths (Bovenzi., Zadini, Franzinella, & Borgogni, 1991). Finally, Anna's exposure to repetitive and forceful work may have increased her risk for CTS by increasing the pressure levels within the carpal canal and causing ischeamic-induced damages to the median nerve (Viikari-Juntura & Silverstein, 1999).

Speculated interactions between correlates/risk factors. Based on the assumptions of the biopsychosocial model, potential interactions between the above-related factors can be proposed. Such interactions would, theoretically, further elevate Anna's risk for CTS as the adverse affect of individual correlates/risk factors may combine in an additive (or exponential) manner. For example, personological factors could interact with exposure to occupational factors to increase CTS risk. An illustration of such an interaction could be the negative health effects of diabetes combining with the adverse effects of occupational strain. More specifically, diabetic peripheral neuropathy may aggravate median nerve ischemia, resulting in damage and/or weakening of the median nerve. With underlying median nerve weakness, resistance to prolonged occupational strain may be compromised, thereby further increasing the likelihood of injury when exposed to such strain. Another example may be seen in potential interactions between poor physical conditioning and occupational factors. In particular, poor levels of physical conditioning (associated either with obesity or lack of exercise) may cause premature neuromuscular fatigue in response to prolonged occupational exposure. Such fatigue may increase the risk for median nerve damage/injury through either (a) deleterious effects of prolonged fatigue, or (b) fatigue-induced decreases in protective postural/anthropomorphic movements.

Alternatively, personological factors may interact with psychosocial factors to increase

Anna's risk for CTS. For instance, the negative health effects of rheumatoid arthritis may combine with the adverse effects of depression. Specifically, rheumatoid arthritis may lead to damage of the median nerve through inflammation of synovial sheaths and median nerve compression. Furthermore, the immunocompromising effects of depression may reduce the body's ability to control systemic inflammation. With compromised resistance, the likelihood of further inflammation of the synovial sheaths may be increased. Another example may be seen in potential interactions between poor health-related conditions (i.e., obesity, lack of exercise) and job-related psychosocial factors (i.e., low job satisfaction). Specifically, obesity and/or lack of exercise may compromise the energy and/or motivational resources necessary for successful completion of physically demanding work tasks. With declines in occupation-related successes, work-related positive reinforcement would decrease. Such decreases in positive reinforcement would, in turn, lead to reductions in job satisfaction. Reductions in job satisfaction may then result in further diminishing of energy and/or motivational resources.

In addition, psychosocial factors may interact with occupation factors to increase Anna's risk for CTS. For instance, job-related psychosocial factors (i.e., low job satisfaction) may interact with occupational strain. In particular, low levels of job satisfaction may result in apathy towards engaging in protective anthropomorphic movements. Poor occupational health, in turn, could increase the likelihood of median nerve damage/injury in response to occupational strain. In a similar manner, depression-induced anhedonia could compromise the motivational and/or energy resources necessary to sustain prolonged protective anthropomorphic movements, also increasing the likelihood of median nerve damage/injury.

Rational for the Present Study

and Research Hypotheses

Although thought by some to be benign (Smith, 2002), carpal tunnel syndrome is currently one of the most common disabling conditions (U.S. Department of Labor, Bureau of Labor Statistics, 1997) and is responsible for substantial medical costs and lost work days (Patterson & Simmons, 2002). In attempts to curtail the impact of CTS, numerous prevention programs have been designed and implemented. Unfortunately, none of these programs have effectively reduced the incidence of CTS. This lack of effectiveness may be a corollary to the current lack of consensus regarding CTS risk factors. In light of these considerations, the current study was designed to realize two purposes. First, the study endeavored to provide additional clarity to the risk factor literature by identifying those occupational and personological factors most strongly related to CTS. Identification of primary risk factors may lead to appropriate primary prevention programs for CTS and corresponding reductions in incidence and related costs. Second, the proposed study hoped to build upon the risk factor research by delineating which, if any, psychosocial constructs increase risk for CTS. This information could potentially lead to more holistic care for the CTS patient. For instance, if a strong association is found between generalized anxiety and CTS, health care providers may wish to briefly assess for anxiety when evaluating a CTS patient. It could be speculated that increased awareness of any such associations (e.g., anxiety and CTS) could lead to increases in the quality of care afforded to the CTS patient.

The primary hypothesis of the study reflects a biopsychosocial conceptualization of CTS, and proposes that CTS risk would be best predicted through consideration of occupational, personological, and psychosocial variables. No a priori predictions were made concerning differential risk magnitudes associated with different categories (i.e., occupation, personological, psychosocial) of risk factors. Following is a list of the specific study hypotheses.

Hypothesis # 1: CTS participants will endorse higher levels of occupational repetition than will control participants.

Hypothesis # 2: CTS participants will endorse higher levels of occupational repetition-force than will control participants.

Hypothesis # 3: CTS participants will endorse higher levels of occupational vibration than will control participants.

Hypothesis # 4: CTS will be significantly associated with obesity, such that risk for CTS will increase as BMI rises above 25 (i.e., overweight).

Hypothesis # 5: CTS participants will report significantly lower levels of vigorous physical exercise than control participants.

Hypothesis # 6: CTS participants will report significantly higher levels of premorbid diabetes mellitus.

Hypothesis # 7: CTS participants will report significantly higher levels of premorbid arthritic diseases.

Hypothesis # 8: Female participants in the CTS group will report significantly higher levels of female-related complications; those being gynecological surgery and menstrual/hormonal problems.

Hypothesis # 9: CTS participants will endorse significantly higher levels of anxiety than participants without CTS.

Hypothesis # 10: CTS participants will endorse significantly higher levels of depression than participants without CTS.

Hypothesis # 11: CTS participants will endorse significantly higher levels of somatization symptoms than control participants.

Hypothesis # 12: CTS participants Brief Symptom Inventory-18 total scores will be significantly higher than control participants.

Hypothesis # 13: CTS participants will endorse significantly lower levels of internal health locus of control beliefs than would participants without CTS.

Hypothesis # 14: CTS participants will report significantly lower levels of job satisfaction than control participants.

Hypothesis # 15: CTS participants will endorse significantly lower levels of mental and physical health functioning, as measured by the Short Form Health Inventory 36 (Version 1; SF-36), than will control participants.

The study variables and coding methods are provided in Appendix B.

CHAPTER III

METHODS

Study Design: Case-Control Methodology

The study design incorporated a case-control methodology. Case-control studies compare cases with a disease/syndrome to controls without the disease/syndrome. The two groups are matched on well-known risk factors (e.g., gender and age), and then evaluated for differences in prior exposure to other risk factors (Schlesselman, 1982). Perillo (1993) discussed the strengths and limitations of case-control research studies. The case-control methodology is well designed to study rare diseases, relatively quick and inexpensive to carry out, does not place participants at risk, and allows for elucidation of lesser-known risk factors by controlling for well-known risk factors. Limitations of the case-control design include inability to establish causal relationships, susceptibility to recall bias, susceptibility to motivational factors influenced by disease states, and potential selection bias (Perillo).

The selection of cases in case-control research is typically accomplished through the use of a diagnostic protocol, which is used to identify those individuals who meet an a priori case definition. Control participants serve to provide a baseline estimate of the occurrence of certain risk factors from which the population cases were drawn (Perillo, 1993). As such, selected control participants should be representative of the population from which case participants were drawn and should have equal opportunity for exposure to the risk factors of interest (Perillo).

In the current study, the CTS case participants were clients scheduled for a CTS evaluation at the Orem Outpatient Clinic located within the Timpanogos Regional Hospital. The control participants were a sample of Orem Outpatient Clinic clients, matched for gender, who were scheduled for a medical evaluation unrelated to CTS, or another work-related musculoskeletal disorders (WMSD) of the upper extremities. The decision to exclude individuals presenting for an evaluation of an upper-extremity WMSD was based upon research that has shown overlapping occupational risk factors for CTS and these disorders (Grieco, Molteni, De Vito, & Sias, 1998). Given this overlap, the use of individuals with a WMSD as controls may have restricted the range of occupational risk factor exposure, thereby not allowing for establishment of an accurate baseline of occupational exposure among the population from which the CTS participants were drawn. The rationale for selecting participants from the same clinic was to increase the likelihood that both groups would have equal opportunity for exposure to the risk factors of interest. More specifically, the assumption was made that the clinic serves CTS and non-CTS clients from approximately the same catchment areas (i.e., Orem, Provo, Lindon, Lehi, Highland, Alpine, Springfield, and Spanish Fork, in central Utah). Furthermore, clinic physicians accept clients with a range of insurance coverage plans, including, federal insurance (e.g., Medicaid), state insurance (e.g., Workers' Compensation), and private insurance plans. This suggests the client population was representative of the range of the socioeconomic strata (SES) within the catchment area. This enhances confidence in the assumption that case and control subjects had equal opportunity for exposure to the range of risk factors of interest (e.g., jobs ranging from high risk factory workers to low risk executives; lower SES [higher risk for female obesity] to higher SES [lower risk for female obesity], etc). To enhance the accuracy of participant assignment (i.e., case group vs. control group assignment) all participants underwent the same diagnostic procedures (discussed below). Following participant selection and assignment, participants completed the risk factor protocol.

Measures

The study incorporated two diagnostic procedures, three self-report measures of CTS symptomatology, and eight self-report risk factor measures. The diagnostic procedures, which included a clinical assessment for CTS symptoms and EDX testing of median nerve functioning, were used to establish participant eligibility and assign participants to their respective groups. The remaining measures of CTS symptomatology and risk factor exposure were all contained within a packet completed by participants. The measures of CTS symptomatology included a list of common CTS symptoms, the Levine's Symptom Severity Scale, and the Levine's Functional Status Scale. The risk factor measures included the following assessments: (a) a demographic and physical health questionnaire, (b) a measure of physical activities, (c) the SF-36, (d) the Brief Symptom Inventory-18, (e) the Multidimensional Health Locus of Control Scale, (f) the Occupational Hand Use Scale, and (g) a measure of job satisfaction.

CTS Clinical Assessment

The clinical assessment for CTS was carried out by a hand surgeon (Dr. Johnson) and his clinical staff. Potential CTS participants were administered a physical examination to assess for the presence and severity of CTS symptoms. The physical examination included a review of CTS symptoms, administration of provocative and sensory discrimination tests, and assessment for confounding conditions (e.g., arthritis of the small joints, flexor and extensor tensynovitis, ulnar neuropathy at Guyon's canal, etc.). Participants whose physical examinations were suggestive of CTS then underwent EDX testing to verify eligibility for case inclusion.

Electrodiagnostic Testing Protocol

Participants were administered two separate electrodiagnostic assessments, resulting in a total of four nerve conduction recordings. The first assessment was conducted using a portable NUEROMetrix *NC-Stat* Median Motor/Sensory Biosensor Device (Neurometrix; Waltham, MA). The *NC-Stat* electrodiagnostic biosensors were placed on the distal wrist crease and connected to the midpoint of the proximal joint on the third digit. The biosensors stimulated the motor and sensory median nerve fibers and recorded the latencies (i.e., conduction time from distal wrist crease to proximal joint of third digit). The NUEROMetrix testing provided measures of both motor and sensory distal latencies. Participants' scores were compared to normative values from the general population, which varied according to age. The sensitivity and specificity of these tests were reported to be .90 and .86, respectively (Leffler, Gonzani, & Cross, 2000). The NEUROMetrix *NC-Stat* biosensor assessments were conducted by Dr. Johnson's clinical staff as well as the student researcher (who received training in the procedure).

The second EDX assessment was conducted using a standard electrodiagnostic machine, which provided motor and sensory nerve conduction values for both the median and ulnar nerves. The median motor nerve conduction value was measured by stimulating the motor nerve at the wrist and recording the conduction latency at the apollicis brevis. The obtained motor latency value was then compared to an ulnar latency value, which was derived by stimulating the ulnar motor nerve at the wrist and recording the conduction latency at the adductor minims. Differences in peak latencies (motor minus ulnar) equal to or greater than 1.5 ms were considered to be indicative median nerve dysfunction. The sensitivity and specificity values for this test were estimated to .67 and .97, respectively (Jarvik & Yuen, 2001). In addition, Palmar sensory testing was conducted to obtain assessments of sensory nerve functioning. The Palmar testing protocol stimulates both the median and ulnar sensory nerve fibers at the palm and records the conduction values across the wrist. Differences in peak latencies (median - ulnar) greater to .30 ms were considered to be suggestive of median nerve dysfunction. The sensitivity and specificity values for the Palmar sensory tests were reported to be .82 and .95, respectively (Jarvik & Yuen). The standard electrodiagnostic assessments were conducted by Dr. Alan College. All EDX tests were consistent with AAN, AAEM, and AAPMR (1993) standards and guidelines for electrodiagnostic testing.

Participants were administered the EDX testing as part of a separate study being conducted to investigate the reliability of EDX assessments. The majority of participants were administered both of the above-specified EDX assessments. However, several of the case participants presented before the reliability study had begun, and as a result, were assessed only with one of the above-specified assessments (either NEUROMetrix or standard EDX). In addition, while it was intended that all participants undergo EDX testing, 20 of the control participants presented to the clinic on days when EDX testing was not available (i.e., appropriate staff members were not present). As such, these participants were assigned to the control group based on negative findings during an assessment for clinical symptoms of CTS. In review, all CTS participants were administered at least one EDX assessment battery (with the majority undergoing both). Additionally, 24 of the 44 control participants were administered an EDX assessment, and the remaining 20 were assigned to the control group based on a negative findings during a clinical assessment for symptoms of CTS.

Self-Report Assessment of Carpal Tunnel Syndrome Symptoms

The assessment of CTS symptoms is a 9-item self-report measure put together by the student researcher, the principal investigator, and a physician experienced in the assessment and treatment of CTS. The symptoms listed in the measure were taken directly from AAN, AAEM, and AAPMR (1993) guidelines for the clinical assessment of CTS. The assessment asks participants to indicate: (a) if they have experienced each particular symptom, (b) the duration each symptom has been experienced, and (c) if they experience symptoms bilaterally. For inspection of this measure the reader is referred to Appendix C.

Levine Symptom Severity Scale. The Levine Symptom Severity Scale is an 11-item self-administered questionnaire assessing for the presence and severity of six common CTS symptoms.

Each item contains five possible responses with corresponding numerical equivalents increasing from 1 (no symptoms) to 5 (very severe symptoms; Levine et al., 1993). The mean individual item score provides the overall symptom severity rating. Levine et al. conducted a study assessing the psychometric properties of the Levine Symptom Severity Scale on a sample of 67 patients. According to the authors, the test-retest (duration interval of one day) Pearson correlation coefficient was .91, which is suggestive of excellent reliability. The internal consistency assessment revealed a Cronbach alpha of .89, indicating high interitem correlations. In addition, significant correlations were found between the overall symptom severity score and loss of grip strength and loss of pinch strength, which demonstrates criterion validity. Finally, sensitivity to change was established by administering the scale to participants before and after carpal tunnel release. The authors reported "substantial responsiveness to clinical change" with a corresponding effect size of 1.4 (Levine et al.). For inspection of this assessment the reader is referred to Appendix C.

Levine Functional Status Scale. The Levine Functional Status Scale is an 8-item scale that assesses difficulty levels associated with eight daily living activities frequently compromised by CTS. Respondents rate the difficulty of each activity on the following 5-point scale: (a) no difficulty, (b) mild difficulty, (c) moderate difficulty, (d) severe difficulty, and (e) cannot do at all due to hand or wrist symptoms. The overall functional status score is derived by calculating the mean of the individual items (Levine et al., 1993). Levine et al. assessed the psychometric properties of the Levine Functional Assessment Scale using 67 participants. The authors reported a test-retest reliability (one day duration between administrations) Pearson correlation coefficient of .93, and a Cronbach alpha (internal consistency) of .89. Furthermore, total scores on the Functional Status Scale correlated significantly with grip strength, pinch strength, and two-point discrimination, which are indications of criterion validity. Finally, using pre-/post-operative change scores the authors indicated that the scale was sensitive to clinical change (effect size = .82). For inspection of this measure the reader is referred to Appendix C.

CTS Case Definition

The present study used the following case definition to establish eligibility for CTS subjects: EDX testing results suggestive of abnormal slowing of the median nerve, *and* the presence of clinical symptoms, *and* no confounding syndromes/disorders. The reader is referred to Table 2 for a summary of the CTS case definition.

The criterion for abnormal slowing of the median nerve was met if any of the four EDX tests were suggestive of median nerve dysfunction. More specifically, the abnormal slowing criteria would be met if any of the following testing results occurred: (a) NEUROMetrix distal motor latency value greater than the normative values for the participant's age range, (b) NEUROMetrix distal sensory latency value greater than the normative values for the

Table 2

Study Case Definition

Inclusionary criteria for case subjects
All criteria must be met. 1. Abnormal EDX testing results on any of the following assessments: (a) NEUROMetrix distal motor latency value greater than population norms. (b) NEUROMetrix distal sensory latency value greater than population norms. (c) Standard EDX median -- ulnar motor nerve latency greater than 1.5. (d) Standard EDX median -- ulnar senstory nerve latency greater than .30. 2. Endorsement of at least two clinical symptoms of CTS on the CTS self-report measure. 3. No confounding condition in the physical evaluation.

participant's age range, (c) standard EDX motor nerve assessment resulting in a median minus ulnar latency value equal to or greater than 1.5 ms, and (d) standard EDX sensory nerve assessment resulting in a median minus ulnar latency value equal to or greater than .30 milliseconds.

The criterion for the presence of clinical symptoms of CTS was met if participants reported experiencing at least two symptoms of CTS that had persisted for at least 3 weeks to 3 months. The criterion for the lack of confounding syndromes/disorders was met if the physical examinations carried out by Dr. Johnson and his clinical staff did not identify any such complications.

The use of both EDX testing results and the presence of clinical symptoms as inclusionary criteria was taken directly from the consensus guidelines established for the classification of CTS in epidemiological studies (Rempell, Evanoff, et al., 1998). The second guideline states, "The combination of electrodiagnostic study findings and symptom characteristics provides the most accurate carpal tunnel syndrome diagnosis" (p. 1448).

Control Participant Inclusionary Criteria

For inclusion in the control group it was required that participants: (a) be seeking a medical evaluation at the Orem Outpatient Clinic, (b) be free of CTS symptomatology (i.e., no symptom of CTS during the clinical assessment and/or EDX testing reveals normal conduction values), and (c) be free of work-related musculoskeletal problems.

Demographic and Physical Health Risk
Factor Assessment Inventory

The demographic and physical health inventory is an 11-item self-report measure designed to assess various demographic and physical health variables that have been implicated as risk factors for CTS. The inventory was put together by the student researcher, the principal investigator and a physician experienced in the diagnosis and treatment of CTS. The primary variables included in the protocol were based on the results of the above literature review. The secondary variables were included as exploratory variables. The only primary variable assessed in the inventory is BMI, which is calculated from participants' self-reported height and weight. The remaining nine items solicit information on secondary variables (i.e., smoking, drinking, marital status, education, ethnicity). For inspection of this inventory the reader is referred to Appendix C.

Occupational Hand Use Scale

The Occupational Hand Use Classification (OHU) is a five-item measure designed to assess levels of exposure to job-related risk factors (Nathan et al., 1984). Participants are asked to respond to questions inquiring into levels of force, repetition, heavy load, keyboarding, and amounts of time spent upright (i.e., standing on feet; Nathan et al.). Respondents answer each question on a 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. Responses for the five questions are used to rate respondents in the following five categories: (a) repetition, (b) force, (c) typing, (d) amount of time spent on feet, and (e) combined repetition and force (Nathan et al.). Nathan et al. conducted a study using 605 workers from four different industries to evaluate the psychometric properties of the study. Concurrent validity was established by correlating the scores from workers in each category with observation of those workers ($p < .001$). Pearson correlations revealed an internal consistency value of .79 (Spearman-Brown formula). In addition, factor analysis revealed the following three robust factors: (a) general "blue collar" factor, (b) repetition factor, and (c) negative keyboarding factor (Nathan et al.).

In addition to the five OHU items, six questions were included to obtain information pertaining to subjects' exposure to occupational vibration, current occupation, length of employment, average weekly wage, and number of work days missed. The OHU may be found in Appendix C.

Short Form Health Inventory 36 (Version 1)

The Short Form Health Inventory (SF-36) is a 36-item self-administered inventory designed to measure quality of life specific to physical and mental health (Stewart & Ware, 1992; Ware, Snow, Kosiniske, & Gandek, 2000). Participants are asked to respond to each question according to their perceptions of their health. Raw scores are plotted onto the following eight separate subscales: (a) physical functioning, (b) role-physical, (c) bodily pain, (d) general health, (e) vitality, (f) social functioning, (g) role-emotional, and (h) mental health. In addition, the eight SF-36 subscales may be aggregated into two global measures of mental and physical health. Ware et al. and Stewart and Ware reported on the findings of 14 studies investigating the psychometric properties of the SF-36. Across the studies median internal consistency coefficients for the SF-36 subscales were equal or greater than .80. The sole exception was the social functioning subscale, which was found to have a median coefficient value of .76 across the studies. In addition, the authors also indicated that the SF-36 has shown evidence of construct and concurrent validity (Ware et al.; Stewart & Ware). Furthermore, assessment of the global and mental and physical mental health scales have indicated excellent internal consistency (i.e., mental health coefficient alpha = .88; physical health coefficient alpha = .93) and validity (Ware et al.; Stewart & Ware). For inspection of this measure the reader is referred to Appendix C.

Multidimensional Health Locus of Control Scale

The Multidimensional Health Locus of Control Scale (MHLC) is an 18-item measure that assesses perceptions regarding amounts of control individuals believe to have over their health. Each item is answered on a 6-point Likert type scale, ranging from 1 = strongly agree to 6 = strongly disagree. Scores from raw items are scaled onto the following four factors: (a) internal, (b) powerful others, (c) chance, and (d) God (Wallston, 1991). Wallston, Stein and Smith (1993) reported that investigations of the internal consistency of the MHLC have reported Cronbach's alphas ranging between 60 - .75. Furthermore, Wallston indicated that ample evidence exists to support the validity of the MHLC. Individuals who score high on the internal subscale tend to believe that they have a high degree of control over their health through volitional behavioral patterns. Individuals who score high on the powerful others subscale hold beliefs consistent with an external health locus of control, ascribing much of the control to physicians and other health care providers. Individuals who score high on the chance subscale also have an external health locus of control, but tend to believe their health is largely a function of chance. Individuals who score high on the God health locus of control scale tend to hold beliefs that God is largely in control of their health. For inspection of this measure the reader is referred to Appendix C.

Brief Symptom Inventory 18

The Brief Symptom Inventory-18 (BSI-18) is an 18-item self-administered questionnaire that assesses symptoms of anxiety, depression, and somatization (Derogatis, 2000). Each item contains five statements with corresponding numerical equivalents of 0 - 4 (0 = not at all; 1 = a little bit; 2 = moderately; 3 = quite a bit; 4 = extremely). Raw scores from individual items are plotted onto four clinical scales: (a) somatization, (b) depression, (c) anxiety, and (d) Global Severity Index (GSI; Derogatis). Zambora, Brintzenhofeszoc, and Jacobsen (2001) carried out a validation study of the BSI-18 (using the BSI as the criterion) in a group of 1,543 cancer patients. Results of the study suggested high internal consistency (Cronbach's alpha = .89), high total score correlation (r = .84) and adequate item-to-total correlations (.34 - .70). Furthermore, the study revealed strong supporting evidence for the hypothesized four-factor structure of the BSI-18. This finding was consistent with a previous factor analytic study of the BSI-18 (Derogatis, 2000). Zambora et al. reported a principal components factor analysis with a varimax rotation "identified four factors that had eigenvalues greater than (or very close to) 1.0 and met the scree test score" (p. 243; overall variance = 57.8%; Zambora et al.). For inspection of this measure the reader is referred to Appendix C.

Physical Activities Assessment

The physical activities assessment is 13-item self-report questionnaire that inquires into various types of physical exercise. Respondents are asked to read each item of physical activity and indicate the following: (a) if they regularly engage in this activity (yes or no), (b) the average number of days per week they engage in the activity, and (c) the average duration of typical exercise sessions. The physical activities assessment provides four broad measures of physical activity speculated to be relevant to CTS. These measures include: (a) amount of vigorous physical exercise, (b) amount of physical activity without strain on the hand/wrist, (c) amount of physical activity with strain on the hand/wrist, and (d) total amount of physical activity. The physical activities assessment was constructed by the student researcher and the principal investigator. For inspection of this measure readers are referred to Appendix C.

Job Satisfaction Assessment

The job satisfaction assessment is a one-item measure of job satisfaction. Participants are asked to rate the degree to which they are satisfied with their job on a 7-point Likert scale (1= strongly disagree - 7 = strongly agree). The decision to use a one-item assessment of job satisfaction was based on research suggesting that single item measures of job satisfaction are as accurate and reliable as multi-item assessments of job satisfaction (Evans, 1972). For inspection of this assessment readers are referred to Appendix C.

Participants and Procedures

Participants were recruited from the Orem Outpatient Clinic at Timpanogos Regional Hospital. The case participants were a sample of consecutively recruited patients seeking a medical evaluation for CTS from Dr. Curtis Johnson. Control participants were a sample of nonrandomly recruited patients seeking a medical consultation for conditions other than CTS or another WMSD of the upper extremities. Despite the nonrandom recruitment, similar refusal rates for case and control participants enhances confidence that characteristics across groups were similar (e.g., SES, ethnicity, etc). Potential participants were informed they may be eligible to participate in a study investigating CTS, and should they choose to participate, they would be compensated with a sum of $50. Those individuals who expressed interest in study participation were then given a brief verbal overview of the study. Participants who continued to express interest in participating in the study read and signed an informed consent document (see Appendix D). After providing consent, subjects were administered the diagnostic protocol (procedures described above). Participants who met study criteria were then assigned to their respective groups and provided with the study packet (i.e., risk factor measures), along with an addressed stamped envelope to be mailed upon completion. When the completed packet was received by the student research, each participant was then sent a check for $50. The total number of CTS participants who completed the study was 87. The total number of control participants who completed the study was 74. Finally, participants were given the option of receiving a brief summary of the study results.

CHAPTER IV

RESULTS

Introductory Statement

The present section will report the results of the statistical analyses used to test each of the 15 study hypotheses. However, prior to reporting these results, several other analyses will be presented. First, the results of statistical analyses assessing the equivalence of study groups on age and gender will be reported. Second, the results of analyses assessing the nonequivalence of study groups on diagnostic symptoms of CTS will be reported. It should also be noted that statistical analyses were conducted for several additional variables other than the 15 primary hypotheses. The majority of the additional variables analyzed were exploratory psychological factors. The inclusion of additional variables was done to better address the present study objective of identifying specific psychological variables associated with CTS. As the review of literature revealed only broad nonspecific measures of psychological dysfunction, the inclusion of exploratory psychological variables was necessary. Additional variables other than psychological factors were most commonly included for the sake of completion of the measures used.

Equivalence of Groups on Gender and Age

Overall, 87 carpal tunnel participants were compared with 74 control participants, for an overall total of 161 study participants. The CTS group consisted of 61 females and 26 males and the control group consisted of 47 females and 27 males. The ages of the study participants ranged from 19 to 85 years, with a mean age being 46.23 (15.54). Participants were classified into 4-year age brackets, which corresponded to the age bracket classification system used by NEUROMetrix. The age brackets include: (a) < 30, (b) 30 - 34, (c) 35 - 39, (d) 40 - 44, (e) 45 - 49, (f) 50 - 54, (g)

55 - 59, (h) 60 - 64, (i) 65 - 69, and (j) > 69. Table 3 presents descriptive statistics for gender by age bracket distribution among the CTS and control participants.

To assess the equivalence of study groups on gender, a chi square test of independence was conducted. Actual and expected gender count proportions for both groups are presented in Table 4. Results of the analysis revealed no significant between groups differences on gender ratios, *chi square* = .684, $p = .408$. This suggests that the participant selection and assignment procedures employed in the present study successfully matched participants on gender.

To assess for the equivalence of groups on age, an independent samples *t*-test was carried out. Means and standard deviations are presented in Table 4. Results of the analysis indicated that CTS participants were significantly older that control participants, $t\,(159) = 2.67$, $p = .008$. In addition, a Cohen's *d* effect size (*ES*) was calculated to measure the magnitude of association between age and control group status. The *ES* was calculated by multiplying the *t* value by 2 and dividing the product by the square root of the degrees of freedom, $(2t)/\sqrt{df}$. The results of the

Table 3

Gender and Age Distributions

	Gender by age category distribution			
Age brackets (years)	CTS females ($n = 61$)	Control females ($n = 47$)	CTS males ($n = 26$)	CTS males ($n = 27$)
< 30	5	6	3	4
30 - 34	4	6	1	4
35 - 39	9	11	1	5
40 - 44	10	4	3	3
45 - 49	8	5	3	6
50 - 54	7	6	7	2
55 - 59	6	2	1	2
60 - 64	4	3	2	--
65 - 69	2	1	1	--
> 69	6	3	4	1

Table 4

Gender, Age, and Educational Attainment for Case and Control Groups

Variable	Means *SD*/actual: (expected) proportions	SEM	*t* value/ chi-square value	*p* value	*ES/OR*
Gender					
CTS group					
Females	61 : (58.5)		.684	.408	.877
Males	26 : (28.5)				
Control group	48 : (50.5)				1.15
Females	27 : 20.7				
Males					
Age					
CTS group	49.01 (15.01)	1.61	2.67	.008	.42
Control group	42.97 (13.33)	1.55			
Education					
CTS group	3.41 (1.33)	.145	-2.740	.007	.43
Control group	4.00 (1.35)	.159			

calculation produced an *ES* of .42, which is suggestive of a small-to-moderate association. Taken together, these results suggest that the participant and selection assignment procedures did not successfully match participants on age. As a result, age was statistically controlled in the multivariate analyses.

Further inferential and descriptive statistics were reported for education levels and ethnicity. Education levels were coded on a 6-point scale with higher numbers indicative of higher levels of education (i.e., 1 = less than 12 years to 6 = graduate/advanced degree). Means and standard deviations for both groups are presented in Table 4. An independent samples *t*-test revealed that CTS participants endorsed significantly lower levels of education, $t\ (157) = -2.74$, $p = .007$. The calculation of a Cohen's *d* ES produced a value of .43, which is indicative of a small-to-moderate magnitude.

With respect to ethnicity, the overwhelming majority of the study participants were Caucasian. Specifically, 152 of the 161 (93.8%) of the participants were White. Other ethnicities represented were Native Americans ($n = 2$), Pacific Islander ($n = 2$, Hispanic ($n = 1$), Asian ($n = 1$), and Other ($n = 3$).

Diagnostic and Clinical Symptom Dysfunction Due to Carpal Tunnel Syndrome

Essential to the comparative methodology of the current study is that case and control participants differ significantly on measures of CTS. To assess for between-group differences on CTS symptom dysfunction, several independent samples *t* tests were conducted. Means, standard deviations, and effect sizes for the self-report assessment of CTS symptoms, the Levine's Symptom Severity Scale, and the Levine's Functional Status Scale are presented in Table 5. Results of the analysis comparing self-report assessment of CTS symptoms revealed that case participants endorsed significantly more symptoms of CTS than control participants, $t(151) = 21.47$, $p < .000$. Likewise, case participants scored significantly higher on the Levine's Symptom Severity Scale, $t(155) = 18.74$, $p < .000$, and the Levine's Functional Status Scale, $t(153) = 11.85$, $p < .000$). These findings suggest that group assignment procedures successfully differentiated CTS and control participants.

Likewise, the EDX diagnostic testing results were also significantly different between case and control participants. As previously indicated, four separate EDX tests were conducted including: (a) distal motor latency, (b) distal sensory latency, (c) median - ulnar motor nerve conduction latencies, and (d) median - ulnar sensory conduction latencies. Independent samples *t*-tests were conducted to assess between group differences on each of the four EDX tests. Means, standard deviations, and effect sizes are presented in Table 5. The analyses conducted on the

Table 5

Diagnostic and Clinical Symptom Dysfunction of Study Groups

Measures	Means (*SD*)	SEM	*t* value	*p* value	*ES*
Self-Report Assessment of CTS Symptoms					
CTS group	4.85 (.86)	.096	21.47	.000	3.4
Control group	.86 (1.39)	.164			
Levine's Symptom Severity Scale					
CTS group	2.76 (.64)	.070	18.74	.000	3.0
Control group	1.22 (.42)	.049			
Levine's Functional Status Scale					
CTS group	2.27 (.72)	.08	11.85	.000	1.91
Control group	1.12 (.33)	.423			
NEUROMetrix distal motor latency					
CTS group	4.79 (1.04)	1.04	4.69	.000	.83
Control group	3.77 (.455)	.063			
NEUROMetrix distal sensory latency					
CTS group	4.31 (1.00)	.128	3.52	.001	.70
Control group	3.73 (.455	.070			
Comparison motor EDX median-ulnar difference					
CTS group	1.99 (1.17)	.163	4.97	.000	1.03
Control group	1.00 (.49)	.079			

motor and sensory distal latencies both suggested that CTS participants had significantly greater conduction values (distal motor latency: t (127) = -4.965, p = .000; distal sensory latency: t (101) = -3.521, p =.001). Likewise, the CTS participants had significantly larger median-ulnar motor comparison latency differences, t (89) = -4.975, p = .000). Finally, the CTS participants had significantly larger median-ulnar sensory comparison latencies, t (102) = -3.95, p = .000).

Overall, the results of analyses assessing symptom dysfunction and electrodiagnostic testing suggested that the groups were nonequivalent with respect to CTS symptomatology. CTS participants reported significantly more symptoms of CTS, higher levels of symptom severity, worse functional status, and more median nerve dysfunction. As such, the diagnostic and group assignment procedures used in the present study successfully differentiated between cases with CTS and controls without CTS.

Univariate Analyses for Occupational Factors

Hypothesis 1

Hypothesis 1stated that CTS participants would endorse significantly higher levels of occupational repetition than would control participants. This hypothesis was tested by analyzing participants' scores on pertinent items of the Occupational Hand Use Scale. The means and standard deviations for both groups are shown in Table 6. An independent samples *t* test revealed that CTS participants endorsed significantly higher levels of repetition than control participants, $t(160) = 3.86, p = .000$. The calculation of a Cohen's *d* ES between repetition and the CTS group produced a value of .61, which is reflective of a moderate to large magnitude. Finally, a bivariate correlational analysis revealed a point-biserial correlation (*r*) of .29 between repetition and CTS group status.

Hypothesis 2

The second hypothesis predicted that CTS participants would endorse significantly higher levels of combined repetition and force. This hypothesis was tested by analyzing participants' responses on pertinent items on the OHU scale. Means and standard deviations for both groups are shown in Table 6. An independent samples *t* test indicated that CTS participants reported significantly higher levels of repetition and force, $t(160) = 3.21, p = .002$. Calculation of a Cohen's *d* effect size produced a value of .50, which is indicative of a moderate magnitude. The point-biserial correlation between combined repetition and force and CTS group status was .24

Table 6

Univariate Analyses for Occupational Factors

Measures	Means (*SD*)/actual: (expected proportions	SEM	*t* value/chi square value	*p* value	ES/ OR	*r*
(H:1) Repetition-OHU						
CTS group	3.91 (1.16)	.151	3.86	.000	.61	.29
Control group	3.16 (1.31)	.124				
(H:2) Repetition and force-OHU						
CTS group	7.24 (2.08)	.222	3.21	.002	.51	.24
Control group	6.12 (2.35)	.271				
(H:3) Vibration						
CTS group	9 : (6.4)		2.36	.124	.38	-.11
Control group	3 : (5.6)				1.07	
Force-OHU						
CTS group	3.33 (1.29)	.138	1.80	.073	.28	.14
Control group	2.96 (1.34)	.155				
Typing-OHU						
CTS group	2.52 (1.49)	.159	.504	.615	.07	.03
Control group	2.39 (1.51)	.175				
Lift heavy loads-OHU						
CTS group	2.75 (1.29)	.139	1.12	.265	.17	.09
Control group	2.52 (1.27)	.147				
More than 4 hours on feet-OHU						
CTS group	3.11 (1.51)	.162	-.132	.895	.01	-.01
Control group	3.15 (1.54)	.178				
Total OHU						
CTS group		.413	2.25	.025	.30	.17
Control group		.468				

Hypothesis 3

The third hypothesis stated that CTS participants would endorse significantly higher levels of occupational vibration than control participants. This hypothesis was tested by comparing participants' responses on a single-item dichotomous assessment of vibration exposure. Actual and expected exposure counts for both groups are presented in Table 6. A chi-square test for independence revealed no significant between-group differences, chi square = 2.36, $p = .124$. The chi-square test also provides an odds ratio as a measure of effect magnitude. As illustrated in Table 6, the odds ratio for vibration and CTS group status was .38 and nonsignificant. The point-biserial correlation between vibration and the CTS group was -.11. It should be noted, however, that only 12 of the 161 participants reported exposure to occupational vibration. As such, the statistical power of the analysis was likely limited in the ability to detect any between-group differences.

Several other occupational variables assessed by the OHU were tested for sake of completeness. First, occupational force was tested via an independent samples *t* test. Means and standard deviations are presented in Table 6. Results of the analysis revealed that occupational force was of borderline significance for CTS, $t(160) = 1.80$, $p = .073$. Calculation of a Cohen's *d* effect size produced a value of .28, which is considered small in magnitude. The point-biserial correlation between force and CTS group status was .14. In addition, writing/typing/keyboarding was tested by analyzing participants' responses to relevant questions on the OHU. Means and standard deviations are presented in Table 6. Results of an independent samples *t* test found no significant between group differences, $t\ (160) = .504$, $p = .615$. Calculation of a Cohen's *d* ES produced a value of .07, which is minimal. The point-biserial correlation between writing/ keyboarding and CTS group status was .03. Furthermore, the variable "lift heavy loads" was tested by analyzing participants' responses to pertinent questions on the OHU. Means and standard deviation are presented in Table 6. An independent samples *t* test revealed no significant between group differences, $t\ (160) = 1.12$, $p = .265$. Calculation of a Cohen's *d* effect size produced a value of .17, which is considered small in magnitude. The point biserial correlation between lift heavy loads and CTS group status was .09. The OHU also includes the variable "on feet more than four hours per day." An independent samples *t* test revealed no significant differences between groups on this variable, $t(160) = -.132, p = .895$. Calculation of a Cohen's *d* ES produced a value of .01, which is minimal. The correlation between on feet more than four hours per day and CTS group status was -.01. Finally, total scores on the OHU were compared between case and control groups. This variable was tested by analyzing the sum of all five OHU questions. Means and standard deviations are presented in Table 6. An independent samples *t* test revealed that CTS participants' total OHU scores were significantly higher than case participants, $t(160) = 2.31$, $p = .022$. Calculation of a Cohen's *d* effect size produced a value of .36, which is considered small-to-moderate in magnitude. The point-biserial correlation between total OHU scores and CTS group status was .18.

Univariate Analyses for Personological Factors

Hypothesis 4

The fourth hypothesis stated that BMI values for CTS participants would be significantly higher than control participants. The BMI values were obtained through the following formula: (weight/(height * height) * 703). As previously indicated, BMI values are typically classified according to the following criteria: (a) BMI of 18.5 - 24.99 = normal weight, (b) BMI of 25 - 29.99 = overweight, and (c) BMI equal to or greater than 30 = obese. As illustrated in Table 7, the mean BMI for the CTS group was 29.88 (6.46), while the mean BMI for the control group was 25.50 (4.66). An independent samples *t* test revealed that the CTS participants possessed significantly higher BMI values than the control participants, $t\ (160) = 4.86, p = .000$. The calculation of a Cohen's *d* effect size produced a value of .76, which is reflective of a large magnitude. The point-biserial correlation between BMI and CTS group status was .35.

Table 7

Univariate Analyses for Personological Factors

Measures	Means (*SD*) actual:(expected proportions	SEM	*t* value/chi-square value	*p* value	ES/ OR	*r*
(H:4) BMI						
CTS group	29.88 (6.46)	.693	4.86	.000	.76	.35
Control group	25.51 (4.66)	.538				
(H:5) Vigorous physical activity						
CTS group	76.36 (141.88)	15.29	-4.54	.000	.72	-.34
Control group	221.83 (254.55)	29.59				
Physical activity w/o strain on hand/wrist						
CTS group	238.77 (417.71)	45.04	-1.71	.088	.27	-.13
Control group	378.20 (603.81)	70.19				
Exercise with strain on hand/wrist						
CTS group	626.10 (562.85)	60.69	2.64	.009	.42	.20
Control group	417.81 (404.89)	47.06				
Total exercise						
CTS group	871.30 (752.70)	87.50	.474	.636	.07	.03
Control group	813.44 (754.55)	87.71				
(H:6) Diabetes						
CTS group	10 (6.4)		6.21	.013	1.15	.23
Control group	0 (3.6)				- -	
(H:7a) Unspecified Arthritis						
CTS group	27 (22.3)		3.86	.049	1.27	.18
Control group	8 (12.7)				.522	
(H:7b) Rheumatoid Arthritis						
CTS group	2 (2.5)		.325	.569	.979	-.05
Control group	2 (1.5)				1.73	
(H:8a) Gynecological surgery						
CTS group	22 (16.7)		6.108	.013	1.36	.25
Control group	5 (10)				3.69	
(H:8b) Hormonal-menstrual problems						
CTS group	9 (9.9)		.255	.613	.954	-.05
Control group	7 (6.1)				1.26	

Hypothesis 5

The fifth hypothesis stated that CTS participants would endorse significantly lower levels of vigorous physical exercise. This hypothesis was tested by analyzing participants' scores on pertinent items of the physical activities measure. Means and standard deviations for both groups are presented in Table 7. An independent samples *t* test indicated that CTS participants reported engaging in significantly less vigorous physical activities than control participants, $t\ (158) = -4.54$, $p = .000$. The calculation of a Cohen's *d* effect size produced a value of .72, which is indicative of a moderate-to-large magnitude. The point-biserial correlation between vigorous physical activity and CTS group status was -.34.

The physical activities assessment also provided measures of physical activities with strain on the wrist, physical activities without strain on the wrist, and total physical activity levels. Separate analyses were conducted for each of these variables. Means and standard deviations for both groups are provided in Table 7. With respect to physical activities with strain on the wrist, an independent samples *t* test revealed that CTS participants reported engaging in significantly higher levels of such activities than the control participants, $t\ (158) = 2.64$, $p = .009$. The Cohen's *d* effect size was .42, which is suggestive of a small-to-moderate association. The point-biserial correlation between physical activities with strain and CTS group status was .20. Additional independent samples *t* tests found no significant between group differences on measures of physical activity without strain on the wrist, $t(158) = -1.71$, $p = .088$, or total physical activity levels, $t\ (158) = .474$, $p = .636$.

Hypothesis 6

The sixth hypothesis stated that CTS participants would report significantly higher levels of premorbid diabetes mellitus. This hypothesis was tested by comparing participants' responses to a single-item dichotomous assessment of diabetes. Actual and expected disease proportions for both groups are provided in Table 7. A chi-square test for independence revealed significantly higher rates of diabetes in the CTS group, *chi square* = 6.21, $p = .013$. The odds ratio for diabetes and CTS group status was 1.156 and the point-biserial correlation between diabetes and the CTS group was .23.

Hypothesis 7

The seventh hypothesis stated that CTS participants would report significantly higher levels of arthritic diseases than control participants. The assessment for arthritic diseases included both unspecified arthritis and rheumatoid arthritis, and separate analyses were conducted for each. Both variables were measured with single-item dichotomous assessments of disease history. Actual and expected disease proportion rates for both groups are shown in Table 7. With respect to unspecified arthritis, a chi square test of independence revealed that CTS participants reported significantly higher levels of positive disease status than control participants, *chi square* = 3.86, $p = 049$. The odds ratio for unspecified arthritis and CTS group status was 1.32 and the point-biserial correlation .18. In contrast, no significant between-group differences were found for rates of rheumatoid arthritis, *chi square* = .325, $p = .569$. The odds ratio was .979 and the point-biserial correlation -.05.

Hypothesis 8

The eighth hypothesis stated that female participants in the CTS group would report significantly more female-related complications than would control participants. The assessment of female-related complication included past gynecological surgery and hormonal-menstrual problems, and separate analyses were conducted for each. Both variables were measured with single-item dichotomous assessments of disease history. Actual and expected disease proportion rates for both groups are presented in Table 7. A chi-square test for independence revealed that CTS participants reported significantly higher levels of past gynecological surgery, *chi square* = 6.108, $p = .013$. The odds ratio for gynecological surgery and

CTS group status was 1.36 and the point-biserial correlation .25. In contrast, no between-group differences were found for hormonal-menstrual, *chi square* = .255, $p = .613$. The odds ratio was .954 and the point-biserial correlation was -.05.

Univariate Analyses for Psychosocial Factors

Hypothesis 9

The ninth hypothesis predicted that CTS participants would endorse significantly more symptoms of anxiety than control participants. This hypothesis was tested by analyzing participants' scores on the anxiety factor of the Brief Symptom Inventory-18. Means and standard deviations are presented in Table 8. An independent samples *t* test revealed significantly higher anxiety scores in the CTS group, $t(160) = -1.97$, $p = .05$. A Cohen's *d* effect size calculation produced a value of .31, which is suggestive of a small-to-moderate magnitude. The point-biserial correlation between anxiety and CTS group status was .15.

Hypothesis 10

The tenth hypothesis stated that CTS participants would report significantly higher levels of depressive symptoms than control participants. This hypothesis was tested by analyzing participants' scores on the depression subscale of the BSI-18. Means and standard deviations are presented in Table 8. An independent samples *t* test revealed that CTS participants endorsed significantly higher levels of depressive symptoms, $t(160) = -2.610$, $p = .010$. A Cohen's *d* effect size calculation produced a value of .41, which is indicative of a small-to-moderate magnitude. The point-biserial correlation between depression and CTS group status was .20.

Hypothesis 11

The eleventh hypothesis predicted that CTS participants would report significantly more

Table 8

Univariate Analyses Results for Psychosocial Factors

Measures	Means (*SD*)	SEM	*t* values	*p* values	ES	*r*
(H:9) Anxiety-BSI						
CTS group	3.37 (3.80)	.407	-1.97	.05	.31	.15
Control group	2.30 (2.97)	.343				
(H:10) Depression-BSI						
CTS group	3.62 (4.93)	.529	-2.61	.010	.41	.20
Control group	1.93 (2.84)	3.28				
(H:11) Somatization-BSI						
CTS group	1.88 (2.28)	.244	-2.88	.007	.45	.22
Control group	.986 (1.53)	.177				
(H:12) Total BSI score						
CTS group	8.88 (9.91)	1.06	-2.75	.007	.42	.21
Control group	5.22 (6.27)	.724				
(H:13) Internal health locus of control						
CTS group	26.45 (3.98)	.432	1.85	.066	.29	-.14
Control group	27.62 (3.97)	.459				
External-powerful others health locus of control						
CTS group	16.22 (5.89)	.639	-2.48	.014	.39	.19
Control group	14.02 (5.22)	.602				
External-chance health locus of control						
CTS group	14.18 (5.10)	.553	1.182	.239	.18	-.09
Control group	15.14 (5.13)	.592				
God health locus of control						
CTS group	12.91 (6.75)	.732	-.810	.419	.12	.06
Control group	12.14 (5.04)	.582				
(H:14) Job satisfaction						
CTS group	4.86 (1.49)	.173	3.88	.000	.61	-.28
Control group	5.91 (1.85)	.199				
Physical functioning SF-36						
CTS group	67.90 (23.30)	2.51	5.37	.000	.85	-.39
Control group	87.02 (21.38)	2.48				
Role functioning SF-36						
CTS group	50.00 (40.94)	4.41	4.75	.000	.75	-.35
Control group	79.05 (35.60)	4.13				
Bodily pain SF-36						
CTS group	49.61 (21.85)	2.35	7.38	.000	1.17	-.50
Control group	78.24 (27.13)	3.15				

(*table continues*)

Measures	Means (*SD*)	SEM	*t* values	*p* values	ES	*r*
General Health SF-36						
CTS group	60.56 (20.15)	2.27	5.16	.000	.82	-.38
Control group	77.20 (20.46)	2.37				
Vitality SF-36						
CTS group	49.36 (12.15)	1.31	4.73	.000	.75	-.35
Control group	58.59 (12.39)	1.44				
Social functioning SF-36						
CTS group	71.22 (29.27)	3.15	3.5	.000	.58	-.27
Control group	86.14 (20.95)	2.43				
Role emotional SF-36						
CTS group	66.66 (40.41)	4.40	2.72	.007	.43	-.21
Control group	82.43 (30.82)	3.58				
Mental Health SF-36						
CTS group	64.65 (16.26)	1.76	2.66	.008	.42	-.20
Control group	70.70 (11.52)	1.33				
(H:16) Physical component summary SF-36						
CTS group	40.82 (10.19)	1.12	6.39	.000	1.02	-.45
Control group	51.62 (10.90)	1.26				
(H:16) Mental component summary SF-36						
CTS group	46.40 (11.33)	1.03	1.49	1.37	.24	-.11
Control group	48.73 (7.54)	.876				

symptoms of somatization than control participants. This hypothesis was tested by analyzing participants' scores on the somatization subscale of the BSI-18. However, inspection of these items (somatization subscale) revealed that two of the questions overlap with actual symptoms of CTS (e.g., "numbness of tingling in any part of the body"). As such, these two items were omitted, and the analysis was conducted using the remaining four items. Means and standard deviations for both groups are presented in Table 8. The results of an independent samples *t* test on the corrected somatization subscale indicated that CTS participants reported significantly higher levels of somatization, $t(160) = -2.88$, $p = .004$. A Cohen's *d* effect size calculation produced a value of .45, which approaches a moderate magnitude. The point-biserial correlation between somatization and the CTS group was .22.

Hypothesis 12

The twelfth hypothesis stated that Total BSI-18 scores would be significantly higher for CTS participants. Means and standard deviations for both groups are presented in Table 8. An independent samples *t* test revealed that participants in the CTS group scored significantly higher on Total Brief Symptom Inventory-18 scores, $t\,(160) = -2.75, p = .007$. A Cohen's *d* effect size calculation produced a value of .42, which is suggestive of a moderate-to-large association. The point-biserial correlation between total BSI scores and the CTS group was .21

Hypothesis 13

The thirteenth hypothesis predicted that CTS participants would endorse lower levels of internal health locus of control. This hypothesis was tested by analyzing participants' scores on the internal health locus of control subscale from the Multi-dimensional Health Locus of Control Scale. Means and standard deviations are presented in Table 8. An independent samples *t* test revealed borderline lower scores on the internal health locus of control subscale for the CTS participants, $t(158) = 1.85, p = .066$. A Cohen's *d* effect size calculation produced a value of .29, which is suggestive of a small-to-moderate magnitude of association. The point-biserial correlation between internal health locus of control and CTS group status was .29. Further analyses were conducted on the remaining three health locus of control subscales (i.e., external-powerful others, external-chance, and God). All between-group comparisons for the additional variables were analyzed using independent samples *t* tests. Means and standard deviations for both groups are presented in Table 8. Significant between-groups differences were found for external-powerful others health locus of control, with CTS participants scoring higher than control participants, $t\,(158) = -2.48, p = .014$. A Cohen's *d* effect size calculation produced a value of .39, which is suggestive of a small-to-moderate magnitude of association. The point-biserial correlation between external-powerful others subscale and CTS group status was .19. In contrast, no significant between groups differences were found for external-chance health locus of control, $t(156) = -1.075$, $p = .284$, or God health locus of control, $t(156) = .913$, $p = .362$.

Hypothesis 14

The fourteenth hypothesis stated that CTS participants would report significantly lower levels of job satisfaction than control participants. This hypothesis was tested by analyzing participants' responses to a single item (Likert rating scale) assessment of job satisfaction. The means and standard deviations are presented in Table 8. An independent samples *t* test revealed that CTS participants endorsed significantly lower levels of job satisfaction than control participants, $t(159) = 3.88$, $p = .000$. The Cohen's *d* effect size for job satisfaction was .61 (which is suggested of a moderate magnitude) and the point-biserial correlation between job satisfaction and CTS group status was -.28.

Hypothesis 15

The fifteenth hypothesis stated that CTS participants would endorse significantly higher levels of physical and mental dysfunction than control participants. This hypothesis was tested by analyzing participants' scores on the Short Form Health Inventory-36. The analyses included separate tests for each of the eight subscales: (A) physical functioning, (b) role-physical, (c) bodily pain, (d) general health, (e) vitality, (f) social functioning, (g) role-emotional, and (h) mental health; and the two aggregate mental and physical component summaries. All between-group comparisons were done using independent samples *t* tests. Means, standard deviations, and odds ratios for both groups are presented in Table 8. The results of the analyses consistently revealed higher levels of physical and mental dysfunction among the CTS group. In particular, CTS participants endorsed significantly higher levels of physical dysfunction, $t(158) = 5.37$, $p = .000$);

significantly lower physical role functioning, $t(158) = 4.75, p = .000$; significantly more bodily pain, $t(158) = 7.389, p = .000$); significantly lower levels of general health, $t(158) = 5.168, p = .000$); significantly lower levels of vitality, $t(157) = 4.733, p = .000$; significantly lower social functioning, $t(158) = 3.65, p = .000$; significantly lower emotional role functioning, $t(156) = 2.72, p = .007$; and significantly lower levels of mental functioning, $t(157) = 2.66, p = .008$. With respect to the component summary scores, CTS participants scored significantly lower on the physical component summary, $t(154) = 6.39, p = .000$. However, there were no between-group differences on the mental component summary, $t(154) = 1.49, p = .137$.

The results of the SF-36 analyses seem particularly noteworthy. Specifically, the CTS group consistently endorsed significantly lower levels of physical, social, and emotional health functioning than the control group on all 10 subscales. In addition, the majority of the effect sizes were suggestive of moderate-to-large magnitudes. Indeed, in the present analysis, the SF-36, perhaps more than any other psychosocial measure, strongly differentiated between the cases and controls. Given this finding, it was decided to compare the SF-36 scores obtained from the present CTS sample with existing general population norms as well as norms for musculoskeletal disordered patients. This was accomplished by computing standardized mean difference effect sizes for the eight subscales and the two summary scales. As seen in Table 9, the CTS participants' scored considerably lower than the general population values on all 10 measures of health functioning. The effect sizes for the eight subscales ranged from -.42 to -1.12, with the majority reflective of moderate-to-large magnitudes. The effect sizes for the physical and mental component summaries were -.90 and -.33, respectively. When the CTS group was compared to musculoskeletal disordered patients, the effect sizes on the eight subscales ranged from .01 to -.79. Three comparisons produced effect sizes reflective of moderate or large magnitudes (i.e., bodily pain, social functioning, and mental health subscales). Of the remaining five subscale effect size

Table 9

SF-36 Comparisons Between the CTS Group and Normative Groups

SF-36 subscales	CTS group mean (*SD*)	Normative group general U.S. population mean (*SD*)	ES	Normative group musculoskeletal problems mean (*SD*)	ES
Physical functioning	67.90 (23.30)	84.15 (23.28)	-.69	67.58 (25.66)	.01
Role physical	50.00 (40.94)	80.96 (34.0)	-.82	56.15 (41.09)	-.07
Bodily pain	49.61 (21.85)	75.15 (23.69)	-1.12	66.57 (24.39)	-.73
General health	60.56 (20.15)	71.95 (20.34)	-.56	59.85 (20.55)	.01
Vitality	49.36 (12.15)	60.86 (20.96)	-.67	56.82 (21.55)	-.42
Social functioning	71.22 (29.27)	83.28 (22.69)	-.46	87.17 (20.25)	-.63
Role emotional	66.66 (40.41)	8.26 (33.04)	-.42	73.14 (37.95)	-.16
Mental health index	64.65 (16.26)	74.74 (18.05)	-.58	78.13 (17.61)	-.79
Physical comp sum	40.82 (10.19)	50.00 (10.00)	-.90	41.6 (10.42)	-.07
Mental comp sum	46.40 (11.33)	50.00 (10.00)	-.33	52.79 (9.76)	-.60

calculations, one was suggestive of a small-to-moderate magnitude (vitality), and the remaining four were minimal. The effect sizes for the physical and mental summary scales were -.07 and -.60, respectively. This suggests that the present sample of CTS participants reported considerably lower levels of mental and social health than other musculoskeletal disordered groups.

Multivariate Analyses

The present study hypothesized that prediction of CTS would be maximized through use of a biopsychosocial model. The biopsychosocial model used in the present study included occupational, personological, and psychosocial variables. While the majority of the study variables were identified through the literature review, exploratory variables were also included.

As CTS is believed to be a multifaceted syndrome with a host of aetiological factors, no a priori predictions were made regarding which risk factor categories would show stronger (or weaker) associations with the syndrome.

To test the predictive accuracy of a biopsychosocial model of CTS, several multiple logistic regression analyses were conducted. The first logistic included several occupational variables as predictors of CTS group status. The second logistic model included several personological variables as predictors of CTS group status. The third logistic model included several psychosocial variables as predictors of CTS group status. The occupational, personological, and psychosocial variables included in these analyses were those that showed statistically significant associations with CTS group status in univariate testing ($p < .05$). The final model was comprised of variables from the first three logistic regressions that significantly added to the prediction of CTS group status (sig. < .05).

Before reporting the results, a brief overview of multiple logistic regression will be provided to justify its use with the present data. In addition, to facilitate interpretation of logistic regression analyses, brief explanations and examples will be provided while presenting the first logistic model.

Multiple logistic regression is indicated when assessing the unique and combined impact of several independent (predictor) variables on one binary dependent (outcome) variable (e.g., CTS; Hosmer & Lemeshow, 1989; Kahn & Semps, 1989). A statistical technique with some similarities to multiple logistic regression is discriminate analysis. Discriminate analysis is a technique for differentiating between groups based on multiple variables. Howell (2002) discussed some of the advantages of multiple logistic regression over discriminate analysis that included: (a) the production of odds ratios, (b) the interpretation of predictive values in terms of probabilities, and (c) fewer statistical assumptions.

Multiple linear regression is another multivariate statistical technique with similarities to multiple logistic regression. Multiple linear regression, however, is contraindicated when the dependent variable is binary. The reason being that binary outcome prediction violates the normal distribution assumptions that underlie multiple linear regression procedures (Rosner, 1995). Given these considerations, the use of multiple logistic regression analyses seemed the most appropriate statistical technique for analyzing the present data.

To facilitate the interpretation of the logistic analyses, explanations and examples from the first logistic model will be included throughout the presentation of the findings. The occupational logistic regression model was comprised of three occupational variables as predictors of CTS group status (i.e., repetition, repetition and force, and total OHU scores). As previously indicated, these variables were selected because they reached statistical significance during the univariate analyses. Table 10 provides the results of the occupational logistic model in predicting CTS group status. It should be noted that age was statistically controlled for in this, and all remaining, logistic analyses.

An initial step in the interpretation of the logistic regression is to ascertain if the logistic model significantly predicts the outcome variable at greater than chance level (Howell, 2002). This is accomplished by assessing how well the regression line from the logistic model fits the data (Schlesselmen, 1982; Hosmer & Lemeshow, 1989). To do so, a chi-square goodness-of-fit test first assesses how well a "no variable" model (i.e., a model without any predictor variables) fits the data. This provides a measurement of the overall variability in the data. A second chi-square goodness-of-fit test then assesses the fit of the complete logistic model (i.e., all predictor variables and one constant). The amount of variability remaining after entering the predictors represents the reduction in the chi-square associated with the logistic model, and indicates if the model was successful in predicted the outcome at a greater than chance level (Howell).

Table 10

Occupational Logistic Model Predicting CTS with Three Predictor Variables

Variable	β	SE	Wald	*df*	Sig.	*R*	Exp (B)
Age	.047	.014	12.137	1	.000		1.049
Repetition	.558	.281	3.928	1	.047		1.746
Repetition and force	.120	.202	.353	1	.552		1.127
OHU total	-.040	.083	.231	1	.631		.961
Constant	-4.216	1.127	1.127	1	.000		.015

For instance, when the goodness-of-fit for the three variable occupational model was compared to the no-variable model, the resulting chi square statistic was 28.151 (p = .000, df = 3). This suggests that the occupational logistic model significantly improved prediction beyond the no variable model.

The next step is to identify which variables in the occupational model significantly increased the predictive power of the model. This may be accomplished by inspecting the logistic coefficients associated with each variable. The logistic coefficients may be found in column β of Table 10. The logistic coefficient represents the magnitude of increase (or decrease) in the log odds associated with a one unit change in the value of the predictor variable (Schlesselman, 1982). For instance, as seen in Table 10, the logistic coefficient for repetition is .556. This suggests that for every one unit change in repetition (while the other values are held constant) the log odds for the dependent variable (CTS) increases by .556.

An alternative method for interpreting the logistic coefficients is through transformation of log odds into odds, which are provided in the Exp (β) column of Table 10. Transformation from log odds to odds is accomplished through exponentiation of the logistic coefficient (i.e., raise *e* to that power), which removes the log from the odds (Howell, 2002). Continuing with the example of repetition, by raising *e* to the .556 power, the resulting product is 1.744. This value is also known as the odds ratio.

The interpretation of an odds ratio is fairly straightforward. An odds ratio of 1.00 is reflective of no association between the predictor variable and outcome. An odds ratio greater than 1.00 (without overlapping 95% confidence intervals) is suggestive of a positive association between the predictor and outcome. An odds ratio less than 1.00 (without overlapping 95% confidence intervals) is reflective of a negative association between the predictor and outcome. If the 95% confidence intervals overlap with 1.0, it is not appropriate to interpret an association. Appropriate interpretation of odds ratios also requires one group to serve as a reference category, against which others may be compared (Schlesselman, 1982). Perhaps for this reason, Bigby (2000) noted that the results of case-control studies are best expressed in terms of odds ratios. Howell (2002) noted additional advantages associated with the use of odds ratios, including: (a) odds ratios are independent of sample size, and (b) odds ratios are not artificially affected by unequal margin distributions. As shown in Table 10, the odds ratio for repetition is 1.744 and the 95% confidence intervals do not overlap (1.006 to 3.023).

The statistical significance of each predictor variable is identified through interpretation of the Wald statistic with its associated significance value. The Wald is a chi square statistic with one degree of freedom. It is the squared ratio of individual logistic coefficients to its standard error (DeBerard, 1998). The Wald statistic may be interpreted as a statistical index reflecting the amount of predictive variance associated with each unique predictor variable. For the current study, a statistical significance cutoff value was set at $< .05$. Thus, variables with a significance value less than $< .05$, will be selected as statistically significant predictors of CTS group status. As seen in Table 10, the Wald statistic for repetition is 3.930 and the significance value is .047.

This suggests that repetition predicts a statistically significant amount of the variance associated with CTS group status. The intercorrelations among the occupational predictor variables are provided in Table 11.

Further inspection of the occupational logistic model reveals that none of the other variables added significantly to the prediction of CTS group status. As such, repetition is the only variable form the occupational model that will be included in the final logistic model.

Table 12 provides a classification summary table illustrating the accuracy of the occupational logistic model in assigning study participants to their respective groups. Using a cut off rate of .50, the occupational logistic model correctly predicted 78.2% of the CTS participants and 55.4% of the control participants. The overall hit rate for the occupational logistic model was 67.7%. This suggests that the occupational logistic regression model was moderately accurate in predicting CTS, although itsoverall predictive accuracy was lacking.

The second logistic model used three personological variables to predict CTS group status. The three predictor variables were BMI, vigorous physical exercise, and levels of physical activity with strain on the wrist.

Chi square goodness-of-fit tests suggested that the personological logistic model significantly enhanced prediction over the no-variable model (*chi square* = 53.045, $df = 4$, $p = .000$). The logistic coefficients, standardized error, Wald statistic, degrees of freedom, significance values, and odds ratios are provided in Table 13. The intercorrelations among personological predictor variables are provided in Table 14.

As shown in Table 13, all three personological variables possessed Wald statistics large enough to reach statistical significance. The odds ratios for BMI and exercise with strain on the wrist were 1.162 and 1.002, respectively (both confidence intervals nonoverlapping). With respect to vigorous physical exercise, the odds ratio was .996 with nonoverlapping 95% confidence

Table 11

Intercorrelations Among the Predictor Variables in the Occupational Logistic Regression

Variables	Constant	Age	Repetition	OHU total	Repetition and Force
Constant	--	--	--	--	--
Age	-.793	--	--	--	--
Repetition	-.115	.048	--	--	--
OHU Total	-.372	.049	-.016	--	--
Repetition and Force	-.024	.121	-.652	-.611	--

Table 12

Occupational Logistic Regression: Case Versus Control Group Classification Matrix

	Expected		
Observed	CTS group	Control group	% correct
CTS group	68	19	78.2
Control group	33	41	55.4
Overall percentage correctly predicted			67.7

Table 13

Personological Logistic Model Predicting CTS with Three Predictor Variables

Variable	β	SE	Wald	*df*	Sig.	*R*	Exp (B)
Age	.014	.014	1.00	1	.317		1.014
BMI	.150	.040	13.852	1	.000		1.162
Vigorous exercise	-.004	.001	9.133	1	.003		.996
Exercise w/o wrist strain	.002	.000	11.414	1	.001		1.002
Constant	-4.908	1.363	12.960	1	.000		.007

Table 14

Intercorrelations Among Personological Predictor Variables

Variables	Constant	Age	Vigorous exercise	Exercise w/wrist strain	BMI
Constant	--	--	--	--	--
Age	-.490	--	--	--	--
Vigorous exercise	-.246	.203	--	--	--
Exercise w/wrist strain	-.233	-.090	-.224	--	--
BMI	-.847	.004	.104	.174	--

interval (i.e., .994 to .999). As such, vigorous physical exercise added to the predictive accuracy through a negative association with CTS group status. In contrast, the odds ratio for physical activities with strain on the wrist was 1.002 (with nonoverlapping confidence intervals), which suggests a positive association with CTS group status.

The classification accuracy of the personological logistic model is presented in Table 15. Inspection of the table suggests that the personological model possessed greater predictive accuracy than did the occupational model. Specifically, the personological model was able to correctly classify 80.2 of the CTS participants and 64.4% of the control participants. The overall hit rate for the personological model was 73%. Thus, while the predictive gains in CTS classification were minimal, the gains in control prediction and overall hit rate were considerable.

The third multiple logistic regression model entered six psychosocial variables to predict CTS group status. These variables included: somatization, depression, anxiety, powerful others health locus of control, job satisfaction, and the physical component summary (PCS) of the SF-36. Chi square goodness-of-fit tests revealed that the psychosocial logistic model significantly improved prediction over the no-variable model. Table 16 provides the logistic coefficients,

Table 15

Personological Logistic Regression: Case Versus Control Group Classification Matrix

	Expected		
Observed	CTS group	Control group	% correct
CTS group	69	19	80.2
Control group	26	47	64.4
Overall percentage correctly predicted			73

Table 16

Psychosocial Logistic Model Predicting CTS with Six Predictor Variables

Variable	β	SE	Wald	*df*	Sig.	Exp (B)
Age	.016	.014	1.148	1	.284	1.016
PCS	-.082	.020	15.925	1	.000	.922
Job satisfaction	-.356	.124	8.313	1	.004	.700
Somatization	.007	.139	.002	1	.961	1.007
Depression	.039	.076	.169	1	.681	1.032
Anxiety	-.002	.096	.000	1	.984	.998
POHLC	.039	.037	1.117	1	.291	1.040
Constant	4.463	1.614	7.650	1	.006	86.72

standard error, Wald statistic, degrees of freedom, significance values, and odds ratios. Table 17 provides the intercorrelations among the psychosocial predictor variables. Of the six psychosocial variables, only the SF-36 PCS subscale and job satisfaction possessed Wald statistics large enough

Table 17

Intercorrelations Among the Psychosocial Predictor Variables

Variable	Constant	Age	Physical Component Summary	Somatization	Depression	Anxiety	Powerful Other/ Health Locus of Control	Job satisfaction
Constant	--	--	--	--	--	--	--	--
Age	-.452	--	--	--	--	--	--	--
PCS	-.789	.184	--	--	--	--	--	--
Som	-.287	.084	.286	--	--	--	--	--
Dep	-.081	.072	.057	-.016	--	--	--	--
Anx	-.057	.023	-.020	-.390	-.659	--	--	--
PO HLC	-.279	-.140	.089	-.070	-.200	.161	--	--
Job sat	-.430	-.085	.104	.128	.169	-.073	-.125	--

to reach statistical significance. The odds ratios for the PCS and job satisfaction were .922 and .700, respectively (both with nonoverlapping confidence intervals). This suggests that both PCS and job satisfaction added significantly to the prediction of CTS group status (i.e., as values decreased likelihood of CTS group status increased).

The classification accuracy of the psychosocial logistic model is presented in Table 18. Inspection of the table suggests that the psychosocial model predicted case and control group status with similar accuracy rates. The psychosocial model correctly predicted 75.3% of the CTS participants and 77% of the control participants. The overall hit rate for the psychosocial logistic model was approximately 76.1%. When compared to the accuracy of the two preceding models, the psychosocial model showed poorest accuracy predicting CTS group status but the highest accuracy in predicting control group status. In addition, the overall hit rate for the psychosocial model was more accurate than those from the occupational and personological models.

Table 18

Psychosocial Logistic Regression: Case Versus Control Group Classification Matrix

	Expected		
Observed	CTS group	Control group	% correct
CTS group	61	20	75.3
Control group	17	57	77
Overall percentage correctly predicted			76.1

The final multiple logistic regression analysis used the significant variables from the three preceding models to predict CTS group status. Specifically, the model included repetition, BMI, vigorous exercise, physical activity with strain on the wrist, the PCS, and job satisfaction.

Chi-square goodness-of-fit tests revealed that the final logistic model significantly improved the prediction of CTS group status over the no variable model (*chi square* = 82.083, *df* = 7, *sig.* = .000). The logistic coefficients, standard errors, Wald statistics, degrees of freedom, significance values, and odds ratios for each of the variables are presented in Table 19. Table 20 provides the intercorrelations among the predictor variables in the final logistic model.

Inspection of Table 19 reveals that five of the six variables possessed Wald statistics large enough to reach statistical significance. Furthermore, the Wald statistic for the remaining variable reached borderline statistical significance. Following will be a brief discussion of each variable in the final model.

As illustrated in Table 19, repetition was a strong predictor of CTS group status. The Wald statistic for repetition was 10.426 and the significance level was .001. In addition, the odds ratio for repetition was 1.841 with nonoverlapping confidence intervals. This suggests that each one unit increase in repetition is associated with an 84% increase in CTS group status.

Table 19

Final Logistic Model with Six Predictor Variables

Variable	β	SE	Wald	*df*	Sig.	*R*	Exp (B)
Age	.018	.017	1.071	1	.301		1.018
Repetition	.610	.189	10.426	1	.001		1.841
Job satisfaction	-.410	.143	8.236	1	.004		.663
BMI	.082	.049	2.860	1	.091		1.086
PCS	-.058	.022	6.750	1	.009		.944
Vigorous exercise	-.003	.001	5.565	1	.018		.997
Exercise strain	.002	.001	11.466	1	.001		1.002
Constant	-.818	2.517	.106	1	.745		.441

Table 20

Intercorrelations Among the Predictor Variables in the Final Logistic Model

Variable	Constant	Age	Wrist strain	PCS	Vigorous exercise	BMI	Job satisfaction	Repetition
Constant	--	--	--	--	--	--	--	--
Age	-.423	--	--	--	--	--	--	--
Wrist strain	-.067	-.070	--	--	--	--	--	--
PCS	-.622	.117	-.058	--	--	--	--	--
Vig exe	-.171	.173	-.309	-.052	--	--	--	--
BMI	-.742	.021	-.106	-.318	.127	--	--	--
Job sat	-.327	-.142	-.169	-.062	.152	.149	--	--
Rep	-.351	.336	.095	.002	-.031	-.039	-.145	--

In addition, both vigorous exercise and physical activities with strain on the wrist were significant predictors of CTS group status. Vigorous exercise was associated with a Wald statistic of 5.565 with a corresponding significance value of .018. The odds ratio for vigorous exercise was significant at .997, suggesting that every one unit decrease in vigorous exercise levels is associated with a .003% increase in CTS group status. While this may seem trivial, it should be noted that the scale for vigorous exercise ranged from 0 to 1,140. As such, despite the small incremental values, a scale of such magnitude could result in considerable predictive power. In contrast, physical activity with strain on the wrist was positively associated with CTS group status. Specifically, the Wald statistic was 11.446, which resulted in a significance value of .001. The odds ratio of 1.002 was significantly elevated and possessed nonoverlapping confidence intervals. An odds ratio of this value suggests that every one unit increase in physical activities with wrist strain is associated with a .002% increase in CTS group status. As with vigorous exercise, the large nature of the physical activities scale suggests that this variable could also be a strong predictor of CTS.

The PCS was also a significant predictor of CTS group status in the final model. Specifically, the PCS possessed a Wald statistic of 6.750 with a significance value of .009. The odds ratio for the PCS was significant at .994, with nonoverlapping confidence intervals. This suggests that each one unit decrease on the PCS is associated with 5.5% increase in CTS group status.

Job satisfaction was a surprisingly strong predictor of CTS group status in the final model, Wald = 8.23, sig. = .004. The odds ratio for job satisfaction was significant at .633, with nonoverlapping confidence intervals. This indicates that every one unit decrease in job satisfaction is associated with a 42.7% increase in CTS group status.

Finally, BMI was of borderline significance in the final logistic model. Specifically, the Wald statistic for BMI was 2.86 and the significance value .091. The odds ratio for BMI was 1.086, although the 95% confidence intervals were overlapping. Given the strong associations in the univariate and personological logistic analyses, it is difficult to dismiss the importance of BMI based on a borderline significance value.

The classification accuracy of the final logistic regression model is provided in Table 21. The final logistic model was able to correctly classify 86% of the CTS participants and 74 of the control participants, for an overall hit rate of 80.5. This classification model supercedes the predictive accuracy of the first three models, with a particularly noteworthy accuracy in predicting CTS group status.

Table 21

Final Logistic Regression: Case Versus Control Group Classification Matrix

	Expected		
Observed	CTS group	Control group	% correct
CTS group	70	11	86
Control group	54	19	74
Overall percentage correctly predicted			80.5

CHAPTER V

DISCUSSION

Introductory Statement

Overall, the findings of the present study support the hypothesis that a biopsychosocial model enhances the predictive accuracy of CTS. However, before discussing the applicability of a biopsychosocial model, the present section will provide a systematic discussion of the numerous findings in the present study. Towards this end, the discussion will be organized into several different sections. The first section will provide an in-depth discussion of the occupational findings, including both the univariate and multivariate analyses. After this review, the occupational findings from the present study will be compared with the findings from other occupational studies. The subsequent two sections will review the personological and psychosocial findings from the present study. This discussion for both these sections will follow the same structure outlined for the occupational section. Following these sections, the findings from the final logistic regression analysis will be discussed. Again, the results from the present study will be compared to those of other similar studies. Following discussion of the final model, plausible explanations for the positive associations found between the predictor variables and the CTS group will be provided. The next section will provide a discussion of variables were found to have strong univariate associations with CTS. After discussion of the univariate model, the subsequent section will explore the applicability of a biopsychosocial model for conceptualizing and predicting CTS. The final two sections will cover the limitations of the current study as well as recommendations for future research.

Discussion of Occupational Findings

The present study investigated a total of eight occupational variables. Three of these variables were primary study hypotheses, which included repetition, repetition and force, and vibration. In addition to the primary occupational hypotheses, the following five secondary variables were also assessed: (a) occupational force, (b) lift heavy loads, (c) on feet for more than four hours per day, (d) typing/keyboarding, and (e) Occupational Hand Use total scores.

Univariate Hypothesis Testing

The results of the univariate analyses provided initial support for two of the study hypotheses. In particular, CTS participants endorsed significantly higher levels of occupational repetition and repetition and force. These findings were not surprising, however, given the consistent positive associations found in the literature review between these variables and CTS. In contrast, the hypothesis that CTS participants would report significantly higher levels of vibration was not supported in the univariate analysis. This finding was somewhat of a surprise given the consistent and large associations found in the literature review between vibration and CTS.

With respect to the remaining secondary occupational variables, univariate analyses revealed no significant between-group differences on force, typing/keyboarding, lift heavy loads, and on feet more than four hours a day. Total OHU scores, however, were significantly higher in CTS participants. This latter finding was not unexpected given the significant associations with repetition and repetition and force, as well as the borderline significant association with force (all of which load on the OHU scale).

In summary, the results of univariate analyses revealed statistically significant associations between repetition, repetition and force, and total OHU scores and CTS group status. As such, these variables were included in a multiple logistic regression analysis. In contrast, no relationship between CTS group status and typing/keyboarding, lift heavy loads, on feet more than four hours a day, and vibration were found.

Multiple Logistic Regression Hypothesis Testing

The occupational logistic model entered the above-specified three occupational variables as predictors of CTS groups status. The overall results of the occupational model were significant, suggesting it predicted CTS group status at a greater-than-chance level. The three variable logistic model accurately classified 77% of the CTS participants and 58% of the control participants. The total hit rate for the model was 68.3%. Notwithstanding, repetition was the only variable that significantly added to the predictive power of the model. The remaining two variables were nonsignificant predictors.

Comparisons with other Occupational Studies

In the present study, repetition, among a host of other putative occupational risk factors, emerged as the only occupational variable associated with CTS. It seems appropriate to compare this finding with other studies that have used the Occupational Hand Use scale (Nathan et al., 1992a, 1992b; Nathan & Keniston, 1993; Nathan, Meadows, & Doyle, 1988a, 1988b). These comparisons place into sharp contrast the positive association between repetition and CTS found in the present study, as the remaining studies reported no such associations (either with repetition or any other occupational variable).

Several factors may help explain this discrepancy. First, Nathan and colleagues have typically relied on EDX testing results (only) to diagnose CTS (Nathan et al. 1992b; Nathan & Keniston, 1993; Nathan et al., 1988a, 1998b). This procedure is limited as it may result in a substantial number of false positives (Pritchard et al., 1998). Thus, the diagnostic protocol used in the studies conducted by Nathan and colleagues may have attenuated the power to detect between group differences. In contrast, the more stringent case definition employed in the present study likely provided greater diagnostic accuracy, which in turn, would result in greater statistical power to detect between group differences. In addition, the studies carried out by Nathan and colleagues typically used industrial workers as study participants (Nathan et al., 1992a, 1992b; Nathan et al., 1988a, 1988b). This practice may be problematic as it restricts the range of exposure to potential risk factors (i.e., repetition). Such a restriction in range, again, may limit the likelihood of detecting between-group differences. In contrast, participants in the present study were employed in a host of different jobs and occupational categories. Hence, by providing a wider range of occupational exposure, the present study may have increased the likelihood of detecting significant between group differences.

Our findings support those of Latko et al. (1999) and Nordstrom, Veirkant, DeStefano, and Layde (1997), who also found repetition to be the only significant occupational variable associated with CTS. For instance, Nordstrom and colleagues found repetition, but not typing, to be a significant predictor of CTS.

The occupational findings from the present study are also consistent with several other studies, but to a lesser degree. For example, Silverstein et al. (1987) also found repetition, but not force, to be a unique predictor for CTS. In contrast, however, the authors reported that combined repetition and force was associated with a large, statistically significant odds ratio. Wieslander, Norback, Gothe, and Juhlin (1989) also found repetition, but not force, to be related to CTS. However, contrary to our findings, the authors reported that vibration was significantly related to CTS.

With further diminishing similarities, Yagev, Carel, and Yagev (2001) found repetition and force to be significantly associated with CTS, while the present study found only repetition to be significantly associated. Finally, Cosegrove et al. (2002) found no occupational variables were significantly related to CTS.

Discussion of Personological Findings

The present study proposed six personological hypotheses. These were: (a) that participants in the CTS group would possess significantly higher BMI values than control participants; (b) participants in the CTS group would report significantly less vigorous exercise than control participants; (c) participants in the CTS group would report significantly higher levels of diabetes mellitus; (d) participants in the CTS group would report significantly higher levels of arthritic disease, including unspecified arthritis and rheumatoid arthritis; (e) female participants in the CTS group would report significantly higher levels of menstrual/hormonal problems than will female participants in the control group; and (f) female participants in the CTS group would report significantly higher levels of gynecological surgery than female participants in the control group.

The measure created to assess vigorous physical exercise provided three additional physical activities variables. These were: (a) physical activities with strain on wrist, (b) physical activities without strain on the wrist, and (c) total amount of exercise. In total, nine personological variables were investigated in the current study.

Univariate Hypothesis Testing

The results of the univariate analyses provided initial support for five of the personological hypotheses. Specifically, CTS participants possessed significantly higher BMI values, endorsed significantly less amounts of weekly vigorous physical exercise, reported significantly higher levels of premorbid diabetes and unspecified arthritis, and females in the CTS group reported significantly higher levels of past gynecological surgery. In contrast, the univariate analyses suggested that CTS was not significantly associated with rheumatoid arthritis or menstrual problems/complications.

With respect to the additional exercise variables, univariate analyses indicated that CTS participants reported significantly higher levels of physical activities with strain on the wrist. The study groups did not differ significantly on physical activities without strain on the wrist or total physical activity levels.

Unfortunately, several of the personological variables that reached statistical significance in univariate testing were not included in the logistic regression. The excluded variables were the medial-disease history variables including diabetes, unspecified arthritis, and gynecological surgery. The reason for excluding these variables was due to a large numbers of missing values that resulted from an inability to procure the necessary medical records. More specifically, the data for these variables were obtained through review of the participants medical charts. Included in the medical charts was a one-page medical summary that inquired into past/present diseases and medical conditions. One of two problems precluded the gathering of these data. First, the medical charts for the participants could not be located (either by the student researcher or recordkeeping staff). Second, some of the charts located lacked the medical summary sheet. The missing data became problematic during the logistic regressions as SPSS excludes the entire case if all variables are not present. The end result would have been a significant reduction in statistical power in both the personological logistic regression and the final logistic regression. This consideration, along with the low base rates of these diseases in our study population, led to the decision to exclude diabetes, unspecified arthritis, and gynecological surgery in the logistic regressions. In addition, when these variables were included in the personological regression, they were nonsignificant and did not add to the overall predictive accuracy of the model. Likewise, when the missing values were substituted with values based on national base rates of disease prevalence, the variables remained nonsignificant and did not add to the predictive accuracy of the model.

Thus, a total of nine personological variables were assessed via univariate analyses. The results suggested that BMI, vigorous exercise, physical activities with strain on the wrist, diabetes, unspecified arthritis, and gynecological surgery were all significantly related to CTS. Variables not associated with CTS were physical activity without strain on the wrist, rheumatoid arthritis, and menstrual/gynecological problems. Due to missing data, however, only BMI, vigorous exercise, and physical activity with strain on wrist were entered into a logistic regression analysis.

Multiple Logistic Regression Hypothesis Testing

The personological logistic model entered the above-stated three variables as predictors of CTS group status. The results of the overall model suggested that it predicted CTS group status at a greater-than-chance level. The three variable model accurately classified 80% of the CTS participants and 64% of the control participants. The total hit rate for the model was 73% classification accuracy. All three variables entered into the model significantly added to the prediction of CTS group status. As such, these variables were included in the final logistic regression analysis.

Comparisons with Other Personological Study Findings

The present study included BMI, physical activities, and several medical-disease conditions in the personological category. The exclusion of the medical-disease variables limits the scope of studies with which meaningful comparisons may be drawn.

Notwithstanding, the present finding that BMI was significantly associated with CTS is consistent with a large body of research. Significant associations between increasing BMI and CTS have now been demonstrated in both longitudinal (Nathan et al., 1992b; Roquelaure et al.,

2001) and cross-section research trials (Cosegrove et al., 2002; Lam &Thurston, 1998; Vessey, Villard-Mackintosh, & Yates, 1990). Furthermore, the connection has been found with a wide-range of study populations including: (a) industrial workers (Leclerc et al., 2001), (b) general population and epidemiological participants (Ferry et al., 2000; Vessey et al., 1990); (c) electrodiagnostic clinic populations (Werner, Alberts, Franzblau, & Armstrong, 1994); (d) workers compensation populations (Atcheson, Ward, & Lowe, 1998; Cosegrove et al., 2002; Stallings, Kasdau, Soergel, & Corwin, 1997); (e) surgical populations (Giersipen, Eberle, & Pohlabeln, 2000; Karpitskaya, Novak, & Mackinnon, 2002; Wieslander et al., 1989); (f) hospital populations (de Krom, Knipschild, Kester, & Spaans, 1990); (g) national surgery populations (Tanaka, Wild, Cameron, & Freund, 1997); (h) forestry workers (Bovenzi, Zadini, Franzinelli, & Borgogni, 1991); (i) all female and all male populations (Cosegrove et al., 2002; Ferry et al., 2000), and with the present study, orthopedic clinic populations. Hence, the present finding that increasing BMI is associated with increased rates of CTS replicates a robust empirical finding.

The present study also found CTS participants engaged in less vigorous exercise than control participants. In contrast to the large number of studies on obesity, only two studies assessing exercise and CTS were located for the present review (Nathan et al., 1992b; Nathan & Keniston, 1993). The finding that CTS group status was significantly associated with exercise levels is consistent with the findings from both these studies. In particular, Nathan and colleagues found significant negative correlations between CTS and "advocational exercise levels."

Interestingly, the measure of vigorous exercise used in the present study included both activities with and without wrist strain (e.g., weight lifting, mountain biking, racquet sports, etc.). Thus, the negative association found between vigorous exercise and CTS persisted regardless of wrist strain involvement. However, the present study also found that physical activities with strain on the wrist (e.g., gardening, housework, etc.) were associated with increased risk for CTS. When considered together, these findings seem to suggest that vigorous exercise may moderate the deleterious effects of wrist-stressing activities. That is, physical activities with strain on the wrist increase risk for CTS only in the absence of vigorous physical exercise. In contrast, physical activities with strain on the wrist, when performed in the context of vigorous exercise, decrease the risk associated with CTS. Thus, individuals who engage in vigorous physical exercise, even when wrist strain is involved, may receive nonspecific health benefits that outweigh the specific deleterious effects of wrist strain. Consistent with this speculation, Nathan and Keniston (1993) also reported decreased CTS risk with vigorous physical activities causing strain on the wrist (e.g., cutting/chopping wood, martial arts, weight training, etc), but increases in CTS risk with light physical activities causing strain on the wrist (gardening, yard work, housework, etc.).

Discussion of Psychosocial Findings

The present study proposed six psychosocial hypotheses. These included: (a) CTS participants would endorse significantly higher levels of anxiety than control participants; (b) CTS participants would endorse significantly higher levels of depression than control participants; (c) CTS participants would endorse significantly higher levels of somatization that control participants; (d) Total BSI scores for CTS participants would be significantly higher than those from the control group; (e) CTS participants would endorse significantly lower levels of internal health locus of control than control participants; (f) CTS participants would report significantly lower levels of job satisfaction than control participants; and (g) CTS participants would report significantly more physical and mental dysfunction than control participants, as measured by the MCS and PCS from the SF-36.

Three additional variables were also included in the present study. These variables were the remaining scales on the multi-dimensional health locus of control scale, which included: (a) external-powerful others health locus of control; (b) external-chance health locus of control; and (c) God health locus of control. In total, the present study investigated nine psychosocial variables.

Univariate Hypothesis Testing

The results of the univariate analyses provided initial support for six of the nine psychosocial hypotheses. In particular, CTS participants endorsed significantly higher levels of anxiety, depression, somatization, and total BSI scores. In addition, CTS participants reported significantly lower levels of job satisfaction and lower levels of physical health on the PCS scale.

While CTS participants reported lower levels of internal health locus of control, the difference did not quite reach statistical significance ($p = .066$). There were no significant between group differences on the SF-36 MCS.

With respect to the remaining three health locus of control scales, the CTS group scored significantly higher on the external-powerful others scale. There were no significant between group differences on the external-chance health locus of control scale or the God health locus of control scale.

In summary, nine psychosocial were assessed via univariate analyses. Six of those nine variables reached statistical significance, including: anxiety, depression, somatization, total BSI scores, job satisfaction, SF-36 PCS, and external-powerful others health locus of control. These variables were then entered into the multiple logistic regression analysis. No between-group differences were found for internal-health locus of control, external-chance health locus of control, God health locus of control, and SF-36 MCS.

Multiple Logistic Regression Hypothesis Testing

The psychosocial logistic model used the above-specified six variables to predict CTS group status. Results of the overall model indicated that it predicted CTS group status at a significantly greater than chance level. The psychosocial model accurately classified 75% of the CTS participants and 77% of the control participants. The overall hit rate for the model was 76%. Only two of the six psychosocial variables significantly added to the predictive accuracy; those being, the PCS and job satisfaction. The nonsignificant predictors included anxiety, depression, somatization, and external-powerful others health locus of control. When total BSI scores were entered instead of separate variables for anxiety, depression, and somatization, the variable was also nonsignificant. Thus, the PCS scale and job satisfaction were entered into the final logistic regression analysis.

Comparison with Other Studies

The findings of the present study suggested that the PCS and job satisfaction were significant predictors of CTS group status, while anxiety, depression, somatization, external-powerful others health locus of control were nonsignificant predictors in multivariate models.

These findings are consistent with those from the Leclerc et al. (2001) study, which found low job satisfaction to be a significant predictor of CTS (in females) and depressive and somatic symptoms nonsignificant predictors of CTS.

The present findings are not consistent with those from the Leclerc et al. (1998) study, which found a significant relationship between psychological problems and CTS, and a nonsignificant association between job satisfaction and CTS. Likewise, the present findings are not consistent with those from the Roquelaure et al. (2001) study, which found psychological distress to be a significant predictor of CTS. Lastly, the present findings are not consistent with those from the Nordstrom et al. (1997) study, which found no relationship between job satisfaction and CTS.

The positive findings regarding psychological distress reported by Roquelaure et al. (2001) merits discussion. Specifically, the authors indicated that when the General Health Questionnaire (GHQ) scores for all study participants were used, no relationship was found with CTS. This would be consistent with the findings from the current study. However, the authors then proceeded to stratify their sample on GHQ results and ran an analysis using only those participants which scored in the 90th percentile or above on the GHQ. Thus, the results of their findings seem better interpreted as severe psychological problems being a significant predictor of CTS, as it is of many physical maladies. This stratification, may in part, explain the discrepancies. The reason for the discrepancies with the other studies remains unclear.

It is difficult to make comparisons with the Mathis et al. (1994) study, which found higher rates of current and lifetime anxiety disorders in CTS patients than in low back pain patients. First, the present study did not assess for anxiety disorders, but rather symptoms of anxiety. Second, while the control participants in the present study were patients at an orthopedic clinic, they were not a single group with the same physical condition (i.e., low back pain). As such, the control participants in the present study likely represented a wider range of patient populations. Likewise, comparisons with the Ferry et al. (2000) and Vessey et al. (1990) are also difficult. Specifically, the Ferry and colleagues' study coded for "nonpsychotic psychiatric illness," while the Vessey et al. (1990) study coded for "neuroses." First, the lack of specificity of these variables is such that comparisons with anxiety, depression, and somatization seem tenuous. Furthermore, even the global measure of psychological distress used in the present study is of considerable more specificity than "nonpsychotic psychiatric illness" and "neurosis." In addition, both studies coded for these variables in a review of medical databases. This practice seems less precise than inquiring of study participants directly. For instance, a medical data base may be lacking in the psychological histories of many participants, as individuals may be reticent to disclose psychological problems to medical professionals. Furthermore, the extent to which the databases included an integration of individuals' psychological histories into the medical database is unclear.

Only one study using the SF-36 with a sample of CTS participants was located (Atroshi, Gummesson, Kristianstad, Johnsson, & Sprinchorn, 1999). The study compared SF-36 scales with general population norms. The authors reported that CTS participants had significantly worse scores on the PCS, but little or no differences on the MCS. In somewhat of a contrast, the present study found considerable differences between the CTS group and the general population norms on all scales.

Discussion of the Final Logistic Regression Model

The final multiple logistic regression analysis entered six variables as predictors of CTS group status. The variables included in the final model were those that added significantly to the predictive accuracy in the first three logistic regressions. The model was comprised of one occupational predictor (repetition), three personological predictors (BMI, vigorous exercise, and exercise without strain on wrist), and two psychosocial predictors (SF-36 PCS and job satisfaction). The results of the analysis suggested that the six variable model (along with one constant) significantly predicted CTS group status. In addition, five of the six individual variables added significantly to the overall prediction, while the remaining variable reached borderline significance. The six variable model accurately classified 86% of the CTS participants and 74% of the control participants. The total hit rate for the final model was accurate classification of 80.5% of the study participants. Thus, the final model superceded the prediction accuracy of the initial three models by at least 4%.

The five significant predictor variables came from all three categories and including the following: (a) repetition, (b) vigorous exercise, (c) physical exercise with strain on the wrist, (d) PCS, and (e) job satisfaction. The borderline significant predictor was BMI.

Comparisons with Other Studies

The present study investigated a host of occupational, personological, and psychosocial variables as predictors of carpal tunnel study. Specifically, the study included 8 occupational variables, 11 personological variables, and 19 psychosocial variables, for a total of 38 variables. In the final analysis, five variables (representative of all three categories) emerged as significant predictors of CTS group status (repetition, vigorous exercise, physical activity with stain on the wrist, SF-36 PCS, and job satisfaction). In addition, BMI was a borderline significant predictor.

To provide meaningful comparisons with the existing research, the findings from the present studies will be compared with studies that also investigated numerous, wide-ranging variables (i.e., occupation, personological, and psychosocial). Overall, the findings from the present study overlapped considerably with the existing research. This would not be unexpected, however, given the majority of the variable were selected from a literature review that included these studies. On the other hand, given the large number of variables investigated in each study, along with the differing methodologies and study populations, substantial discrepancies between studies would also be expected, and were found.

The results from the present study revealed some consistencies with the Leclerc et al. (2001) study. Specifically, both studies found a relationship between job satisfaction and CTS and no relationship between depressive/somatic symptoms and CTS. Comparisons with occupational findings are difficult however, as the Leclerc and colleagues' study investigated repetitive and forceful work, whereas the present study analyzed repetition and force separately. Thus, the

Leclerc et al. findings suggested that certain forceful activities, within the context of repetitive and forceful work, were associated with CTS. This leaves the extent to which repetition contributed to the positive associations with force unclear. In contrast, our findings suggested that repetitive work was uniquely associated with CTS. With this caveat, the conflicting findings with respect to force may, in part, be explained by differences in the study populations. Leclerc and colleagues used industrial workers as participants, while the majority of participants in the present study worked in white collar occupations. When compared to white-collar workers, factory workers would seemingly be more likely to be exposed to more frequent and intense forceful work activities. Hence, with minimal exposure to force, it seems unlikely white collar workers would be subject to the deleterious effects of force. On the other hand, research has suggested that a stronger relationship exists between repetition and CTS, as compared to force and CTS (Nordstrom et al., 1997; Silverstein et al., 1987; Viikari-Jinkura & Silverstein, 1999). Thus, while industrial workers may be more likely to be exposed to force, without differentiating between repetition and force, the findings from the Leclerc et al. study could also be interpreted as repetitive work being the main factor associated with CTS.

The present findings are similar to those of the Roquelaure et al. (2001) study, which also found a significant association between BMI and CTS. In contrast, however, the positive association with psychological distress and negative association with repetition reported by Roquelaure and colleagues were not consistent with the present findings. The lack of association with repetition could be attributed to a restricted range of exposure, as all study participants worked repetitive jobs in a shoe factory. This may be particularly relevant in this study as the follow-up was only 1 year. As such, without a control group of workers with either nonrepetitive jobs or workers from a wide range of occupations, differences in repetition may have been masked. Nordstrom et al. (1997) conducted a case-control study and found repetition, BMI, vibration, and musculoskeletal conditions were significantly associated with CTS. The present study supported the findings that repetition and BMI were significantly related to CTS. In contrast, we were unable to confirm the relationships between vibration and musculoskeletal conditions and CTS. The differences in vibration may be due to the low base rate of vibration exposure in the present sample; that is, only 12 of the 161 participants responded affirmatively to vibration. Comparisons are not appropriate with respect to musculoskeletal conditions. Specifically, while univariate analyses were run on some musculoskeletal conditions (e.g., arthritis), missing data required their exclusion from logistic analyses.

The present study supported the findings of Leclerc et al. (1998) that repetition and BMI are significantly associated with CTS. In contrast, however, the present study was unable to confirm that the presence of psychological problems (either individual constructs such as anxiety, depression, and somatization, or a global measure such as the BSI total) were significantly associated with CTS. Furthermore, while our findings suggested that low job satisfaction was a strong predictor of CTS, Leclerc et al. (1998) found no such relationship. The reasons for these discrepancies are unclear.

Finally, Latko et al. (1998) conducted a study investigating a host of variables and found only repetition was significantly with CTS. The results of the present study are similar with respect to the occupational variables. The only discrepancy between studies was the lack of association with BMI found in the Latko et al. study and the borderline significant association found in the present study.

Repetition and Carpal Tunnel Syndrome

In the final analysis, repetition was one of the strongest predictors of CTS group status. The adjusted odds ratio for repetition 1.841, with nonoverlapping 95% confidence intervals. An odds ratio of this magnitude suggests that each one unit increase in repetition is associated with an 84% increase in CTS. Furthermore, repetition was the only occupational factor to retain significance as a predictor throughout the sequence of analyses. The finding that repetition was a significant predictor of CTS supports a large body of existing research as well as its inclusion as a correlate in the CTS risk factor typology.

Despite being the most extensively validated occupation factor associated with CTS, Szabo (1998) noted that the plausibility of the speculated biological explanations for repetition are less convincing than those for other occupational factors. Nevertheless, CTS researchers have put forth several plausible explanations for the deleterious effects of repetition on median nerve functioning. For instance, Cantatore et al. (1997) suggested that repetitive work may result in increased pressure in the carpal canal, which subsequently compresses the median nerve. Viikari-Juntura and Silverstein (1999) speculated that increases in pressure in the carpal canal may result in loss of blood flow and ischemic-induced damage to the median nerve. Werner, Franzblau, Albers, Buchele, and Armstrong (1997b) proposed that carpal canal pressure increases occur through gradual synovial thickening associated with prolonged repetitive hand/wrist movements. Supporting the notion that repetitive work increases pressure in the carpal canal, Rempell, Bach, Gordon, and So (1998) conducted a study in which healthy volunteers performed repetitive tasks and pressure ratings within the carpal canal were obtained. The results of the study revealed significant elevations in pressure during the work phase. However, pressure levels returned to baseline after only 14 seconds of task completion. Nevertheless, Rempel and colleagues asserted that the pressure increases during repetitive tasks, although somewhat mild and short lived, were likely substantial to damage median nerve functioning. Furthermore, a postmortem study found histological changes in the carpal canal were correlated with repetitive movements of the hand/wrist (Wieslander et al., 1989). This study lends support to the notion that increased levels of repetition results in synovial thickening and/or tensynovites of the flexor tendons.

In summary, the common speculated pathway between repetition and median nerve damage is increased levels of pressure in the carpal canal. Elevated pressure levels may have several deleterious effects, all of which result in damage to median nerve functioning.

Exercise and Physical Activities and Carpal Tunnel Syndrome

In the final logistic model two physical activity variables were significant predictors of CTS group status. Those were: (a) vigorous exercise and (b) physical activities with strain on the wrist. Vigorous exercise had an adjusted odds ratio of .997, with nonoverlapping 95% confidence intervals. This suggests that every unit decrease in vigorous exercise levels is associated with a .003% increase in CTS group status. As previously indicated, while this value may seem trivial, the scale for vigorous exercise ranged from 0 to 1,140. As such, despite small incremental values, vigorous exercise could still be a strong predictive factor. Physical activities with strain on the wrist was a positive predictor of CTS group status. The adjusted odds ratio 1.002, with nonoverlapping 95% confidence intervals. An odds ratio of this value suggests that every one unit increase in physical activities with wrist strain is associated with a .002% increase in CTS group status.

While vigorous exercise was negatively associated with CTS and physical activities with strain on the wrist positively associated with CTS, there were no significant between group differences on the measure of physical activity without strain on the wrist. These findings lend credence to speculations that that vigorous exercise may influence CTS through one of two pathways. First, vigorous exercise may reduce risk for CTS through nonspecific health benefits. Second, vigorous exercise may moderate the relationship between wrist-stressing physical activities and CTS by providing protective benefits against the deleterious effects of such activities. Regardless of the pathway however, it seems reasonable to suggest that the vigorous nature of the exercise is more of a determining factor (in CTS risk) than the strain placed on the hand or wrist during such exercise. Consistent with this suggestion, Nathan and Kenniston (1993) concluded that light physical activities with wrist strain increase risk for CTS, whereas vigorous physical activities (with wrist strain), which increase heart rate and generate perspiration, decrease risk for CTS.

Existing exercise guidelines support the notion that vigorous physical activities are associated with unique health benefits. For instance, Mercola (2004) indicated that while moderate exercise helps reduce the risk for heart disease, vigorous physical activity provides the most dramatic effects. The author further noted that vigorous exercise is associated with lower blood pressure, higher HDL cholesterol levels, reduced risk of heart disease, reduced risk of diabetes, and less overall adiposity. Likewise, the BUPA Health Information Team indicated that evidence suggests moderate intensity physical activity--equivalent to brisk walking for 30 minutes is enough to realize benefits in health and prevent illness. Generally speaking however, increased vigorous activity is related to increased aerobic fitness and the greater the aerobic fitness the greater the health benefits (Lacour, Kosta, & Bonefoy, 2002).

The speculated mechanisms by which physical exercise may reduce risk for CTS tend to be general, rather than specific. For instance, Szabo (1998) suggested that the majority of CTS is likely due to intrinsic factors and CTS is closely correlated with health habits and lifestyle. Similarly, Nathan and Keniston (1993) indicated that the health of the median nerve is likely closely related to the health of the body. The authors further noted that healthy people tend to exercise more than unhealthy people. Accordingly, vigorous exercise may lead to increased general health that may lead to increased functioning of the median nerve. It may also be speculated that individuals who exercise more tend to be more slender. As obesity is a well-established risk factor for CTS, exercise may decrease CTS rates by moderating the relationship between obesity and CTS. Regular exercise is also associated with increased levels of psychological well-being. As several studies have found psychological distress to be significantly associated with CTS, exercise may serve to attenuate CTS rates by enhancing psychological well-being.

In summary, vigorous exercise seems to be associated with reduced rates of CTS. In contrast, nonvigorous physical activities with strain on the wrist, when performed in the absence of vigorous exercise, were found to be associated with increased risk for CTS.

Job Satisfaction and Carpal Tunnel Syndrome

In the final logistic model, job satisfaction added significantly to the prediction of CTS group status. The adjusted odds ratio for job satisfaction was .663, with non-overlapping 95% confidence intervals. This value suggests that every one unit decrease in job satisfaction is associated with a 42.7% increase in CTS group status. In other words, CTS participants reported significantly lower levels of job satisfaction than control participants. This finding was somewhat of a surprise, as the literature review revealed fewer positive than negative findings regarding job satisfaction and CTS. 1Furthermore, even in the study that found a positive relationship between CTS and job satisfaction, the authors concluded the relationship was weak (Leclerc et al., 2001).

In discussing the potential relationship between job-related factors and CTS, Bongers et al. (1993) first suggested it was possible to bring about physiological changes via interventions in the social arena. For instance, by reducing job satisfaction, postural and force related variables may begin to change. Individuals with reduced levels of job satisfaction may become apathetic towards engaging in protective anthropomorphic movements and postural constraints, and/or some combination of both. With the passing of time, poorer occupational health may bring about increased rates of CTS.

On the other hand, individuals with low job satisfaction may have enhance perceptional/ attentional allocations to sensitive/painful symptoms. With increased perceptional/attentional allocations, the dissatisfied worker may be more likely to notice symptoms of CTS and less resistant to the pain associated with such symptoms. It is also possible that low job satisfaction may exacerbate already existing symptoms of CTS through enhanced perception, stress, biomechanical load, and so forth. Finally, it is plausible that individuals who receive a diagnosis may attribute blame to job-related factors and subsequently lower their perceptions of job satisfaction.

Physical Component Summary and Carpal Tunnel Syndrome

In the final logistic model, the PCS of the SF-36 was a significant predictor of CTS group status. The PCS is an aggregate measure derived of physical health derived from SF-36 subscales. The PCS provides a higher order construct of physical health without substantial loss of data. The odds ratio for the PCS was .994, with nonoverlapping 95% confidence intervals. This suggests that every one unit decrease on the PCS is associated with a 5.5% increase in CTS group status.

The results of these findings suggest that CTS is associated with considerable physical health dysfunction. Specifically, the results indicate that the overall physical health of CTS participants may be considerably worse than the physical health of individuals seeking other types of orthopedic consultations.

To facilitate more specific comparisons, the SF-36 scales from the CTS group were compared to the general population norms as well as norms for musculoskeletal patients by using standardized mean difference effect sizes. When the PCS from the CTS group was compared to that of the general population, the resulting effect size was large in magnitude (-.90). This suggests that the overall physical health of the CTS participants is significantly worse than that of the general population. In contrast, when the PCS for the CTS group was compared to the normative values for musculoskeletal disordered patients, the resulting effect size was -.07, suggesting little difference between the physical health perceptions of the musculoskeletal disordered group and the CTS group (although the CTS sample scored considerably worse on mental health scales). Consistent with this finding, Atroshi et al. (1999) reported that CTS participants scored significantly worse on the PCS than the general population normative value. When considered together, these findings suggest that CTS is associated with considerable physical health dysfunction.

It seems possible that selection bias may have, in part, contributed to some the large difference between groups. That is, staff members may have been more likely to approach less severe clients seeking evaluations of a more benign nature. On the other hand, the negative association with the physical component summary is consistent with the findings from other physical variables (vigorous exercise, BMI, physical activities with strain on the wrist) and CTS. This suggests that the connection between CTS and low PCS scores may be the result of declines in overall levels of physical health. The declines could be CTS-related reductions in physical health or the result of nonspecific general health reducing habits/behaviors/conditions.

Body Mass Index and Carpal Tunnel Syndrome

In the final logistic model, BMI was a borderline statistically significant predictor of CTS group status ($p = .091$). The adjusted odds ratio for BMI was 1.086, although, the 95% confidence intervals were overlapping. This finding was not expected given the large differences in mean BMI's between the CTS group, 29.88 ($SD = 6.46$), and the control group, 25.45 (4.67).

Essentially, the two groups were in different categories, with the CTS group falling in the obese category and the control group falling in the overweight category. Furthermore, BMI was a strong predictor of CTS group status in the personological logistic model. It could be that covariance with exercise and physical health variables attenuated the strength of BMIs predictive power in the final analysis. Regardless, given the borderline significance, a discussion regarding speculated mediating pathways with CTS will be provided.

Despite being one of the best documented risk factors (i.e., variable marker) for CTS, the pathophysiological connections between obesity and CTS are not well understood (Werner et al., 1997a). Notwithstanding, several researchers have put forth etiological speculations. For instance, Werner et al. suggested that the connection between obesity and CTS may be due to increased fatty tissue deposited within the carpal canal. Given the carpal canal's compartmentalization, fatty tissue buildup may result in median nerve compression and subsequent damage. Alternatively, the authors speculated that, compared to slender individuals, obese individuals may have increased hydrostatic pressure within the carpal canal. Increased pressure, in turn, may also result in compression of the median nerve. Werner and colleagues also speculated that obese individuals may place greater stress on hands/wrists; thereby increasing risk of median nerve dysfunction.

Nathan and Keniston (1993) noted that slender individuals tend to have better overall health than overweight or obese individuals. The authors noted that the health of the median nerve is likely strongly related to the overall health of the individual. As such, obese individuals may be more likely to suffer median nerve compromise related, at least in part, to overall worse levels of health. Werner et al. (1997a) agreed with this postulate, stating that obesity may be reflective of overall health or condition, and therefore the functioning of the median nerve.

Interestingly, Nathan et al. (1992b) noted that many of the risk factors for CTS (exercise, obesity, age) are similar to those of more serious diseases/illnesses, including cardiovascular disease, neuroendocrine dysfunction, diabetes, and cancer. Likewise, Stallings et al. (1997) indicated that the risk factors for CTS are the same as those from cardiovascular and pulmonary diseases.

In summary, the present study found BMI to be a borderline significant predictor of CTS group status. This finding was somewhat surprising, given the empirical support for BMI as a variable marker of CTS. The following section will discuss the noteworthy univariate findings.

The preceding pages have discussed in detail the significant findings from the multiple logistic regression analyses. The present document also proposed a univariate model of CTS that takes into consideration both univariate testing and effect size (see Appendix E). The inclusion of a univariate model was done to highlight those variables that may have been significantly associated with CTS in univariate testing but did not retain significance throughout multivariate analyses. It seems possible that variables with strong associations with CTS may not have reached significance in multivariate testing due to multicolinearity with other predictor variables. Alternatively, variables with strong associations with CTS may not have retained significance because other variables accounted for too much of the predictive variance (e.g., PCS scores). In either case, the failure to reach significance in multivariate analyses would not diminish the strength of the relationship between the variable and CTS found in the univariate analyses. As such, it was decided to include a discussion of the occupational, pesonological, and psychosocial factors with strong univariate associations with CTS.

Discussion of Nonsignificant Findings

Several noteworthy variables were not found to be associated with CTS, either in the univariate analyses or logistic regression analyses. The nonsignificant variables included vibration, combined repetition and force, force, and typing, and psychological symptoms (i.e., depression, anxiety, somatization).

The present study hypothesized that CTS participants would endorse significantly higher levels of vibration exposure. However, results of a univariate analysis showed no significant between-group differences with respect to vibration. This lack of association is most likely due to the low base rate of vibration exposure in the study group. Specifically, only 12 of the 161 participants reported vibration exposure, which likely significantly limited the power to detect any between-group differences. The infrequency of vibration exposure in the present study may, in part, be explained by the preponderance of participants with white collar occupations. For instance, Wieslander et al. (1989) indicated that blue collar workers are much more likely to be exposed to vibration than white collar workers. Consistent with this notion, the majority of the study participants were white collar workers and the base rate for vibration exposure quite low.

Another hypothesis proposed in the current study was that CTS participants would endorse significantly higher levels of combined repetition and force than control participants. This hypothesis received initial support in the univariate analyses, however, failed to reach significance in the multiple logistic regression. It should be noted that this does not mean no relationship exists between combined repetition and force and CTS; but rather, other variables accounted for more of the predictive variance. Notwithstanding, the failure of combined repetition and force to reach statistical significance in the logistic regression was not expected given the fairly consistent findings, and large odds ratios associated with the variable. It remains unclear why this variable was not a significant predictor of CTS group status. It could be that the relationship between force and CTS group status was particularly weak in the present sample, thereby attenuating the effect of the variable. However, this does not seem likely as force reached borderline significance during the univariate testing. It may also be possible that repetition and force covaried, thereby diminishing the predictive variance accounted for by the combined variable. Consistent with this speculation, several CTS researchers have noted that distinguishing between repetition and force is a difficult, if not impossible task (Leclerc et al., 2001; Nordstrom et al., 1997). As such, combined repetition and force may lack in precision and may therefore be expected to vary with measurements.

Despite common lore that intimately connects the use of computers with CTS, the results of the present study did not reveal any connection between CTS and computer use (i.e., typing/keyboarding). Likewise, the results of several other studies have shown no connection between increased computer use and CTS (Nordstrom et al., 1997; Stevens, Witt, Smith, & Weaver, 2001).

One of the primary purposes of the present study was to identify specific psychological constructs associated with CTS. Towards this end, the BSI-18 was incorporated in the study protocol as it provides separate scales for anxiety, depression, and somatization. In addition, the BSI-18 provides a global measure of psychological distress, which is the sum of the three individual scales. The results of the univariate analyses provided initial support for the hypotheses that CTS participants would endorse significantly higher levels of anxiety, depression, somatization , and global psychological problems. However, none of these variables remained significant predictors of CTS group status in the logistic analysis. Again, this finding does not indicate that no relationship exists between the aforementioned psychological constructs and CTS, but rather, that the constructs were not significant in the model. While the reasons for the findings are unclear, they do suggest that job-related psychosocial variables may be stronger predictors of CTS than traditional psychological variables (e.g., depression, anxiety, somatization, etc.).

Carpal Tunnel Syndrome and the Biopsychosocial Model

Overall, the results of the present study are consistent with a biopsychosocial conceptualization of CTS. The biopsychosocial model suggests that a wide array of interrelated biological, psychological, and social factors are important at any given state of a health or illness (Engel, 1977). The biopsychosocial model embraces a systems theory approach when considering health-related conditions. This stands in contrast to the medical or biomedical model that suggests all health-related symptoms can be explained by aberrant somatic processes. Furthermore, the biomedical model maintains that psychological and social factors are largely independent of disease and vice versa (Mechanic, 1968).

The present study used a biopsychosocial model to guide the selection of study variables included as potential correlates of CTS. As a result, a wide-range of occupational, biological, personological, and psychosocial variables were considered and those with the most empirical support were selected. In addition, the present study hypothesized that maximal prediction for CTS would result from a biopsychosocial model of prediction. Consistent with this hypothesis, the present findings suggested that biological and psychosocial factors resulted in the highest predictive accuracy. In particular, when psychosocial and biological variables were considered, the predictive accuracy was increased over singular models of prediction by 4 - 13%.

CHAPTER VI

LIMITATIONS AND RECOMMENDATIONS

Limitations of the Current Study

The present study incorporated a case-control methodology. While case-control designs hold certain advantages (especially in the study of diseases with relatively low base rates), findings from these designs are limited by several constraints. For instance, findings from the present study do not allow for speculations regarding causality or temporality. Specifically, as the present design is cross-sectional in nature, the results from the design are correlational. As such it remains unclear if the identified correlates are antecedents, concomitants, or consequences of CTS. An example may be taken from speculations regarding job satisfaction. The present findings are consistent with the notion that increased levels of job dissatisfaction leads to increased CTS rates (i.e., through increased perception to symptoms and decreased resistance/motivation to cope with symptoms and/or through postural changes resultant of low job satisfaction). On the other hand, the present findings are also consistent with the hypothesis that increasing symptoms of CTS cause decreases in job satisfaction (i.e., resentment of job following diagnosis, decreases in motivation due to long-term symptomatology).

In addition, findings from the present study are susceptible to confounds and/or spurious relationships. Hence, the positive associations found in the present study may be artifacts of a yet-to-be identified factor associated with CTS. For instance, the negative relationship found between job satisfaction and CTS may be confounded by sensitivity to pain and/or autonomic reactivity. Specifically, it could be that the relationship between job satisfaction and CTS disappears when sensitivity to pain is considered. Another possible confound may have resulted from the use of control participants from an orthopedic clinic. Specifically, individuals seeking an orthopedic evaluation may represent a highly active population (e.g., individual seeking evaluation following sports-related or exercise-related injuries). If this were the case, the negative association with vigorous exercise and the positive association with obesity may have been artifacts of inappropriate levels of baseline exposure with which CTS participants were compared.

Relatedly, the statistics planned for the primary data analysis did not allow for conclusions regarding the interplay of the correlates. For instance, the correlates identified may work together in an additive manner, such that risk for CTS increases along with the number of risk factors experienced. On the other hand, certain risk factors may serve to moderate or mediate other risk factor relationships. For instances, reductions in BMI may be the pathway through which vigorous exercise exerts its effects (moderator). On the other hand, increases in BMI may moderate the relationship between vigorous exercise and CTS (i.e., as BMI increases the salutary effects of vigorous exercise declines in potency). Alternatively, increases in BMI may mediate CTS directly through elevated rates of adiposity in the carpal canal. Or, BMI and vigorous exercise may combine in an additive or exponential fashion to increase risk for CTS. Unfortunately, the present study does not allow for such conclusions. Randomized prospective clinical trails are needed elucidate such relationships.

The present study also revealed that the BSI-18 is not an ideal measure for assessing psychological dysfunction among CTS participants. In particular, two of the items on the somatization subscale significantly overlap with actual symptoms of CTS. The result being artificially elevated rates of somatization among CTS participants. In the present study this was resolved by dropping these items and using the mean of the reaming four items. However, this may have attenuated the reliability of the measure, as reliability tends to increase along with the number of items. Furthermore, give the brief nature of the measure, the loss of two items may have been significantly detrimental to the psychometric properties, as with these exclusions one third of the somatization items were lost.

The present findings are also tempered by the possibility of recall motivation/biases. For instance, state dependent learning suggests that an individual's particular state of mind affects memory and recall processes (Eysenck, 1977). As such, individuals in a depressive state may be more likely to notice and process depression related cues. If applied to participants in the present study, the pain/disability associated with CTS may have resulted in recall biases in which participants were more likely to process poor health related memories and cues.

Another limitation of the present study was the failure to successfully match subjects according to age. While age was controlled for statistically in the logistic regressions, this may have allowed for multicollinearity among age and the study variables. The failure to successfully match participants according to age is reflective of a broader difficulty inherent in conducting long distance studies. While attempts were made to be present at least once a week at the study site, this still seemed insufficient to ensure proper execution of study procedures (e.g., participant selection and assignment procedures). This was particularly problematic as staff members were needed to carry out study procedures and the data collection phase was of considerable duration (i.e., more than a year). Indeed, staff motivation to carry out the study procedures was a continual issue in the present study.

Recommendations for Future Research

Perhaps most pressing is the need for longer-term prospective research trials. In particular, the present literature review revealed only six longitudinal-prospective studies. Furthermore, the longest follow-up periods were only 5 years, which may be insufficient for the potential deleterious effects of risk factors to manifest (Nathan et al., 1992a, 1992b). In addition, the findings from longitudinal studies are needed to yield stronger conclusions for the risk factor typology. Specifically, the majority of risk factors remain at the preliminary level (i.e., correlates), and prospective trails are needed to establish their placement in the typology.

Noteworthy omissions in the present study were measures of pain sensitivity/ catastrophization and autonomic reactivity. Theoretical connections between these factors and CTS are not difficult, especially in lieu of findings participants' self-reported pain is not consistent with underlying damage to the median nerve. For instance, increases in pain sensitivity/ catastrophization could result in greater perception of pain/symptoms that may increase autonomic arousal levels. Increased autonomic arousal levels may, in turn, further increase perception of pain/symptoms and/or further increase likelihood of pain/symptoms through increases in stress-related hormones.

The findings of the present study also suggest that future research should focus more on job-related psychosocial factors, as opposed to traditional psychological factors. It would be of considerable importance for future research to tease apart the relationships between physical health-conditioning and job-related psychosocial factors. That is, are these factors separate or related, mediating or moderating, proximal or distal, and so forth. To do so, randomized, prospective clinical trails are needed.

In general, future research is needed to solidify the risk factor typology for CTS, and therefore guide intervention programs. The present study suggests that many of the risk factors for CTS are similar to those for the major illness/conditions. As such, reduction in CTS specific risk may ensue from general physical health implementations. Fortunately, health-conditioning factors are modifiable variables. Unfortunately, however, research has suggested that modification of these variables is quite difficult, and the difficulty seems to increase as the length of follow-up increases (Lowe, 2003). Based on the present findings, intervention programs should likely include general health components, occupational components (occupational repetition), and job-related psychosocial components.

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APPENDICES

Appendix A:

Table of Literature Review Study Characteristics

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
1	Leclerc et al. 2001	Prospective; Follow-up = 3 yrs.	598 Industrial Workers	Medical Examination or Diagnosis in chart	Occupational Variables: Repetitive and forceful work; 10 specific forceful work activities (e.g., tighten with force), number of years on the job; Personological Variables: gender, age, BMI, smoking, Psychosocial Variables: somatic and depressive symptoms, job control, psychological demand of job, social support at job, job satisfaction	The following variables were predictive of CTS in men: Age, Jobs requiring that men "tighten with force", Jobs that required that men "hold in position." The following variables were predictive of CTS in women: Age, Increased BMI, Low Job Satisfaction	ORs for men: Age= 30-39 yrs = 1.05; "Tighten with Force" = 4.09; "Hold in Position" = 3.59; ORs for women: Age= 30-39 yrs = 1.55; Increased BMI = 2.38; Low Job Satisfaction = 1.79	8 of the specific occupational activities; years on the job; smoking; somatic/depressive symptoms, job control, psychological demand of job, social support at work.
2	Werner et al. 1997a	Prospective; Follow-up = 1-2 yrs.	108 industrial workers;	1) Hand diagram; 2) Clinical symptoms and functional status	Occupational Variables: Repetition levels; Personological Variables: Age; Gender; Degree of right-handedness; Body Mass Index (BMI)	Repetition	1.35	Age; Gender; Right-handedness; BMI

(table continues)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
3	Gorsche et al. 1999	Prospective (incidence study); Follow up periods at 243 days and 391 days	421 workers with negative EDX testing at baseline	Symptoms and clinical signs	Occupational Variables: hand-held tool use, duration of employment; Personological Variables: rheumatoid arthritis, hypothyroidism, diabetes, alcoholism; gender, race, BMI;	Nothing	Female Gender = 1.8 OR	Personal-Medical Variables: rheumatoid arthritis, hypothyroidism, diabetes, alcoholism; race, BMI; Occupational Variables: hand-held tool use, duration of employment
4	Roquelaure et al. 2001	Prospective (incidence study); Follow-up = 1year	162 footwear factory workers	Physician Assessment; 1) presence of parasthesia; 2) positive provocative tests; and 3) lack of confounding diagnosis	Occupational Variables: repetition, force; Personological Variables: 2) female gender, age, thyroid dysfunction, diabetes mellitus, gynecological disease, BMI, smoking, co-existing WMSD; Psychosocial Variables: psychological distress (GHQ score), "use of anxiety-relieving drugs"; job control, job-related psychological demand & social support.	The following variables were predictive of CTS at one-year follow-up: 1) BMI > 30; 2) Psychological Distress [GHQ score > 30]; 3) Rapid Trigger Movements.	BMI= 4.4; Psychological Distress= 4.3; Rapid Trigger Movements= 3.8	Repetition; Force; Use of Anxiolytic Drugs; Job Control; Psychological Demand of Job; Social Support at Job; Female Gender; Age; Thyroid Dysfunction; Diabetes; Gynecological Surgery; Smoking; Co-Existing WMSD

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
5	Nathan et al. 1992a	Longitudinal; Follow-up = 5 yrs.	116 industrial workers	Electrodiagnostic Testing (EDX)	Occupational Variables: 5 OHU categories = 1) very light resistance/low repetition, 2) light resistance/very high repetition, 3) moderate resistance/moderately high repetition, 4) heavy resistance/moderate repetition, 5) very heavy resistance/high repetition; Personological Variables: age, gender, race, hand dominance, wrist depth/width ratio, BMI, exercise levels,	The following variables were predictive of CTS at 5-year follow-up: BMI; Age; Wrist depth/width Ratio; Hand Dominance; Exercise Level	None Reported	Repetition; Force; Repetition + Force; Gender; Race;
6	Nathan et al. 1992b	Longitudinal; Follow-up = 5 yrs.	316 industrial workers	EDX testing & symptom profile	Occupational Variables: 5 OHU categories = 1) very light resistance/low repetition, 2) light resistance/very high repetition, 3) moderate resistance/moderately high repetition, 4) heavy resistance/moderate repetition, 5) very heavy resistance/high repetition; Personological Variables: age, gender, hand dominance,	The following variables were predictive of CTS at 5-year follow-up: Age; Gender; Hand Dominance	None Reported	Gender; Repetition; Force (i.e., resistance);

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
7	Bekkelund, Torgergsen, et al. 2001	Cross-sectional	Cases = 42 female professional floor cleaners; Controls = 41 female secretaries; N= 83	EDX testing	Occupational Variables: Repetitive and forceful work number of years at work; Personological Variables: age	Repetitive and Forceful work	None Reported	Age; Number of years at work
8	Ferry et al. 2000	Nested Case-Control Study	Cases = 1,264 females with CTS diagnosis ; Controls = 1,264 age-matched females; N= 2,528	Medical Data Base Codes	Personological Variables: Smoking, social class, Several specific hormonal/menstrual problems/disorders (e.g., irregular periods, frequent periods); oral contraceptive use; Rheumatoid arthritis, osteoarthritis (unspecified, spine), unspecified arthritis; Several other musculoskeletal problems (e.g., tenosynovitis, bursitis), Diabetes; Obesity; Psychosocial Variables: Non-psychotic psychiatric illness; Irritable Bowel Syndrome; respiratory consultations (used as proxy for consultation propensity).	Another Musculoskeletal Disorder; Osteoarthritis of spine; Lower social class; Obesity; Respiratory Consultations	Musculoskeletal disorder = 1.98; Osteoarthritis of the spine= 1.92; Lower social class= 1.17; Obesity=1.68; Respiratory consultations= 1.45	Several musculoskeletal conditions; smoking; hormonal/menstrual problems; oral contraceptive use; Rheumatoid arthritis; unspecified osteoarthritis, unspecified arthritis, Diabetes, Non-psychotic psychiatric illness, irritable bowel syndrome; GI Tract symptoms

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
9	Roquerlaure & Cano 1993	Prospective; follow-up = 2 years	60 participants with hyperthyroidism	Clinical Symptoms and EDX testing (various case-definitions: Definite; Possible, subclincal)	CTS symptoms at follow-up	No statistical analyses were done; but trend for CTS to follow progression of hyperthyroidism		
10	Mathis et al. 1994	Cohort Study	44 CTS patients; 50 low back pain patients	Clinical diagnosis by hand surgeon	Psychosocial Variables: Axis I & II disorders (used SCID NP & SCID II)	CTS patients had higher rates of current and lifetime anxiety disorders; CTS patients had significantly lower rates of substance abuse		
11	Werner et al. 1994	Cross-sectional study	Cases = 261 CTS patients from EDX lab.; Controls= 342 non-CTS patients from same lab; N= 603	EDX & symptom profile	Personological Variables: BMI; Age; Gender	BMI; Age; Gender	Obese (BMI > 29) v. Slender (BMI < 20): OR = 8.2; Obese & heavy (heavy = BMI 25-29) v. slender & normal: OR= 2.9; Age 45-66: OR= 2.0; Female Gender: OR= 1.5	

(table continues)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
12	Solomon et al. 1999	Case-control	Cases= 626 CTS Surgical Patients; Controls= 3,618 age- and gender-matched non-CTS patients; N= 4244	Clinical diagnosis by hand surgeon	Personological Variables: thyroid disease, diabetes mellitus, inflammatory arthritis, hemodialysis, corticosteroid use; hormonal replacement therapy; white race, female gender	Hypothyroidism; Hemodialysis; Diabetes; Corticosteroid use (in past 90 days); Estrogen replacement therapy; Female Gender	Inflammatory arthritis: OR= 3.1; Diabetes: OR= 1.4; Hypothyroidism: 1.7; Hemodialysis: 9.0; Corticosteroid Use: 1.6; Estrogen Replacement Therapy: 1.8	white race

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
13	Vessey et al. 1990	Epidemiological Study	125 women from population of 17,032	Clinical diagnosis by physician	Personological Variables: social class; age; smoking; oral contraceptive use and duration; Obesity, 23 disease conditions (including osteoarthritis, unspecified arthritis, menstrual disorders); Psychosocial Variables: Neurosis	Age; Cigarette Smoking; Duration of Oral Contraceptive Use; Obesity (measured via Quettelet's Index Weight [QIW] which is a measure of body fat); Menstrual Disorder	Study reported referral rates; 1) Age > 50: RR= 1.29; 2) Smoking > 25 cigarettes per day and between ages 20-44: RR= 1.24; Smoking > 25 cigarettes per day and age > 45: RR= 5.28; 3) Duration of oral contraceptive use > 120 months and age > 45: RR= 2.23; 4) QIW between 2.2-2.39 and age > 45: RR= 1.51; QIW between 2.4-2.59 and age > 45: RR= 1.72; QIW > 2.59 and age> 45: RR= 2.16; 5)	social class; numerous disease conditions (including osteoarthritis and unspecified arthritis); Neurosis

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
14	Lam & Thurston 1998	Cross-sectional (patient study)	96 CTS surgery patients (compared to age- and gender distribution of the New Zealand population	Clinical diagnosis by hand surgeon	Occupational Variables: Forceful work: 1) light clerical work; 2) heavy clerical work; 3) light manual work; 4) moderate manual work; 5) heavy manual work; 6) other; Personological Variables: age, gender, obesity;	Age; Female Gender; BMI; Significant occupational differences by sex: female > moderate manual work; males > heavy clerical work	None Reported	
15	Franklin et al. 1991	Cross-sectional (population-based incidence study)	Cases from The Washington State Department of Labor and Industries database	Diagnostic codes in database	Personological Variables: Age; Sex;	Age, Sex	None Reported	
16	Pascual et al. 1991	Cross-sectional (retrospective)	53 women with gynecological surgery compared to 70 women with normal menstrual cycles; N= 123	Symptom profiles and EDX testing	Personological Variables: Oopherectomy v non-oopherectomy	Women with Oopherectomy significantly more likely to have CTS	A relative risk (RR) rate was reported; Oopherectomy RR = 4.5.	

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
17	Palumbo et al. 2000	Patient Study	26 patients with hypothyroidism compared to 24 healthy volunteers	Symptom profiles and EDX testing	Personological Variables: Hypothyroidism v non-hypothyroidism	Hypothyroidism patients had significantly higher rates of CTS and duration of CTS was significantly related to duration of hypothyroidism	None Reported	
18	Nakamichi & Shintaro 1995	Cross-sectional	155 Japanese women with CTS v. 272 controls w/o CTS	Symptom profiles and EDX testing	Personological Variables: Height; Hand Size	Shorter Height; Shorter hand size	None Reported	
19	Gamstedt et al. 1993	Cross-sectional	99 diabetic patients	Symptom profiles and EDX testing	Occupational Variables: Exposure to vibration; Personological Variables: Diabetic v Non-Diabetic	Significant association between CTS and occupational vibration; for diabetes only reported high prevalence rates (19/99) no statistical techniques	None Reported	
20	Chammas et al. 1995	Cross-sectional	120 diabetic patients; 60 type I and 60 type II; 120 healthy controls	Symptom profiles and EDX testing	Personological Variables: Type I diabetes; Type II diabetes	Both type I & type II diabetics had significantly higher rates of CTS	None Reported	

(table continues)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
21	Yagev et al. 2001	Cross-sectional	326 subjects who underwent nerve conduction studies (NCS);	Symptom profiles and EDX testing	Occupational Variables:1) low force-high repetition; 2) High force-low repetition; 3) high force-high repetition; 4) other; Personological Variables: education level; smoking; Occupational Variables:	Low force-high repetition; High force-low repetition	Low force-high repetition OR = 3.4; High force-low repetition OR = 3.21	Education level; smoking
22	Winn & Habes, 1990	Cross-sectional	27 CTS patients and 34 asymptomatic controls matched for age and sex	Symptom profiles and EDX testing	Personological Variables: Carpal Canal Area	CTS patients had significantly larger carpal canal areas than non-CTS controls	None Reported	
23	Stevens et al. 2001	Cross-sectional (survey study)	257 participants with heavy computer use	Symptom profiles and EDX testing	Occupational Variables: keyboard usage (repetition)	Rates of CTS of keyboard users were not significantly different from normal population CTS rates		

(table continues)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
24	Stallings et al. 1997	Case-control	300 CTS patient compared to 300 non-CTS patients; all workers comp. disability claims	Symptom profiles and EDX testing	<u>Personological Variables:</u> Obesity; Age	CTS patients significantly more likely to be obese and significantly older than control patients	Obesity OR = 3.75; No OR reported for age	
25	Nathan & Keniston 1993	Cross-sectional	6 different population cohorts (e.g., Japanese industrial workers, American industrial workers, etc); N= 4137	EDX testing (One of several analyses)	<u>Occupational Variables:</u> 1) OHU-Force; 2) Specific Job; 3) Duration of Employment; 4) Repetitions; 5) Industry; <u>Personological Variables:</u> 1) age; 2) Gender; 3) BMI; 4) Hand Dominance; 5) Wrist Depth/Width Ratio; 6) Race; 7) Nation; 8) Advocational Exercise Level;	In regression analysis BMI-age-wrist ratio explained 80 % of explainable variance, while duration of employment-specific job-repetitions-occupational hand use predicted 13% of explainable variance (1/6 as much). In addition, American industrial workers had significantly higher prevalence of slowing than Japanese industrial workers.	No OR reported	

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
26	Schottland et al. 1991	Cross-sectional	93 workers w/ repetitive jobs; 85 controls	EDX testing	<u>Occupational Variables:</u> repetitive and forceful work <u>Personological Variables:</u> Age	No significant differences in slowing between workers in exposed to repetitive and forceful work and controls; Age significantly associated with CTS	None Reported	
27	Nathan et al. 1988a	Cross-sectional	471 industrial workers randomly selected and administered EDX testing	EDX testing	<u>Occupational Variables:</u> OHU categories: 1) very light resistance-low repetition; 2) light resistance-very high repetition; 3) moderate resistance-moderately high repetition; 4) heavy resistance-moderate repetition; 5) very high resistance-high repetition	No significant findings	None Reported	
28	Feldman et al. 1987	Cross-sectional	586 industrial workers	symptoms, electromyography, and EDX testing	<u>Occupational Variables:</u> High risk (high levels of repetition and repetitive flexion-extension, pinching and deviated postures) v. low risk jobs	Workers in high risk jobs were more likely to have symptoms of CTS	None Reported	

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
29	Johnson et al. 1983	Cross-sectional (patient study)	27 CTS participants; 40 non-CTS participants	EDX testing	Personological Variables: Age; Wrist Squareness	Increases wrist ration (i.e., wrist squareness) significantly associated with EDX slowing	None Reported	Age
30	Radacki 1994	Cross-sectional (patient study)	665 consecutive CTS patients	EDX slowing or history of carpal tunnel release	Personological Variables: wrist ratio (i.e., wrist squareness)	positive correlation between increased wrist ratio and EDX slowing	None Reported	
31	Werner et al. 1997b	Cross-sectional	363 industrial workers; 164 clerical workers	EDX testing	Occupational Variables: repetition (low, medium, high; rated by industrial engineers and hygienists); Personological Variables: BMI; Age, Sex,	BMI; Age; Did not report any findings regarding repetition; Also reported significant finding for work (with industrial workers having greater CTS than clerical workers); however, no specific work-related risk factors were reported on.	BMI: OR = 4.0; Age (increase by 10 years): OR= 3.3	Gender
32	Karpitskaya et al. 2002	Retrospective case-control	514 CTS surgery patients compared to 100, gender-matched, general surgery patients	History of carpal tunnel release	Personological Variables: Age; BMI; Smoking; Diabetes; Thyroid Disease	Diabetes; Thyroid disease; BMI (obesity)	Diabetes OR= 3.02; Thyroid disease OR= 3.70; BMI (obesity) OR= 1.77	Age; Smoking

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
33	Stevens et al. 1992	Cross-sectional (retrospective, patient study)	1,016 CTS patients	CTS diagnosis in medical charts	Personological Variables: Diabetes; Rheumatoid arthritis; Polymyalgia Rheumatic; Many other conditions were explored but no standardized morbidity ratios could be computed	Diabetes; Rheumatoid Arthritis	Study reported standardized morbidity ratios (SMR); Diabetes SMR for men= 2.5; Diabetes SMR for women= 2.2; Rheumatoid arthritis SMR for men= 3.5; Rheumatoid arthritis SMR for women= 3.9	Polymyalgia Rheumatica
34	Cannon et al. 1981	Case-control	30 CTS participants with CTS compared to 90-sex-matched controls w/o CTS	CTS diagnosis in medical charts	Occupational Variables: years on the job; lost workdays, use of vibrating tools, performance of repetitive tasks; Personological Variables: age, gynecological surgery, oral contraceptive use; diabetes, hypertension, obesity, ethnicity;	History of gynecological surgery; Use of vibrating tools; Performance of repetitive motion tasks; less number of years on the job; higher number of lost workdays	Use of vibrating tools OR= 7.0; History of gynecological surgery OR= 3.7; Performance of repetitive tasks OR= 2.1	Age, Oral Contraceptive Use; Diabetes; Hypertension; Obesity; Ethnicity;

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
35	Cosegrove et al. 2002	Cross-sectional	900 randomly selected CTS workers comp. claimants (railroad workers)	Symptom profiles and EDX testing	Occupational Variables: 1) low force-low repetition; 2) low force-high repetition; 3) high force-low repetition; 4) high force-high repetition; Personological Variables: 1) mean wrist index; 2) age; 3) BMI;	Mean wrist index; Age; BMI;	None-reported	Occupational variables
36	Atcheson et al. 1998	Cross-sectional (retrospective patient study)	297 workers comp. claimants	4 different diagnostic criteria	Personological Variables: concurrent medical conditions (numerous diseases); Obesity; Age	concurrent medical disease; Obesity; Age (authors did not report on analyses for individual diseases; Authors also included occupational variables but simply listed different occupations {no quantification of any specific risk factor})	OR for age = 1.2	
37	Sposato et al. 1995	Cross-sectional study	417 industrial workers	EDX testing	Personological Variables: Wrist squareness; gender; age;	Wrist Squareness (but relationship was weak)	None-reported	age; gender

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
38	Blanc et al. 1995	Cross-sectional (NHIS/OHS prevalence study data)	544 participants with self-reported CTS compared to 32,688 participants w/o self-reported CTS	Self-Report	Occupational Variables: Repetitive hand bending; Personological Variables: female gender; age; ethnicity; education; Marital status; cardiac or pulmonary condition; musculoskeletal condition; other health condition; self-assessed health status;	Repetitive hand bending; Female Gender; Age; Non-white; Cardiac or pulmonary condition; musculoskeletal condition;	Repetitive hand bending OR= 1.5	Education level
39	Pierre-Jerome et al. 1996	Cross-sectional	24 floor cleaners; 19 female controls (non-floor cleaners); N= 63	Magnetic resonance examination and EDX testing	Occupational Variables: Repetitive flexion-extension and circumflexion of the wrist (performed by floor cleaner but not controls; number of years at work; Personological Variables: Age	none	None-reported	Repetitive flexion-extension and circumflexion of the wrist at work; # of years at work; age
40	Tanaka et al. 1995	Cross-sectional (OHS national health interview survey)	44,233 completed interview	"medically called CTS"; self-reported	Occupational Variables: Repetitive bending/twisting of the hand/wrist; vibration; Personological Variables: female gender; age; white race;	Repetitive bending/twisting of the hand/wrist; vibration; female gender; age; white race	repetitive bending/twisting of the hand/wrist OR= 5.2; vibration OR = 1.8; Female Gender OR= 2.2; Age (each year increase) OR = 1.026; white race OR= 4.2	None-reported

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
41	Osorio et al. 1994	Cross-sectional	33 workers	EDX testing	Occupational Variables: repetitive & forceful wrist movements (high, moderate, low likelihood); total number of years worked as cashier; total number of years worked using laser scanners;	Exposure to repetitive and forceful wrist movements showed a dose-response relationship; years worked; Number of years worked and EDX abnormalities significantly correlated; Abnormal EDX results and Age correlated; Abnormal EDX results and years of alcohol intake correlated	Study reported on risk ratios (RR=); high likelihood of exposure RR= 6.7	
42	Stetson et al. 1993	Cross-sectional	Group 1 = 105 workers w/o exposure to repetitive and forceful work; Group 2 = 103 workers with clinical symptoms of CTS; Group 3 = 137 asymptomatic workers	EDX testing	Abnormal EDX results (Slowing of median motor nerve fiber); Occupational Variables: Repetitive and forceful work mechanical stress on palm; pinch grip; wrist deviation	repetitive and forceful work and mechanical stress	None-reported	

(table continues)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
43	Barnhart et al. 1991	Cross-sectional	106 workers with repetitive jobs compared to 67 workers with non-repetitive jobs	Three Case-Definitions: 1) EDX slowing; 2) EDX slowing + clinical sign; 3) EDX slowing + clinical sign and/or symptoms	<u>Occupational Variables</u>: Repetition; <u>Personological Variables:</u> Thyroid Disease; Diabetes; Arthritis; Use of Oral Contraceptives;	Repetition; Diabetes	None-reported	Thyroid disease; Arthritis; Oral Contraceptives;
44	Morgenstern et al. 1991	Cross-sectional	1,058 female grocery store checkers exposed to repetitive flexion-extension of wrist	self-report via questionnaire sent in mail	<u>Occupational Variables:</u> Repetitive work: Number of hours per week (working as checker); Number of years (working as checker); Use of laser scanner; unloading of baskets; load and lift grocery bags; ;<u>Personological Variables</u>: Age; oral contraceptive use; use of exogenous estrogens; history of broken wrist;	Age; number of hours per week (significant for linear trend); number of years (significant for linear trend); These data support the role of occupational repetition	Difference in 10 hours per week: OR = 1.29; Difference in 25 hours per week: OR= 1.88; Difference in 40 hours per week: OR = 2.74	Use of laser; unloading of baskets; load and lift grocery bags; oral contraceptive use; use of exogenous estrogens; history of broken wrist

(table continues)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
45	Chiang et al. 1990	Epidemiological Study	207 workers divided into 3 groups: 1) little exposure to cold + low repetition; 2) little exposure to cold + high repetition; 3) exposure to cold + high repetition	Clinical symptoms, signs and EDX testing	Occupational Variables: Repetition; Cold Exposure; Length of Employment; Personological Variables: Gender; Age;	Groups II & III significantly more likely to have CTS than group I; Repetition was significantly associated with CTS; Cold Exposure + Repetition was significantly related to CTS; Female gender =	Group 2 (no cold + high repetition) and Group 3 (cold + high repetition: OR= 7.40; Group 3 OR= 9.39; Female Gender = 2.6	Age; Length of Employment; Cold Exposure; Gender (with gender and cold exposure, authors alluded to significant association, but logistic regression showed p values greater than .05; .21 & .22, respectively
46	de Krom et al. 1990	Case-control	156 cases from general population and hospital compared to 473 age- and gender matched controls from the general population	Clinical symptoms and EDX testing	Occupational Variables: Activities with wrist flexion; activities with wrist extension; pinch grasp hours; typing hours; Personological Variables hysterectomy; diabetes during pregnancy; oral contraceptive use; menopause; height; weight; obesity (Quetlet's Index); Dieting; Varicosis (in men); Wrist fracture; thyroid disease in women; Rheumatism; diabetes;	Height; Hours per week engaging in activities requiring wrist flexion; Varicosis (in men); "Menopause last year"	Only crude ORs were reported	Activities with wrist extension (although authors alluded to significant association; in the final model this variable was not quite significant (p=.07); pinch grasp hours; typing hours; hysterectomy; diabetes during pregnancy; oral contraceptive use; Obesity; Dieting (although authors alluded to sig. association, in final model this variable was not quite significant (p= .07); wrist fracture; Rheumatism; Diabetes; Thyroid disease (in women)

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
47	Wieslander et al. 1989	Case-control	38 CTS surgery patients; 2 age- and sex matched general surgery and 2 age-and sex matched general populations controls	Clinical diagnosis by hand surgeon + EDX confirmation	Occupational Variables: Vibration (Use of hand-held vibrating tools (< 1 year; 1-20 years; >20 years)); Repetition (< 1 year; 1-20 years; >20 years); Work causing great load on the wrist (i.e., force)(<1 yr.; 1-20 yrs; >20 yrs; Personological Variables: Obesity (i.e., greater than 10% of reference rate); smoking;	Use of hand-held vibrating tools; Repetition; force (mixed findings (with all control subjects included no force category was significant; with only population referents force became significant after 20 yrs. Of exposure); Obesity (mixed results) with all control subjects obesity was non-significant; with only population referents obesity became significant)	Hand-held vibrating tools OR= 3.3; Repetition OR= 2.7	Smoking
48	Nathan et al. 1988b	Cross-sectional	471 industrial workers	EDX testing	Personological Variables: Age; Gender	Age	None-reported	Gender (when age was controlled for, gender became non-significant

(table continues)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
49	Silverstein et al. 1987	Cross-sectional	652 active industrial workers;	Symptoms or Symptoms & Clinical Signs	Occupational Variables: Occupational Categories: 1) low force-low repetition; 2) High force-low repetition; 3) low force-high repetition; 4) High force-high repetition; Repetition; Force; Personological Variables: Oral Contraceptive Use; Gynecological Surgery; Prior upper extremities injury (NA); chronic disease (NA); prior health (NA), recreational activities (NA)	Occupational categories: 2) High force-low repetition; 3) Low force-high repetition; 4) high force-high repetition; Repetition;	High force-low repetition OR= 1.8; Low force-high repetition OR= 2.7; High force-high repetition OR= 15.5; Repetition OR= 5.5	Force; Oral Contraceptive Use; Gynecological Surgery
50	Tanaka et al. 1997	Cross-sectional study (NHIS/OHS national survey study)	44,233 completed surveys	"Medically-called CTS"	Occupational Variables: Repetitive bending/twisting of the hands/wrists; Exposure to hand-held vibrating tools; Personological Variables: gender, race, age, BMI, smoking, education level, family income	Occupational Variables: Repetitive bending/twisting of the hands/wrists; Exposure to hand-held vibrating tools (i.e., vibration); Medical-Personal Variables: gender, race, age, BMI, smoking, education level, family income	Repetitive bending/twisting of hand/wrist OR= 5.5; Vibration OR= 1.9; White race OR= 16.7; female gender OR= 2.3; BMI >/- 25 OR= 2.0; Age OR (>/- 40 v. <40) OR= 1.2	

(table continues)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
51	Nordstrom et al. 1997	Case-control	206 cases with CTS diagnosis in medical database compared to 211 age-matched controls without diagnosis of CTS	Diagnostic codes in database	Occupational Variables: vibration; repetition primary job cumulative hours; typing; Personological Variables: previous musculoskeletal conditions; (e.g., arthritis, osteoarthritis, rheumatoid arthritis); metabolic conditions (diabetes, hypothyroidism, gout); non-participation in sports; smoking/chewing tobacco; Psychosocial Variables: job control; job satisfaction; income level	Occupational Variables: Repetitive bending/twisting of hands; use of power tools; (i.e., vibration); Medical-Personal Variables: musculoskeletal condition; BMI; Psychosocial Variables: low job control	Vibration OR= 3.30 (6-11 hrs per day); Repetitive bending/twisting OR= 2.65 (3-5/6 hrs per day); musculoskeletal condition OR= 2.54; BMI OR= 1.8 per unit increase; Low job control OR= 1.5	typing; diabetes, hypothyroidism; gout; participation in sports; smoking/chewing tobacco; stress perception; workers compensation coverage; job satisfaction; income levels

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
52	Leclerc et al. 1998	Cross-sectional	1,210 industrial workers exposed to occupational repetition compared to 337 control subjects (not exposed to occupational repetition)	Clinical signs and EDX testing results when available in charts	Occupational Variables: repetition; vibration; work sector; number of years on job; cycle time; just in time production (JIT); Personological Variables: sex; BMI; rheumatoid arthritis; diabetes; thyroid disease; wrist accident in past; oral contraceptive use; Psychosocial Variables: psychological problems; work satisfaction; job control; workstation autonomy;	Occupational Variables: repetition; JIT; Medical-Personal Variables: BMI; Psychosocial Variables: psychological problems; job control	JIT OR= 2.24; BMI >/- 27 OR= 2.23; psychological problems: 2.34; job control OR= 1.59	vibration; number of years on job; cycle times; work-related postures and motions (authors alluded that "press with hand" was significant but p value was .13);; sex; rheumatoid arthritis; diabetes; thyroid disease; oral contraceptive use; previous wrist injury; work satisfaction; workstation autonomy
53	Frost et al. 1998	Cross-sectional (retrospective cohort study)	743 industrial workers exposed to repetitive and forceful work compared to 393 chemical workers w/o exposure	Clinical symptoms and signs and EDX testing or past history of carpal tunnel release	Occupational Variables: exposure to repetitive/forceful work with postural extremes; Personological Variables: age; past wrist trauma; BMI; smoking, gender; additional medical condition	Exposure to repetitive/forceful work with postural extremes; Age; Wrist trauma; BMI; Female gender	Exposure to repetitive/forceful work with postural extremes: OR= 4.24; Age (35-49 yrs): OR= 2.30; Past wrist trauma: OR= 3.87; BMI >/- 30: OR= 2.13; Female gender: OR= 1.44	smoking;

(table continues)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
54	Tang et al. 1999	Case-control	61 female CTS patients compared to 61 age-sex- and diabetes matched non-CTS participants	Symptom profiles and selected EDX testing	<u>Occupational Variables:</u> repetitive & forceful movements with postural extremes: 1) intensity of washing clothes manually; 2) intensity of kneading dough manually; 3) intensity of knitting clothes manually; 4) duration of washing clothes manually; 5)duration of kneading dough manually; 6) duration of knitting clothes manually	Repetitive & forceful movements with postural extremes; intensity of washing clothes manually; intensity of kneading dough manually	Intensity of kneading dough manually: OR= 6.25; Intensity of washing clothes manually: OR= 3.86	Intensity of knitting manually; duration of washing clothes manually, kneading dough manually, and knitting clothes manually

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
55	Latko et al. 1999	Cross-sectional	352 industrial workers	Three different case definitions: Most stringent was symptom profile (hand diagram score) and EDX testing	Occupational Variables: repetition; force; localized mechanical stress; posture; low temperature (cold); vibration; jerk/impulse; Personological Variables: age, gender, race, education level; smoking/chewing tobacco; diabetes; thyroid disease; rheumatoid arthritis; gynecological factors; previous injuries; BMI; wrist depth/width ratio (wrist ratio); Psychosocial Variables: job content; perceived stress; social network at work;	No significant findings; Borderline significance for repetition (p.06).	Repetition OR= 1.22 increase for every unit increase in repetition	Occupational Variables: force; localized mechanical stress; posture; low temperature (cold); vibration; jerk/impulse; Medical-Personal Variables: age, gender, race, education level; smoking/chewing tobacco; diabetes; thyroid disease; rheumatoid arthritis; gynecological factors; previous injuries; BMI; wrist depth/width ratio (wrist ratio); Psychosocial Variables: job content; perceived stress; social network at work;

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
56	Giersiepen et al. 2000	Case-control	404 men and 404 women who underwent carpal tunnel release compared to an age- and gender matched sample from the general population	Carpal tunnel release	Occupational Variables: repetition; force; Personological Variables: BMI	Repetition; Force; BMI	repetition for men: OR= 2.89; repetition for women: OR= 2.1.; force for men: OR= 2.69; force for women: OR= 2.29; BMI in men: OR increase of 1.13 for each unit increase in BMI; BMI in women: OR increase of 1.09 for each unit increase in BMI	
57	Dieck & Kelsey 1985	Epidemiological study	40 women who underwent carpal tunnel release; control group of 1,043	carpal tunnel release	Personological Variables: diabetes; varicosis; hormone replacement therapy; weight gain; Quetelet's index; marital status; gynecological surgery; thyroid dysfunction; smoking;	diabetes; hormone replacement therapy; greater quetelet's index; weight gain in past 5 years;	Only crude ORs were reported; did not report ORs from logistic regression	marital status; gynecological surgery; thyroid dysfunction; smoking
58	Tanaka et al. 1994	Prevalence study (OHU National Health Interview Survey)	44,233 adult respondents	"medically called CTS"; self-reported	Personological Variables: Age; Female Gender; Race;	Age; Female Gender; White Race	White Race OR= 1.8; Female Gender OR= 1.6; Age OR= 1.01 per year increase	None-reported

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
59	Bleecker et al. 1985	Cross-sectional	14 male electricians	Clinical symptoms and EDX testing	Personological Variables: carpal canal size	carpal canal size was significantly smaller in CTS-positive individuals	None-reported	
60	Bovenzi et al. 1991	Epidemiological and Clinical study	65 vibration exposed forestry workers who operated chainsaws; Control subjects were 31 maintenance workers	Clinical symptoms and signs	Occupational Variables: Vibration exposure; Personological Variables: Ponderal index (measure of body mass)	Forestry workers exposed to vibration had significantly higher rates of CTS; Increasing body mass (i.e., ponderal index) significantly related to CTS	None-reported	
61	Florack et al. 1992	Cross-sectional (retrospective chart review)	249 participants who had undergone surgery for basal joint arthritis	2 of the following 3: 1) clinical symptoms; 2) clinical signs; 3) EDX testing	Personological Variables: Osteoarthritis (basal joint arthritis) Rheumatoid arthritis; Diabetes; Hypothyroidism; Workers compensation; Female Gender	Osteoarthritis; Diabetes; Workers Compensation; Female Gender	None-reported	Rheumatoid arthritis; Hypothyroidism;

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
62	Armstrong & Chaffin 1979	Cross-sectional (cohort study)	Cases= 18 women with CTS; Controls= 18 women who performed the same job as the cases;	Chart history of CTS symptoms, clinical signs, or carpal tunnel release	Occupational Variables: Force; Use of wrist position that deviated from straight; Personological Variables: Wrist size; Carpal canal width;	Force; Use of wrist position that deviated from straight	None-reported	Wrist size; Carpal canal width
63	Sungpet et al. 1998	Cross-sectional	250 industrial workers	Symptoms and EDX testing	Personological: Gender & age	Female gender and age	None Reported	
64	Rossignal et al. 1997	Epidemiological Study	207	Medical Data Base Codes	Personological: Age and Gender	Female gender and age	None Reported	
65	Swajian 1991	Cohort Study	106 industrial workers	Clinical symptoms and Signs	Personological Variables Age and gender	Female gender and Age	None-reported	

(*table continues*)

Study #	Authors	Experimental design	Participants	Method of diagnosis	Study variables	Significant findings	Odds ratio	Nonsignificant findings
66	Stevens et al. 1988	Population based incidence study	1,016	Diagnostic codes in database	<u>Personological Variables:</u> Age and Gender	Female gender and age	none reported	

Appendix B:

Research hypotheses and Coding Variables

CTS risk factors/ predictor variables/ hypothesis	Risk factor variable coding
1. CTS participants will endorse significantly higher levels of occupational repetition	Continuous Variables Repetition Subscale of the Occupational Hand Use Scale
2. CTS participants will endorse higher levels of occupational combined repetition-force	Continuous Variable Repetitive and Forceful Work Subscale of the Occupational Hand Use Scale
3. CTS participants will endorse higher levels of occupational vibration	Dichotomous and Continuous Variable Self reported exposure to vibration: 1 = yes; 2 = no If yes, self-reported number of hours per week exposed to vibration
4. CTS participants will possess significantly higher BMI values	Continuous Variable
5. CTS participants will be less likely to engage in regular vigorous physical exercise	Continuous Variable Self-reported number of hours per week spend engaging in various physical activities
6. CTS participants will endorse higher levels of pre-morbid diabetes	Dichotomous Variable 1=yes 2=no
7. CTS participants will endorse significantly higher levels of pre-morbid arthritic diseases	Dichotomous Variable 1=yes 2=no
8. CTS female participants will report significantly higher levels of past gynecological surgery and hormonal-menstrual complications	Dichotomous Variable 1=yes 2=no yes
9. CTS subjects will endorse significantly higher levels of anxiety	Continuous Variable Anxiety Subscale of the Brief Symptom Inventory- 18

CTS risk factors/ predictor variables/ hypothesis	Risk factor variable coding
10. CTS participants will endorse significantly higher levels of depression	Continuous Variable Depression Subscale of the Brief Symptom Inventory – 18
11. CTS participants will endorse significantly higher levels of somatization	Continuous Variable Somatization Subscale of the Brief Symptom Inventory - 18
12. CTS participants total scores on the BSI-18 will be significantly higher than control participants	Continuous Variable Total Scores on the Brief Symptom Inventory - 18
13. CTS participants will endorse significantly lower levels of internal health-related locus of control beliefs	Continuous Variable Internal Health Locus of Control Subscale of the Multidimensional Health Locus of Control Scale
14. CTS participants will endorse significantly lower levels of job satisfaction	Continuous Variable Response to a one item self-report assessment of job satisfaction (Likert scale)
15. CTS participants will endorse significantly higher levels of physical and mental health dysfunction	Continuous Variables Short Form Health Inventory – 36 8 subscales and 2 summary scales

Appendix C:

Study Protocol

Orthopedic Associates

Carpal Tunnel Study

Patient Name: ______________________________

Patient Address:

Street & Number ________________________

City, State ____________________________

Zip Code: ______________________________

Birthdate: ______/______/______
mm dd yyyy

Gender: ☐ Male ☐ Female

Today's Date: ______/______/______
mm dd yyyy

Demographics and Physical Health

1. What is your height (feet and inches)?

2. What is your weight (in pounds)?

ft.	in.		

3. What is your race or ethnicity?

__Arabic or Middle Eastern
__Asian
__Black or African American
__Eskimo or Aleut
__Hispanic or Latino
__East Indian (From India)
__Native American or American Indian
__Pacific Islander
__White
__Other ________________

4. How much schooling have you completed?

__Less than 12 years
__High school degree or equivalent
__Some college
__Graduated from college
__Trade school/ AA

__Advanced degree

5. What is your current marital situation?

__ Married
__ Living with significant other
__ Divorced
__ Separated
__ Widowed

__ Single (never married)

6. Do you currently smoke cigarettes?

__Yes __No

6a. Have you ever smoked?

__Yes __No

6b. If yes, when was the last time you smoked?

Date:________________

6c. Please indicated the average number of cigarettes you smoke(d) daily _____ and the total # of years you smoked ______

7. Do you drink alcohol?

__Yes __No

7a. If yes, please choose from the following

__Light/social drinking
__Drinking some weekends
__Drinking most weekends
__Drinking almost daily

General CTS Symptoms

1. **Do you experience pain or numbness in your hand or wrist?**
   - __Yes
   - __No

1a. **If yes, how long have you experienced the pain or numbness in your hand or wrist?**
   - __ Less than 3 weeks
   - __ 3 weeks to 3 months
   - __ 3 months to 6 months
   - __ 6 months to 1 year
   - __ More than 1 year

2. **Do you experience aching or discomfort in the hand, wrist, or forearm?**
   - __Yes
   - __No

2a. **If yes, how long have you experienced this aching or discomfort?**
   - __ Less than 3 weeks
   - __3 weeks to 3 months
   - __ 3 months to 6 months
   - __ 6 months to 1 year
   - __ More than 1 year

3. **Does your hand pain or numbness wake you up at night?**
   - __Yes
   - __ No

4. **Do you experience weakness or clumsiness with your hand?**
   - __Yes
   - __No

5. **Does your pain or numbness feel better if you shake your wrist or hand?**
   - __Yes
   - __No

6. **Do you experience dry skin, swelling, or color changes with your hand or wrist?**
   - __ Yes
   - __ No

7. **Do you experience CTS symptoms in both wrists/hands?**
   - __Yes
   - __No

Specific CTS Symptoms

The following questions refer to your symptoms for a typical twenty-four-hour period during the past two weeks. Please choose one answer from the five choices that most closely describes how you have been feeling over the past two weeks. Please take care to answer all the questions. If a question contains response options that do not perfectly match your symptoms, please choose the alternative that most closely describes your symptoms.

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 of 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?

__ Never
__ Once or twice a day
__ Three or five times a day
__ More than five times a day
__ The pain is constant

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

CTS Symptoms (Continued)

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 a 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 during 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

Hand- and Wrist-Related Activities

Please answer the following questions by choosing the number that best describes the amount of difficulty you have had doing the following activities during a typical day in the past two weeks.					
Activity	**No Difficulty**	**Mild Difficulty**	**Moderate Difficulty**	**Severe Difficulty**	**Cannot Do at All Due to Hand or Wrist Symptoms**
Writing	1	2	3	4	5
Buttoning of clothes	1	2	3	4	5
Holding a book while reading	1	2	3	4	5
Gripping of a telephone handle	1	2	3	4	5
Opening of jars	1	2	3	4	5
Household chores	1	2	3	4	5
Carrying of grocery bags	1	2	3	4	5
Bathing and dressing	1	2	3	4	5

Physical Activities

This section lists several different types of exercise activities. For each activity please indicate if you regularly engage in that activity by circling either "yes" or "no." If you circle yes for an activity, please indicate the average number of times per week that you engage in that activity. Then, please write the average duration of a normal activity session. For example, if I jog 5 days a week for 45 minutes each day, I first circle "Y", then I would circle 5 in the "average number of days per week", and then write 45 minutes "average duration of exercise sessions." If you are unsure please provide your best estimation.

Physical activities	Y= I engage regularly in this activity N= I do not engage regularly in this activity	Average number of days per week	Average duration of exercise sessions in minutes
Walking	Y N	1 2 3 4 5 6 7	duration ________
Jogging	Y N	1 2 3 4 5 6 7	duration ________
Stationary bike	Y N	1 2 3 4 5 6 7	duration ________
Road/Mountain bike	Y N	1 2 3 4 5 6 7	duration ________
Aerobics class, machine (e.g., stair master), or routine exercises (e.g., jumping jacks)	Y N	1 2 3 4 5 6 7	duration ________
Swimming	Y N	1 2 3 4 5 6 7	duration ________
Hiking	Y N	1 2 3 4 5 6 7	duration ________
Weight training	Y N	1 2 3 4 5 6 7	duration ________
Any racquet sports	Y N	1 2 3 4 5 6 7	duration ________
Any non-racquet sports	Y N	1 2 3 4 5 6 7	duration ________
House/yard cleaning	Y N	1 2 3 4 5 6 7	duration ________
Mowing lawn/gardening	Y N	1 2 3 4 5 6 7	duration ________
Others (please list): ________________ ________________ ________________	Y N	1 2 3 4 5 6 7	duration ________

General Health Status

The following questions inquire into your views about your overall health in general. Please answer each question by selecting the item which bests describes how you feel about your health. If you are unsure about how to answer a question, please give the best answer you can.

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

	Excellent	Very Good	Good	Fair	Poor
	1	2	3	4	5

2. Compared to one year ago, how would you rate your health in general now?

	Much better now than one year ago	Some-what better now than one year ago	About the same as one year ago	Some-what worse not than one year ago	Much worse now than one year ago
	1	2	3	4	5

3. 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.) Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports	1	2	3
b.) Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	1	2	3
c.) Lifting or carrying groceries	1	2	3
d.) Climbing several flights of stairs	1	2	3
e.) Climbing one flight of stairs	1	2	3
f.) Bending, kneeling, or stooping	1	2	3
g.) Walking more than a mile	1	2	3
h.) Walking several blocks	1	2	3
i.) Walking one block	1	2	3
j.) Bathing or dressing yourself	1	2	3

4. 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?

	Yes	No
a.) Cut down on the amount of time you spent on work or other activities	1	2
b.) Accomplished less than you would like	1	2
c.) Were limited in the kind of work or other activities	1	2
d.) Had difficulty performing the work or other activities (for example, it took extra effort)	1	2

General Health Status (Continued)

5. 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)?

	Yes	No
a.) Cut down on the amount of time you spent on work or other activities	1	2
b.) Accomplished less than you would like	1	2
c.) Didn't do work or other activities as carefully as usual	1	2

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

	Not at all	Slightly	Moderately	Quite a bit	Extremely
	1	2	3	4	5

7. How much bodily pain have you had during the past 4 weeks?

	None	Very mild	Mild	Moderate	Severe	Very severe
	1	2	3	4	5	6

8. 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
	1	2	3	4	5

9. These questions 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	A Good bit of the time	Some of the time	None of the time
a.) did you feel full of pep?	1	2	3	4	5
b.) have you been a very nervous person?	1	2	3	4	5
c.) have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5
d.) have you felt calm and peaceful?	1	2	3	4	5
e.) did you have a lot of energy?	1	2	3	4	5
f.) have you felt downhearted and blue?	1	2	3	4	5
g.) did you feel worn out?	1	2	3	4	5
h.) have you been a happy person?	1	2	3	4	5
i.) did you feel tired?	1	2	3	4	5

General Health Status (Continued)

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

	All of the time	Most of the time	A Good bit of the time	Some of the time	None of the time
	1	2	3	4	5

11. How TRUE or FALSE is each of the following statements for you?

	Definitely true	Mostly true	Don't know	Mostly false	Definitel y false
a.) I seem to get sick a little easier than other people	1	2	3	4	5
b.) I am as healthy as anybody I know	1	2	3	4	5
c.) I expect my health to get worse	1	2	3	4	5
d.) My health is excellent	1	2	3	4	5

Health-Related Feelings and Stress

Below is a list of problems people sometimes have. Read each one carefully and circle the number that best describes how much that problem has distressed or bothered you during the past 7 days including today. Please do not skip any items. If you change your mind, erase your first circled responses and circle a new choice.

1. Faintness or dizziness 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**2. Feeling no interest in things** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**3. Nervousness or shakiness inside** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**4. Pains in heart or chest** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**5. Feeling lonely** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely
6. Feeling tense or keyed up 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**7. Nausea or upset stomach** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**8. Feeling blue** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**9. Suddenly scared for no reason** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**10. Trouble getting your breath** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely
11. Feelings of worthlessness 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**12. Spells of terror or panic** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**13. Numbness or tingling in parts of your body** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**14. Feeling hopeless about the future** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**15. Feeling so restless you couldn't sit still** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely
16. Feeling weak in parts of your body 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**17. Thoughts of ending your life** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely	**18. Feeling fearful** 0 = not at all 1 = a little bit 2 = moderately 3 = quite a bit 4 = extremely		

Opinions About Health

Each item below is a belief statement about your medical condition with which you may agree or disagree. Beside each statement is a scale which ranges from strongly disagree (1) to strongly agree (6). For each item we would like you to circle the number that represents the extent to which you agree or disagree with that statement. The more you agree with a statement, the higher will be the number you circle. The more you disagree with a statement, the lower will be the number you circle. Please make sure that you answer EVERY ITEM and that you circle **ONLY ONE** number per item. This is a measure of your personal beliefs; obviously, there are no right or wrong answers.

1= Strongly Disagree (SD) 2= Moderately Disagree (MD) 3= Slightly Disagree (D)	4= Slightly Agree (A) 5= Moderately Agree (MA) 6= Strongly Agree (SA)

	SD	MD	D	A	MA	SA
1. If I get sick it is my own behavior that determines how soon I get well again.	1	2	3	4	5	6
2. No matter what I do, if I am going to get sick, I will get sick.	1	2	3	4	5	6
3. Having regular contact with my physician is the best way for me to avoid illness.	1	2	3	4	5	6
4. If my health worsens, it is up to God to determine whether I will feel better again.	1	2	3	4	5	6
5. Most things that affect my health happen by accident.	1	2	3	4	5	6
6. Whenever I don't feel well, I should consult a medically trained professional.	1	2	3	4	5	6
7. I am in control of my health.	1	2	3	4	5	6
8. Most things that affect my health happen because of God.	1	2	3	4	5	6
9. My family has a lot to do with my becoming sick or healthy.	1	2	3	4	5	6
10. When I get sick I am to blame.	1	2	3	4	5	6
11. Luck plays a big part in determining how soon I will recover from an illness.	1	2	3	4	5	6
12. God is directly responsible for my health getting better or worse.	1	2	3	4	5	6
13. Health professionals control my health.	1	2	3	4	5	6
14. My good health is largely a matter of good fortune.	1	2	3	4	5	6
15. The main thing which affects my health is what I myself do.	1	2	3	4	5	6

Opinions About Health (Continued)

	SD	MD	D	A	M A	SA
16. Whatever happens to my health is God's will.	1	2	3	4	5	6
17. If I take care of myself, I can avoid illness.	1	2	3	4	5	6
18. When I recover from an illness, it's usually because other people (for example, doctors, nurses, family, friends) have been taking good care of me.	1	2	3	4	5	6
19. No matter what I do, I'm likely to get sick.	1	2	3	4	5	6
20. Whether or not my health improves is up to God.	1	2	3	4	5	6
21. If it's meant to be, I will stay healthy.	1	2	3	4	5	6
22. If I take the right actions, I can stay healthy.	1	2	3	4	5	6
23. Regarding my health, I can only do what my doctor tells me to do.	1	2	3	4	5	6
24. God is in control of my health.	1	2	3	4	5	6

Job Information

Here are some questions about your employment status. For each question please choose the answer that most accurately represents your current status.

1. What is your current occupational status?
   __ Working full time (35 or more hours per week).
   __ Working part time (fewer than 35 hours per week).
   __ Employed, but not working because of illness, vacation or strike.
   __ Unemployed, laid off or looking for work.
   __ Disabled or unable to work.
   __ Retired.
   __ Homemaker/keeping house.
   __ Student.
   __ Other

2. Have you had to decrease your homemaking activities in the past month because of your carpal tunnel-related problems?
   __ Yes
   __ No

2a. How many days have you been unable to do your homemaking activities because of your carpal tunnel-related symptoms?
   __ About 1 day per week
   __ About 2 days per week
   __ About 3 days per week
   __ About 4 days per week
   __ About 5 days per week
   __ About 6 days per week
   __ Just about every day

3. Are you now covered by a health insurance plan?
   __ Yes
   __ No

3a. If yes, what is the source of your health insurance?
   __ My employer or union
   __ My former employer
   __ My spouse's insurance plan
   __ Medicare
   __ Medicaid
   __ Other / I purchase privately (please specify) ______________________________

Job Information (Continued)

For each of the following job-related questions, please choose the answer that most closely represents what you do each day at work. If you are a homemaker, please answer the questions from the perspective of your daily homemaking activities. If you are unsure about any answers, please provide your best estimation.

<table>
<tr>
<td>4. My current job requires forceful hand use:

1= strongly disagree
2= disagree
3= neutral
4= agree
5= strongly agree</td>
<td>5. My current job requires highly repetitive hand movements:

1= strongly disagree
2= disagree
3= neutral
4= agree
5= strongly agree</td>
<td>6. My current job requires me to lift heavy loads:

1= strongly disagree
2= disagree
3= neutral
4= agree
5= strongly agree</td>
</tr>
<tr>
<td>7. My current job requires writing, typing, or keyboarding for more than 4 hours each day:

1= strongly disagree
2= disagree
3= neutral
4= agree
5= strongly agree</td>
<td>8 My current job keeps me on my feet for more than 4 hours each day:

1= strongly disagree
2= disagree
3= neutral
4= agree
5= strongly agree</td>
<td>9 In my job I am exposed to vibration, such as in use of hand-held or operated vibrating tools:

1= yes
2=no
If yes, please list the approximate number of hours each day you are exposed to vibration:
______</td>
</tr>
<tr>
<td>10. What is your current occupation?</td>
<td>11. How many years have you worked at this job?</td>
<td>12. What is your average weekly wage?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</table>

<table>
<tr>
<td>13.
In the past year, how many days of work have you missed due to sickness or injury (other than carpal tunnel syndrome?
__________</td>
<td>14.
In the past year, how many days have you missed due to your symptoms of carpal tunnel syndrome?
__________</td>
</tr>
<tr>
<td>15.
Have you ever filed a workers' compensation claim?
__ Yes
__ No
If yes, please specify the work-related injury/medical condition ______________________

17.
Have you ever hired a lawyer to represent you in dealing with a workers' compensation insurance company?
__ Yes
__ No
If yes, please specify the relevant work injury/medical condition ________________</td>
<td>16.
Are you currently receiving workers' compensation benefits for you CTS symptoms?
__ Yes
__ No
If yes, please specify the name of the workers' compensation insurance company __________</td>
</tr>
</table>

Your Opinion About Your Job

1. Overall, I am satisfied with my job.

1= Strongly disagree
2= Disagree
3= Slightly disagree
4= Neither disagree or agree
5= Slightly agree
6= Agree
7= Strongly agree

Thank-You For Your Participation!!!

Appendix D:

Informed Consent Document (CTS Symptomatic)

Occupational and Biopsychosocial Risk Factors

for Carpal Tunnel Syndrome

Introduction/Purpose

Professor M. Scott DeBerard from the Department of Psychology at Utah State University in conjunction with the Utah Labor Commission is conducting a research study to discover more about the occupational and non-occupational risk factors related to the development of carpal tunnel syndrome (CTS). For purposes of the current study, the term "non-occupational" risk factors refers to biological, psychological, and social factors that may be associated with the onset of CTS. You have been asked to participate because you are currently experiencing symptoms of CTS which may require treatment. You will not be penalized for participation or for choosing not to participate, and your employer will have no knowledge of individuals who participate.

Procedures

If you agree to participate in this study you will asked to complete several tasks. First you will undergo a diagnostic assessment, which will include two procedures. You will be asked to meet with a physical therapist and undergo an evaluation of your hands, arms, and shoulders. During this evaluation, you will be asked questions pertaining to your symptoms of CTS as well as the symptoms of other related syndromes. Following the physical evaluation, you will be asked to undergo electrodiagnostic (EDX) testing of the median nerve across the carpal tunnel. The purpose of EDX testing is to assess for slowing of median nerve conduction, which may be suggestive of CTS. No lasting, or long term risks are associated with this testing procedure. The total time commitment for the diagnostic assessment is estimated to be 30 minutes. If the assessment results clearly indicate that you have CTS you will be asked to participate further in the study. If you undergo the diagnostic assessment only to find out that you are not eligible for further study participation, you will be compensated with a sum of $10. This would occur if one, or both, of the assessment procedures were not suggestive of CTS. Following the diagnostic assessment, you will be asked to fill out a battery of self-report measures. In particular, you will be asked to complete a demographic and medical assessment, a job-related assessment, three assessments inquiring into various psychological symptoms, and two assessments inquiring into symptoms of CTS. This task should take approximately an hour and a half to complete. For your time and participation in the study you will be compensated with a sum of $100.

Risks

All procedures and self-report measures will be discussed with you prior to the beginning of the study. In addition, a physical therapist will be available to aid in the answering of any questions, should you desire assistance. There may be minimal emotional reaction to some of the questions. At any point in the study, you will be allowed to choose to carry on with the study or terminate your participation with no penalty. Since this is a research project, there may be some unknown risks that are currently unforeseeable.

Benefits

There may or may not be any direct benefits to you from these procedures. Some benefits that you may experience include a thorough evaluation of your CTS, the severity level, as well as any potentially confounding syndromes. The investigator however, may learn more about the occupational and non-occupational risk factors associated with the onset of CTS. Information from this study may benefit other future individuals with CTS.

Explanation and offer to answer questions

A physical therapist will explain different phases of this study to you and answer your questions. If you have other questions or research-related problems, you may reach Dr. DeBerard at (435) 797-1462.

Payment

For your participation in this study you will be paid $100 after the study procedures have been completed. There are no costs to you. As previously alluded to, if you undergo the diagnostic assessment and are not eligible for further study participation, you will be compensated with a sum of $10.

Voluntary nature of participation and right to withdraw without consequences

Participation in research is entirely voluntary. You may refuse to participate or withdraw at any time without consequence or loss of benefit. More specifically, if you withdraw during diagnostic assessment you will still receive $10. If you withdraw after the diagnostic assessment you will still receive $100. In addition, you may be withdrawn by research staff if you are unable to complete any aspect of the study. Should this occur, you will still receive payment (i.e., 10 or 100 dollars) depending on when withdrawal occurs.

Confidentiality

Research records will be kept confidential consistent with federal and state regulations. Only the investigator and his research assistant will have access to the data, and it will be kept in a locked file cabinet in a locked room. The data will be kept indefinitely, but identifying information will be destroyed in 2 years. Data will be stored in numerical form.

IRB approval statement

The Institutional Review Board (IRB) for the protection of human subjects at Utah State University has reviewed and approved this research project. If you have any further questions or concerns about this study, please call the IRB office at (435) 797-1180.

Copy of consent

You have been given two copies of this informed consent. Please sign both copies and retain one copy for your files

Investigator statement

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

____

M. Scott DeBerard, Ph.D.
Professor of Psychology
Uah State University
Principal Investigator
435-797-1462

____

Jason Goodson, M.S.
Student Researcher
Utah State University
Student Researcher
435-232-9230

date created: 10/ 23/2002

I have been explained the procedures of this study and understand what procedures are expected of me through participation in this study. Further, I understand the potential risks and benefits of participating in this study. By signing below I freely agree to participate in this study and acknowledge that I know my rights as a human subject.

____ _______________

Signature Date

Informed Consent Document (Non-CTS Symptomatic)

Occupational and Biopsychosocial Risk Factors

For Carpal Tunnel Syndrome

date created: 10/23/2002

Introduction/Purpose

Professor M. Scott DeBerard from the Department of Psychology at Utah State University in conjunction with the Utah Labor Commission is conducting a research study to discover more about the occupational and non-occupational risk factors related to the development of carpal tunnel syndrome (CTS). For purposes of the current study, the term "non-occupational" risk factors refers to biological, psychological, and social factors that may be associated with the onset of CTS. You have been asked to participate because you are not currently experiencing symptoms of CTS. That is, you will serve as a control subject against which the data from individuals with CTS may be compared. You will not be penalized for participation or for choosing not to participate, and your employer will have no knowledge of individuals who participate.

Procedures

If you agree to participate in this study you will asked to complete several tasks. First you will undergo a diagnostic assessment, which will include two procedures. You will be asked to meet with a physical therapist and undergo an evaluation of your hands, arms, and shoulders. During this evaluation, you will be asked questions pertaining to typical CTS symptoms as well as symptoms of other work-related musculoskeletal disorders (WMSD). Following the physical evaluation, you will be asked to undergo electrodiagnostic (EDX) testing of the median nerve across the carpal tunnel. The purpose of EDX testing is to ensure that you have no median nerve conduction slowing, which may be suggestive of early CTS. No lasting, or long term risks are associated with this testing procedure. The total time commitment for the diagnostic assessment is estimated to be 30 minutes. If the assessment results clearly indicate that you do not have CTS or another WMSD you will be asked to participate further in the study. If you undergo the diagnostic assessment only to find out that you have CTS or another WMSD, you will be compensated with a sum of $10. Following the diagnostic assessment, you will be asked to fill out a battery of self-report measures. In particular, you will be asked to complete a demographic and medical assessment, a job-related assessment, and three assessments inquiring into various psychological symptoms. This task should take approximately an hour and a half to complete. For your time and participation in the study you will be compensated with a sum of $100.

Risks

All procedures and self-report measures will be discussed with you prior to the beginning of the study. In addition, a physical therapist will be available to aid in the answering of any questions, should you desire assistance. There may be minimal emotional reaction to some of the questions. At any point in the study, you will be allowed to choose to carry on with the study or terminate your participation with no penalty. Since this is a research project, there may be some unknown risks that are currently unforeseeable.

Benefits

There may or may not be any direct benefits to you from these procedures. Some benefits that you may experience include the possibility of detecting early onset CTS or another WMSD. The investigator however, may learn more about the occupational and non-occupational risk factors associated with the onset of CTS. Information from this study may benefit future individuals with CTS.

Explanation and offer to answer questions

A physical therapist will explain different phases of this study to you and answer your questions. If you have other questions or research-related problems, you may reach Dr. DeBerard at (435) 797-1462.

Payment

For your participation, you will be paid $100 after you completion of this study. There are no costs to you. As previously alluded to, if you undergo the diagnostic assessment and not eligible for further study participation, you will be compensated with a sum of $10.

Voluntary nature of participation and right to withdraw without consequences

Participation in research is entirely voluntary. You may refuse to participate or withdraw at any time without consequence or loss of benefit. More specifically, if you withdraw during diagnostic assessment you will still receive $10. If you withdraw after the diagnostic assessment you will still receive $100. In addition, you may be withdrawn by research staff if you are unable to complete any aspect of the study. Should this occur, you will still receive payment (i.e., 10 or 100 dollars) depending on when withdrawal occurs.

Confidentiality

Research records will be kept confidential consistent with federal and state regulations. Only the investigator and his research assistant will have access to the data, and it will be kept in a locked file cabinet in a locked room. The data will be kept indefinitely, but identifying information will be destroyed in 2 years. Data will be stored in numerical form.

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Copy of consent

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Investigator statement

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

______________________ ______________________

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Student Researcher
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I have been explained the procedures of this study and understand what procedures are expected of me through participation in this study. Further, I understand the potential risks and benefits of participating in this study. By signing below I freely agree to participate in this study and acknowledge that I know my rights as a human subject.

____________________________________ ______________

Signature Date

Appendix E :

Univariate Model for Carpal Tunnel Syndrome

A univariate model of CTS which takes into consideration both univariate significance testing and effect size was also proposed. The inclusion of a univariate model was done to highlight those factors which may have been significantly associated with CTS in univariate testing but did not retain significance during multivariate analyses. For instance, it is possible that variables with strong associations with CTS did not reach significance in multivariate testing due to multicolinearity with other predictor variables. Alternatively, variables with strong associations with CTS may have not retained significance because other variables accounted for too much of the predictive variance. In either case, the failure to reach significance in multivariate analyses would not diminish the strength of the relationship between the variable and CTS. As such, the present section will discuss the occupational, personological, and psychosocial variables with strong univariate associations with CTS. Variables included in the model were those which reached statistical significance in univariate testing and possessed a medium or large Cohen's d effect size. For the sake of inclusion, a cutoff value of .40 was used to designate the low end of a medium effect size. When odds ratios were reported (i.e., for categorical data) the values were transformed into a Cohen's d effect size. This was accomplished by multiplying 2 by the square root of the chi square value divided by the number of participants subtracted by the chi square value:

$$d = 2 * \sqrt{\text{chi square}} / n - \text{chi square}$$

Using a .40 cutoff, a total of nine variables were included in the univariate model of CTS. Of these nine variables, two were occupational (i.e., repetition and combined repetition and force), three were personological (i.e., BMI, vigorous physical exercise, and exercise with wrist strain), and four were psychosocial (i.e., depression, somatization, job satisfaction, and PCS scores).

The effect sizes of the nine variables ranged from .41 (depression) to 1.02 (PCS scores), with an overall mean effect size of .61. Comparison of effect sizes between categories revealed the mean effect sizes for the personological and psychosocial variables were similar (.63 and .62, respectively). Moreover, while the mean effect size for occupational variables was smaller, the difference was nominal (i.e., .56). The following sections will provide a discussion of each of the individual variables. The discussion will begin with the variables with large effect sizes and then proceed to those with medium effect sizes.

Discussion of Factors with Large Effect Sizes

A cutoff value of .70 was used to designate large effect sizes. Based on this criterion, three variables possessed ES which would be suggestive of large magnitudes. All three variables were measures of physical health, including PCS scores, BMI, and vigorous exercise. The effect size for the PCS was -1.02, the ES for BMI was .76, and the ES for vigorous exercise was .72.

The PCS was found to have the largest univariate association with CTS. As stated above, the effects size for the PCS was -1.02, which indicates that the average PCS score for CTS participants was a full standard deviation smaller than the average PCS score for control participants. As smaller scores are reflective of worse health, this finding suggests that CTS is associated with considerable physical health dysfunction.

Body mass index values were found to have the second largest univariate association with CTS. The effect size for BMI and CTS was .76, which suggests that the average BMI value of

CTS participants was three-fourths of a standard deviation larger than the average BMI value of control participants. In addition, the mean BMI value of the CTS group fell in the obese category (i.e., 29.88), while the mean BMI value for the control group fell in the overweight category. Thus, the BMI values of CTS participants were significantly elevated, even when compared to an overweight population.

The variable with the third largest univariate association with CTS was vigorous exercise. The effect size for vigorous exercise was -.71, which suggests that the average amount of vigorous exercise in the CTS group was three-fourths of a standard deviation less than the average amount of vigorous exercise in the control group. For the CTS participants, the mean number of minutes per week spent exercising was 76.36 (141.88), which equates to approximately 10 minutes per day. For the control participants, the mean number of minutes per week spent exercising was 221.83 (254.55), which equates to approximately 30 minutes per day. As such, it seems that 30 minutes of daily exercise provides protective benefits against CTS development, while 10 minutes per day may be insufficient.

In summary, univariate testing suggests that physical health related variables have strong associations with CTS. Additionally, all the variables found to have large effect sizes were physical health related variables, including PCS scores, BMI values, and vigorous exercise. The following section will discuss the variables with medium effect sizes.

Discussion of Factors with Medium Effect Sizes

A cutoff value of .40 was used to designate medium effect sizes. Using this value, six variables were found to have medium effect sizes. These variables were repetition, combined repetition and force, physical activities with wrist strain, job satisfaction, somatization, and depression. The effect sizes for the six variables ranged from .41 (depression) to .61 (repetition and job satisfaction).

Two occupational variables were found to have medium effect sizes, those being repetition and combined repetition and force. The effect size for repetition and CTS was .61, which suggests that the average repetition rating for CTS participants was more than ½ (specifically 2/5) of a standard deviation larger than the average repetition rating for control participants. With respect to combined repetition and force, the effect size was .51, which indicates that the average score for CTS participants was ½ of a standard deviation larger than the average score for control participants.

The sole personological factor with a medium effect size was physical activities with wrist strain. The effect size for this variable was .42, which suggests that the average number of weekly minutes spent engaging in physical activities with wrist strain was approximately 2/5 of a standard deviation higher in the CTS group. Specifically, the mean number of weekly minutes was 626 (562.85) for CTS participants and 417 (404.89) for control participants. This equates to approximately 90 minutes per day for CTS participants and 60 minutes per day for control participants. This indicates that risk for CTS development may increase with more than 1 hour of daily physical activity with wrist strain.

Three psychosocial variables were found to have medium effect sizes, including job satisfaction, somatization, and depression. The effect size for job satisfaction was -.61, which suggests that the average job satisfaction score for CTS participants was more than ½ of a standard deviation less (specifically 2/5) than the average job satisfaction score for control participants. The effect size for somatization and CTS was .45, which indicates that the average somatizaton score for CTS participants approached being ½ of a standard deviation larger than that of control participants. The primary feature of somatization is frequent somatic complaints which cannot be fully explained by the medical findings. As such, a fairly common clinical characteristic of CTS may be frequent medical complaints and/or evaluations unrelated to CTS. Finally, the effect size for depression and CTS was .41, which suggests that the average depression score for the CTS participants was approximately 2/5 of a standard deviation larger than the average score for the control participants. As the central features of depression are low mood functioning and anhedonia, it may be common for individuals with CTS to complain of low mood states and decreased levels of pleasure and/or motivation.

In summary, six variables were found to have medium magnitudes of association with CTS. Of these variables, two were occupational factors (i.e., repetition and combined repetition & force) three were psychosocial factors (i.e., job satisfaction, somatization, and depression), and one was a personological factor (i.e., physical activities with wrist strain).

CURRICULUM VITAE

Jason Talley Goodson, M.S.

Summer 2004

PERSONAL INFORMATION

Business Address: Jason Talley Goodson, M.S.,
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Milwaukee, Wisconsin, 53295
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Home Address: 6721 S Costa Cove
Salt Lake City, Utah, 84121
Tel. (801) 842-2203

EDUCATION

Utah State University, Logan, Utah (projected completion) Summer, 2005
Degree: Ph.D.
Degree: Master of Science May, 2002
Program: Combined Clinical/Counseling/School Psychology Program
Emphasis: Adult Clinical
Cumulative GPA: 3.98
Relevant Course Work: Empirically Supported Treatments, Psychopathology, Psychology of Addictive Behaviors, Health Psychology, Personality Assessment, Seminar in Meta-Analysis, Research Methods, Multicultural Counseling

University Of Utah, Salt Lake City, Utah May, 1998
Degree: B.A.
Major: Psychology
Cumulative GPA: 3.7

Brigham Young University, Provo, Utah May, 1996
Degree: General Education
Cumulative GPA: 3.4

CLINICAL EXPERIENCE

Consultant; Therapist-in-Training, May 2004 - August 2004
Avalon Hills Residential Facility for Eating Disorders, Logan, UT
Supervisor: Mary Doty, Ph.D.

- Co-facilitate body image group for residential eating disordered clients

Consultant; Therapist-in-Training May 2003 - August, 2004
Hillside Residential Facility
Supervisor: Kevin Masters, Ph.D.

- Co-facilitate group therapy meetings with schizophrenic clients
- Co-facilitate staff training meetings

Graduate Assistant; Therapist-in-Training, Sep., 2003 - May, 2004
UTAH STATE UNIVERSITY COUNSELING CENTER, Logan, UT
Supervisor: Mary Doty, Ph.D.

- Provide individual psychotherapy with an emphasis on treatment of anxiety disorders
- Additional experience in treating depression, sexual addictions, body-image concerns, trauma-related issues, personality disorders
- Supervise and undergraduate peer-counselor
- Attend weekly intern training seminars

Practicum Student; Therapist-in-Training, Sep., 2002-May, 2003
UTAH STATE UNIVERSITY COUNSELING CENTER, Logan, UT
Supervisors: Gwena Couilliard, Ph.D., Mary Doty, Ph.D.,

- Provided individual psychotherapy with clients presenting with anxiety disorders, depression, social skills deficits, and sexual addictions.
- Outreach presentations on healthy relationships and listening skills

Practicum Student; Therapist-in-Training, May, 2003 - October, 2003
Cardiac Rehabilitation Unit, Brigham City Community Hospital, Brigham City, Utah
Supervisor: Kevin Masters, Ph.D.,

- Performed psychosocial assessments, individual stress management interventions, and individual therapeutic interventions with cardiac rehabilitation clients.
- Taught group classes on stress management and diabetes.

Graduate Assistant; Therapist-in-Training, Sep., 2001-May, 2002
UTAH STATE UNIVERSITY, CLINICAL SERVICES, Logan, UT
Supervisor: Pat Truhn, Ph.D.

- Case-coordinator for multidisciplinary team providing services to children and adolescents
- Performed psychoeducational assessments, family therapy, and parent training.
- Performed disability evaluations, wrote integrative evaluation reports, coordinated team services, and provided parental recommendations
- Gained proficiency with the following assessments: WISC-III, WAIS-III, Woodcock-Johnson-III, Multidimensional Anxiety Scale for Children, MMPI, MMPI-A, Millon-III, Mental Status Exam, Sentence Completion Test, Children's Memory Test, Matching Familiar Figures Test, Diagnostic Clinical Structured Interviews

Practicum Student; Therapist-in-Training, Sep., 2000-May, 2001
UTAH STATE UNIVERSITY, CLINICAL SERVICES, Logan, UT
Supervisor: Pat Truhn, Ph.D.

- Performed psychoeducational assessments with children and adolescents
- Wrote integrative evaluation reports and provided parental recommendations

Practicum Student; Therapist-in-Training, Jan., 2000 - Dec., 2000
UTAH STATE UNIVERSITY PSYCHOLOGY COMMUNITY CLINIC, Logan, UT
Supervisors: Susan Crowley, Ph.D., and Gretchen Gimpel, Ph.D.

- Provided individual psychotherapy to adults and adolescents presenting with obsessive-compulsive disorder, anxiety-related symptoms, interpersonal assertiveness skills deficits, anger management issues, and personality disorders

Youth Corrections Counselor, June, 1997-Aug., 1999
WASATCH YOUTH CENTER, Salt Lake City, UT

- Performed individual, group, and family counseling sessions with incarcerated youth
- Formulated and implemented treatment programs of clients
- Gang issues specialist
- Designed and implemented center-wide gang-issues treatment program
- Facilitated weekly gang-issues treatment group
- Facilitated weekly sex offender group
- Facilitated weekly conflict resolution and problem solving group
- Implemented, carried out, and participated in tri-weekly physical and mental conditioning group

Counselor, April-Sep., 1998
THE CHILDREN'S CENTER, Salt Lake City, UT

- Worked with abused children removed from homes
- Implemented behavior modification program

Forensic Psychiatric Technician, 1996-1997
UTAH STATE HOSPITAL, Provo, UT

- Worked with incarcerated and mentally ill clients
- Gained experience in conflict resolution and anger management training
- Implemented behavior modification programs

RESEARCH EXPERIENCE

Paid Research Assistantship Sep., 2002 - Aug., 2003
UTAH STATE UNIVERSITY: Psychology Department, Logan, UT
Supervisor: M. Scott DeBerard, Ph.D.

- Conducted literature review and formulated methodology for a study investigating the risk factors for carpal tunnel syndrome.
- Project funded through the State of Utah Labor Commission

Doctoral Dissertation August, 2004
UTAH STATE UNIVERSITY: Psychology Department, Logan, UT
Chairperson: M. Scott DeBerard, Ph.D.
Title: "Occupational and Biopsychosocial Risk Factors for Carpal Tunnel Syndrome: A Case Control Study."
Proposal Defense Date: January, 2003
Final Defense Date: August 3rd, 2004
Description:

- Comparison of 87 participants with carpal tunnel syndrome with 74 age- and gender-matched control participants.
- Data was collected at the Orem Orthopedic Specialty Clinic located within the Mt. Timpanogos Regional Hospital.

Research Assistant July, 2002 - July, 2003
UTAH STATE UNIVERSITY: Psychology Department, Logan, UT
Principal Investigator: Kevin Masters, Ph.D.
Title: "Effects of social support and home exercise equipment on exercise Adoption by individuals at risk for type 2 diabetes."

Responsibilities:

- Performed pre- and post- psychosocial assessments
- Performed weekly health psychology interventions with participants regarding exercise behavior

Research Assistant, June, 2003-Present
UTAH STATE UNIVERSITY: Psychology Department, Logan, UT
Principle Investigator: Kevin Masters, Ph.D.
Title: "The Efficacy of Long-Distance Intercessory Prayer: A Meta-Analytic Review and Conceptual Critique."
Responsibilities:

- Reviewed and coded primary articles for meta-analysis
- Calculated effect-sizes
- Wrote the methods section
- Manuscript submitted for publication

Masters Thesis, December, 2001
UTAH STATE UNIVERSITY: Psychology Department, Logan, UT
Chairperson: David Stein, Ph.D.
Title: "An Investigation into the Effects of Humor and Laughter on Depressive Symptoms."
Description:

- Designed and carried out a randomized, placebo-controlled, clinical trial investigating the effects of humor on depression, social activities, and daily mood.
- Participants exposed to humor or placebo interventions daily for one month.

PUBLICATIONS

Goodson, J.T., & DeBerard, M.S., (2003, March). Occupational and biospychosocial risk factors associated with carpal tunnel syndrome onset: A review of literature. *Annals of Behavioral Medicine, 25, S128.* (peer-reviewed published abstract).

MANUSCRIPTS SUBMITTED FOR PUBLICATION

Masters, K.S., & Goodson, J.T. *The efficacy of long-distance intercessory prayer: A meta-analytic review and conceptual critique.*

DeBerard, M.S., Colledge, A. L., Bentley, C., Goodson, J. T., & Spielmans, G.I. *Outcomes of lumbar discectomy in Utah workers: A retrospective cohort study.*

MANUSCRIPTS IN PREPARTION

Goodson, J.T., & Deberard, M.S. *Occupational and biopsychsocial risk factors for carpal tunnel syndrome: A Review of Literature and Risk Factor Typology Proposal.*

Masters, K. S., Spielmans, G. I., Heath, E. M., Goodson, J. T., & Knestel, A. *The effects of mail versus telephone interventions in facilitating exercise adoption.*

PRESENTATIONS

Goodson, J.T. & DeBerard, M.S. (2003, March). *Occupational and biopsychosocial risk factors associated with carpal tunnel syndrome onset: A review of literature.* Paper presented at the Society of Behavioral Medicine, 24^{th} Annual Scientific Sessions, Salt Lake City, UT (Cited as Meritorious Student Paper).

Goodson, J.T., & Stein, D.M. (2002, June). *The effects of humor on depression.* Paper presented at the 1^{st} International Summer School on Humor and Laughter: Theory, Research, and Applications, Belfast, Ireland.

Goodson, J.T., & Erhlick, A.W. (2001, November). *Trainee activities and perspectives: Trainees involvement in the children's supplemental security income (SSI) project.* Roundtable Presentation at the Association of University Centers of Disabilities, Bethesda, Maryland.

TEACHING EXPERIENCE

Instructor, Apprenticeship of Psychology, Sep., 2000, May, 2001
UTAH STATE UNIVERSITY: Psychology Department, Logan, UT

- Prepared and presented lectures to undergraduate students
- Assess and evaluate student progress

HONORS AND AWARDS

Meritorious Student Paper, Society of Behavioral Medicine, 2003
Dean's List, Utah State University, 2000-2001
Western Athletic Conference Scholar-Athlete Award, BYU, 1994

ACTIVITIES

Student Representative, Combined Psychology Program, 2001 – 2002, UTAH STATE UNIVERSITY: Psychology Department, Logan, UT.

Volunteer Statistics Tutor, Combined Psychology Program, 2002 UTAH STATE UNIVERSITY: Psychology Department, Logan, UT.

RECENT CONFERENCES ATTENDED

Individual Psychotherapy in Dialectical Behavior Therapy, SLC, UT, 2003

Psychopharmacology Symposium, Denver, CO, 2003

PROFESSIONAL REFERENCES

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