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Sleep Occupation Quality and Occupation-based Hand Function in Carpal Tunnel Syndrome

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SLEEP OCCUATION QUALITY AND OCCUPATION-BASED HAND FUNCTION IN CARPAL TUNNEL SYNDROME

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Requirements for the Degree of
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Angela Messer Goorman
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This project, written by Angela M. Goorman under the direction of Dr. Collen Schneck, Faculty Mentor, and approved by the project committee, has been presented and accepted in partial fulfillment of requirements for the degree of

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Certification

We hereby certify that this Capstone project, submitted by Angela Goorman, conforms to acceptable standards and is fully adequate in scope and quality to fulfill the project requirement for the Doctor of Occupational Therapy degree.

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Executive Summary

Sleep disturbance is considered a health crisis by Centers for Disease Control and Prevention (2013). It is not uncommon for clients with carpal tunnel syndrome (CTS) to also have poor sleep (Patel et al., 2014). The purpose of this study was to investigate the impact of sleep quality on hand function, while controlling for pain level and CTS diagnostic electromyography severity in CTS clients at a Southern Arizona orthopedic practice. This study tested the following hypothesis: Sleep quality is positively associated with hand function above and beyond the association of pain and CTS severity to occupation-based hand function in CTS clients.

This study included 53 adults who were diagnosed at an orthopedic outpatient practice in Southern Arizona, with CTS. The measures used in this study were Manual Ability Measure-20 (MAM-20), Pittsburgh Sleep Quality Index (PSQI), and Visual Analogue Scale (VAS) for pain. Electromyography (EMG) was used to determine CTS diagnosis and CTS severity level. The SPSS 23 program was used to produce descriptive statistics for variables. The sample was predominantly middle-aged with significantly more female than male participants. The mean Rasch-derived manual ability was 62.76, the mean pain level as assessed by visual-analog scale was 5.96, and the mean PSQI score of 10.15 was above the cutoff score of 5 for detecting disturbed sleep. Participants reported an average of just under six hours of sleep per night in the past month. The findings of this study supported the hypothesis. In a multiple regression analysis, sleep quality was significantly associated with manual ability after controlling for CTS severity and pain. Scores on the PSQI accounted for a unique 12.7% of the variance in manual ability. Findings from this study support public health and work place initiatives that include the promotion of sleep quality for CTS. Occupational science and occupational therapy practice are

informed by the findings of this study highlighting that CTS care should include evaluation and treatment of sleep quality for the promotion of hand function outcomes and client-centered outcomes.

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What started in 1999, at Creighton University, the year in which I applied and was accepted to the occupational therapy doctoral program, will be finalized in 2015, at Eastern Kentucky University, with the completion of the capstone process. During this sixteen year process, my husband, Dr. Scott Goorman, has been no different than he has been in all other aspects of my life. He has been my support, my partner, and my beacon.

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CERTIFICATION OF AUTHORSHIP

Submitted to: Dr. Colleen Schneck

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Title of Submission: Sleep quality and hand function in carpal tunnel syndrome clients

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Section 1: Nature of Project and Problem Identification

Introduction

Sleep is power. This brief yet compelling statement was taken from an interview between Dr. Charles Czeisler, the Baldino Professor of Sleep Medicine at Harvard Medical School, and Bronwyn Fryer (2006) of Harvard Business Review. The statement, "sleep is power" clearly speaks to sleep's vital role in overall health and performance. Sleep is significant to human well-being, without enough restorative sleep, occupational performance can be negatively impacted. Without a proper pursuit of sleep, there exists the risk of injury. Sleep disturbance is considered a health crisis by Centers for Disease Control and Prevention (2013).

Sleep as an occupation. Sleep is an area of concern for occupational therapy practice. *The Occupational Therapy Practice Framework: Domain and Process* (3rd ed.; American Occupational Therapy Association, 2014) included rest and sleep as a component of care addressed by occupational therapy practitioners, and defined rest and sleep occupations as the "activities related to obtaining restorative rest and sleep to support healthy, active engagement in other occupations" (p.S20). Sleep as a search topic within the occupational therapy body of literature surfaced as early as Adolf Meyer's era. These early sleep discussions emphasized sleep as a necessary part of a balanced and healthy life (Meyer, 1922). Although Meyer highlighted sleep as an important component of health, there is no evidence in the literature that it was defined as an occupation. The "sleep as an occupation" discussion appears to originate with Pierce (2001, p.253). She wrote, "An understanding of the restorative dimension of occupation must be based in an appreciation of the basic, life-giving occupation of sleep" (2001, p.253). To understand sleep as an occupation, it is important to discriminate what an occupation is. Pierce

(2001, p.139) defined an occupation as a "personally constructed", "individualized", "non-repeated" experience. It is a subjective occurrence that is experienced within a spatial, temporal, social-cultural dimension that is exclusive to that singular encounter. Pierce and Summers (2011, p.736) argued that "sleep meets this criteria… is personally constructed and non-repeatable: only you can know your sleep experience...It occurs in a specific physical space with associated objects…has social and cultural meaning to you. Sleep is definitely an occupation." Considering sleep as an occupation can have a substantial influence on how occupation is used to promote health. Pierce (2014) indicated that sleep is the occupation with the most powerful bond to health.

Sleep and carpal tunnel syndrome. It is not uncommon for clients with carpal tunnel syndrome (CTS), a common diagnosis referred to occupational therapy, to have poor sleep (Patel et al., 2014). Carpal tunnel syndrome occurs when compression of the median nerve is present in the carpal tunnel. Considering the median nerve traverses with nine flexor tendons through the less than one inch carpal tunnel, it is no surprise that CTS is the most common median nerve entrapment neuropathy (Sharma, Sood, & Sharma, 2010). When conducting a query of peer reviewed occupational therapy journals that included the research topic combination of "sleep and CTS" no results were rendered.

A search of the entire body of literature for studies that demonstrated the "sleep and CTS" connection yielded only two articles. A study authored by Patel et al. (2014) and another study conducted in Finland by Lehtinen et al. (1996). Patel et al. (2014) investigated in 66 participants the effect of CTS on sleep quality and revealed that a correlation between sleep disturbances and CTS existed. It was discovered that an increase in CTS functional severity

resulted in a reduction in sleep time and quality. It also was concluded CTS clients experience a significant reduction in sleep duration. The other study, Lehtinen et al. (1996), included 34 participants and revealed that those with CTS often experience fragmentary sleep.

Sleep, occupation-based hand function, and client-centered objectives. No studies beyond the Patel et al. (2014) study, were found that directly quantified the links between the effects of sleep disturbance on everyday occupations within CTS clients. However within the literature search, a qualitative study was found that explored CTS clients' expectations of carpal tunnel decompression surgery and conservative treatment methods (Jerosch-Herold, Mason, & Mason, 2008). This study revealed that CTS clients perceived the success level of decompression surgery or conservative treatment methods based on how well pain status, nocturnal waking (sleep disturbance), and return to meaningful activities were improved. In turn, Jerosch-Herold et al. (2008) found that CTS clients value healthy sleep, low pain levels, and function. Jerosch-Herold et al. (2008) findings are important to consider for occupational therapy practice. They not only underscore how important it is to understand how the interrelationship of sleep, function, and pain within evaluation and treatment for CTS for the promotion client-centered outcomes; but these findings also highlight how vital it is to correct the deficiency in the literature that studies this interrelationship within the occupational therapy body of knowledge is for the promotion of client-centered outcomes.

Sleep and other orthopedic conditions. Despite a shortage in the literature that links CTS and sleep disturbance, there appears to be a significant number of studies that link other orthopedic conditions with sleep disturbance and pain. For example, Buyukyilmaz, Sendir, and Acaroglu (2011) evaluated night-time pain characteristics and quality of sleep in postoperative

Turkish orthopedic patients. Data analysis revealed that a significant correlation existed between patients' pain intensity and quality of sleep. Another orthopedic sleep study included a Saudi Arabian investigation (Alsaadi et al., 2014) that explored the impact of sleep quality on patients' report of pain intensity within recent-onset low back pain participants. This study suggested that sleep can influence clients' perceived level of pain.

Occupational therapy and CTS. A search of the CTS and function literature within occupational therapy's body of knowledge rendered ample results. One study examined the morphology of median nerve through use of ultrasound diagnostic (Roll et al., 2013). Another occupational therapy study (Flinn, Pease, & Freimer, 2012) investigated psychometric properties of the Flinn Performance Screening Tool (FPST) in CTS clients. A third CTS based occupational therapy study investigated the effects of donning a wrist support splint and a formal education program on patients with CTS. It was that these conservative approaches resulted in hand function improvement and symptom reduction (Hall et al., 2013).

Problem Statement

There is relatively little known about the relationship between sleep and CTS. The study authored by Patel et al. (2014) provided an initial foundation for further inquiry into the impact of sleep quality on hand function and pain within CTS. Despite occupational therapy practice's rich history in the assessment and treatment of CTS from a functional standpoint, there is no research that exists that connects occupational therapy with sleep quality's role in hand function, CTS severity level, and pain level within CTS.

Purpose of the Project

The purpose of this study was to investigate the relationship of sleep quality and hand function, while controlling for client reported pain level and CTS diagnostic EMG severity, in CTS clients at a Southern Arizona orthopedic practice.

Independent variable. Sleep quality was the independent variable. Sleep occupation was defined as the individualized and personally constructed pursuit of sleep. Sleep was defined as reoccurring states of loss of consciousness, inhibited sensory activity, inhibition of voluntary muscular activity, and reduced interaction with surroundings (Venes, 2005). Sleep quality was defined as the seven components on the Pittsburgh Sleep Quality Index (PSQI): Subjective Sleep Quality; Sleep Latency; Sleep Duration; Sleep Efficiency; Sleep Disturbance; Use of Sleep Medication; and Daytime Dysfunction.

Dependent variable. The dependent variable, hand function was defined as clients' report of how hard or easy it is to complete the stated 20 hand tasks, measured through the Manual Ability Measure-20 (MAM-20).

Control variables. Reported pain level was defined/measured through a 0-10 Visual Analogue Scale with 0 being no pain and 10 being the worst pain imaginable. Carpal tunnel syndrome severity was defined electrodiagostically as follows: In Mild CTS, the sensory latency 14 cm across the wrist, is greater than 3.7 milliseconds; In Moderate CTS, the sensory latency 14 cm across the wrist, is greater than 3.7 milliseconds, and the motor latency 8 cm across the wrist is greater than 4.2 milliseconds; In Severe CTS, the sensory and/or motor responses are absent, or there is evidence of denervation seen on the needle EMG portion of the study (Weiss, 2013).

Project Objectives

This study's objectives included:

1. Identify whether a correlation exists between sleep quality and hand function within CTS clients.
2. Reveal the impact of CTS severity level, (mild, moderate, and severe) based on Electromyography (EMG) latencies, on sleep quality hand function, and client reported pain level.
3. Extend previous research that examined the associations among CTS severity level, reported pain level, sleep quality, and hand function by exploring these associations through an occupational therapy practice lens.
4. Extend previous research that examined the associations among sleep quality, CTS severity, pain level, and hand function in a new sample of clients.
5. Compare sleep quality and sleep quantity's impact on CTS severity, reported pain level, and occupation-based hand function.

Hypothesis

This study tested the following hypothesis: Sleep quality is positively associated with hand function above and beyond the association of pain and CTS severity to hand function in CTS clients. This author chose to improve the strength of this study by controlling for pain and CTS severity, to gain a better understanding of the power of the relationship that the occupation of sleep and hand function may have.

Theoretical Underpinnings

This study's theoretical framework was grounded in occupational science and the occupational-based practice approach.

Occupational science. This study elicited level two research or relational research within the context of occupational science. Occupational science was founded on the notion that "engagement in occupation is essential to the well-lived human life, as well as being restorative of health and life quality" (Pierce, 2014, p.86). This study aimed to investigate occupation as it is related to health. In this study, occupation's role in the restoration of health and life quality was specifically examined through looking at the role of sleep quality in the restoration of normalized occupation-based hand function within CTS clients.

Occupation-based practice approach. The objectives of this research were designed to highlight the significance of occupation-based assessment and treatment for CTS clients. This is important because first and foremost, clients have the deep-seated desire to successfully complete meaningful occupations, and successfully participate in life roles (Chen, 2011). One way to think of this is to consider that a strictly biomechanical treatment approach of CTS does not fully encompass client-centered or occupation-based practice. The practice of occupational therapy must have a holistic approach. Occupational therapy practitioners should consider how CTS affects an individual's successful participation in occupations and occupational roles. In other words, for occupational therapy to implement treatment simply consisting of modalities and strengthening would be short-sided. As noted earlier, there are two studies in the literature that indicate CTS clients also experience sleep disturbances. Thus, providing evaluation and intervention that are based in occupation, would also include investigating how a client's CTS severity may impact his or her sleep occupation quality and function in everyday upper extremity-based occupations. It is important to dig deeper than merely providing the "cookie-cutter" approach in the treatment of CTS. As Wong et al. (2014) showed, even brief educational instruction proves to have occupational benefit in sleep occupations for orthopedic clients.

The occupation-based practice approach was used as an underpinning within this to study to help create evidence for the importance of CTS to be examined more occupationally and holistically, including examining individuals' occupational strengths and shortcomings. This would specifically include the scope of sleep occupation as it related to everyday occupational hand function, pain level, and CTS severity.

Significance of the Project

Public health. Sleep is a public health issue, and CTS, a result of median nerve compression, is the most prevalent upper extremity compressive neuropathy (LeBlanc & Cestia, 2011). Research in sleep and CTS have many implications for public health. Currently Healthy People 2020 targets a positive influence on sleep health. The Healthy People 2020 (Health People 2020, 2015) sleep health goal states: "Increase public knowledge of how adequate sleep and treatment of sleep disorders improve health, productivity, wellness, quality of life, and safety on roads and in the workplace." This goal certainly can be applied to this study by investigating how sleep can impact occupation-based hand function.

CTS prevalence rates ranges from 2.7 to 5.8 percent within the general adult public in the United States (LeBlanc & Cestia, 2011), and is three times more prevalent among women than men (National Institute of Neurological Disorders and Stroke, 2015). Repetitive movements required in work settings have often been associated with CTS. This relates to Healthy People 2020's objective, OSH-3, to decrease the prevalence of injuries involving missed days from work due to of repetitive motion from 29.6 per 10,000 cases to 26.6. It is hope that the findings from this study can have a small influence towards addressing both of these healthcare objectives.

Work place policy. Since 8% of Americans workers have reported having CTS, this study has the potential to inform work place policy (Luckhaupt, 2013).The Center for Disease Control and Prevention already have a recommendation plan in place for Work-Related Musculoskeletal Disorders (WMSD) Prevention including CTS. These recommendations include modifying ergonomics, shift length reduction, and limited overtime (CDC, 2013). This study has the potential to provide knowledge that could extend these recommendations.

Client-centered outcomes. Furthermore, this type of research can help with gaining a better understanding of desired client-centered treatment outcomes, such as sleep quality, pain levels, and return to meaningful activities for CTS clients (Jerosch-Herold et al., 2008).

Occupational therapy practice. This study was significant to occupational therapy practice due to its unique examination of occupation in the context of sleep, hand function, pain level, and CTS severity. This kind of examination of this quadrumvirate in CTS has never been documented before within the occupational therapy practice literature. Findings of this study have the potential to improve the understanding of the impact of CTS severity, pain level, and sleep quality disturbances on hand function.

Occupational therapy practice has awakened to its significant role in sleep occupation health promotion. Findings from this study have the potential to shed light on the necessity for occupational therapy practice not only to identify deficiencies in sleep occupations, but also to examine how these deficiencies may impact hand function or pain levels within CTS clients. Occupational therapy practice can also benefit from the findings of this study that accentuated the significance for the need of occupational therapy practitioners to broaden their understanding of diagnostic CTS severity levels, gathered from EMG results.

The objectives of this study are especially significant within the occupational therapy practice areas of occupation-based hand therapy and work rehabilitation. According to the American Occupational Therapy Association (AOTA) Fact Sheet (2011), occupational therapy has a unique role in the rehabilitation of the hand through occupation-based hand therapy. AOTA (2011) explained occupation-based hand therapy as:

> Hand therapy typically addresses the biomechanical issues underlying upper-extremity conditions. However, occupational therapy practitioners bring an added dimension to this specialty area. They use an occupation-based and client-centered approach that identifies the participation needs of the client—what he or she wants to be able to do in daily life that is fulfilling and meaningful—and emphasizes the performance of desired activities as the primary goal of therapy (http://www.aota.org/-/media/corporate/files/aboutot/professionals/whatisot/rdp/facts/hand%20therapy%20fact%20sheet.pdf).

CTS clients have a desire to return to meaningful activities (Jerosch-Herold et al., 2008) or occupations, understanding the association between sleep quality and hand function is crucial within occupation-based hand therapy.

In regard to the significance of this study to the work rehabilitation practice area, it is important to note that CTS has been reported to have affected almost 5 million U.S. workers in 2010 (Luckhaupt, 2013). Ellexon and Larson (2011) characterized occupational therapy practice's role in work rehabilitation, describing how occupational therapists' expertise in regard to the influence of a wide range of health conditions on the human system. Occupational therapy practitioners' in depth understanding of the human system includes clients' physiological, cognitive, and psychosocial functions. Ellexon and Larson also explain that occupational therapy

practitioners are expert in evaluation of motor, physical, psychological, and cognitive functions which allows them to compare a client's functional capabilities to specific job requirements so that a customized treatment approach can be implemented. This study informs work rehabilitation occupational therapy practice by extending the understanding of sleep quality's role in the restoration of function for the worker who experiences CTS.

Summary

There is little known about the relationship between sleep and CTS. Patel et al. (2014) provided an initial foundation for further inquiry into the impact CTS severity on sleep quality, upper extremity function, and pain within CTS. Despite occupational therapy practice's rich history in the assessment and treatment of CTS from a functional standpoint, there is no research that connects occupational therapy practice with sleep quality's role in hand function, pain level, and CTS severity level within CTS. Furthermore, this type of research can help with gaining understanding about desired client-centered treatment outcomes, such as improved sleep quality, pain levels, and return to meaningful activities for CTS clients (Jerosch-Herold, 2008). This study also has the potential to further inform work place policy for the reason that 8% of Americans workers have reported having CTS (Luckhaupt, 2013).

This level two occupational science-based study endeavored to find if a correlation exists between sleep quality and hand function within CTS clients. In addition, it was the aim of this author to reveal the impact of CTS severity level, (mild, moderate, and severe) based on Electromyography (EMG) latencies, on sleep quality, hand function, and pain level. The extension of previous sleep and CTS research to include an occupational therapy practice lens, and the extension of previous sleep and CTS research to include a new sample of participants were both objectives of this study. Finally, comparing the influence of sleep quantity verses the influence of

sleep quality on hand function, CTS severity, and pain level within CTS clients was also an objective of this study.

Section 2: Review of the Literature

Introduction

The objective of this capstone project was to examine the links among sleep quality, hand function, CTS severity level, and pain within carpal tunnel syndrome (CTS) through an occupational therapy lens. There is no one study within the occupational therapy practice's body of knowledge that investigates specifically the interrelationship of sleep occupation, hand function, CTS severity level, and pain level within CTS clients.

Literature That Represents Sleep's Role in Occupational Therapy

Occupational therapy, as early as Adolf Meyer's era emphasized sleep as a necessary part of a balanced healthy life (Meyer, 1922). Although sleep was highlighted as an important component of health, there is no evidence that it was considered an occupation. This discussion appears to originate with Pierce (2001, p.253). She wrote, "An understanding of the restorative dimension of occupation must be based in an appreciation of the basic, life-giving occupation of sleep" (2001, p.253). To understand sleep as an occupation, it is important to discriminate what an occupation is. Pierce (2001, p.139) defined an occupation as a "personally constructed", "individualized", "non-repeated" experience. It is a subjective occurrence that is experienced within a spatial, temporal, social-cultural dimension that is truly exclusive to that singular encounter. Pierce and Summers (2011) argued that "sleep meets this criteria. It is personally constructed and non-repeatable: only you can know your sleep experience last night...It occurs in a specific physical space with associated objects…it certainly has social and culturally meaning to

you. Sleep is definitely an occupation." In later writings by Pierce (2014), indicated that sleep is the occupation with the most powerful connection to health.

Others have also written about sleep occupation as an occupational therapy area of focus. This focus was demonstrated by Fung et al. (2013) making the exertion that sleep occupations should be a consideration within all occupational therapy practices, as they are associated with many occupational and functional performance difficulties. Additionally, Leland et al. (2014) completed a scoping review of literature to examine the context of sleep studies to draw attention to effective sleep treatment methods for geriatric population within occupational therapy practice. Their findings suggested that there is a need for occupational therapy led sleep research that investigates the role of occupational therapy in geriatric sleep and restoration.

Other contributions to the surge in the sleep occupation body of knowledge include Green and Brown's (2015) recently published guide for occupational therapists dedicated to sleep and sleep problems. Emphasizing sleep as occupational therapy domain has surfaced with the suggestion that sleep occupations should be a consideration within all occupational therapy practices, as they are associated with many occupational and functional performance difficulties facing many clients served by occupational therapists (Fung et al., 2013). Milton and Lovett (2014) detailed sensory integration's role in sleep, occupation, and dysfunction within a recently published guide for health professionals on sleep and rehabilitation. Both authors suggested that sleep is vital to well-being, and that occupational therapists should be confident in recognizing the impact of sleep disturbances on daily occupations. They specifically highlighted how sleep, tactile, proprioceptive, and vestibular issues are associated with dysfunction of sensory integration.

Literature That Represents CTS within Occupational Therapy Research

Occupational therapy's role within the evaluation and treatment of CTS is long established. Currently in occupational therapy practice, there is an emphasis on occupation-based assessment and treatment for CTS. Occupational therapy practice appears to be moving towards assessment instruments that evaluate clients' ability to complete everyday occupations, verses assessments that look at only a biomechanical properties such as range of motion, hand strength, and two-point discrimination. For example, Chen, Palmon, and Amini (2014) demonstrated that the Manual Assessment Measure 36 (MAM-36) as a function-based tool that correlated with traditional assessments. Another study informed occupational therapy practice of the Flinn Performance Screening Tool (FPST) as an occupation-based screening tool for CTS clients, (Flinn, Pease, & Freimer, 2012) with adequate psychometric properties.

Literature That Represents CTS and Sleep Quality

Since it not uncommon for clients with CTS to have sleep disturbances (Patel et al., 2014), literature that examines the relationship of both sleep and CTS has emerged. It has been confirmed that a correlation between sleep disturbance and CTS exists (Patel et al., 2014). This study investigated the effect of CTS on sleep quality. Its aim was to identify the following: what magnitude CTS affects sleep quality; what areas of sleep quality are affected by CTS; and the relationship of CTS functional severity and sleep quality. The findings of this study showed a correlation between sleep disturbances and CTS. It was discovered that an increased CTS functional severity resulted in reduced sleep time and quality. This study (Patel et al., 2014) concluded a significant reduction in sleep duration is present in CTS clients. Severe level CTS clients were shown to sleep 2.5 hours less than the recommended sleep duration .

Another sleep and CTS study, conducted in Finland (Lehtinen et al., 1996), reported that those with CTS often experience fragmentary sleep. A qualitative study explored CTS clients'

expectations of decompression surgery (Jerosch-Herold et al., 2008). This study reported that for clients with CTS, their perception of success of decompression surgery and conservative treatment was based on relief of pain, decreased nocturnal waking (sleep disturbances), and the ability to return to activities that they believe were significant. In a physical medicine and rehabilitation study, the concept of specific pain qualities were found (tingling and itching) to be associated to pain inference and decreased sleep quality in CTS clients (Jensen et al.,2010).

Literature That Represents Non-CTS Orthopedic Conditions and Sleep Quality

Despite a limited number of studies that link CTS and sleep disturbance, there are quite a few studies that link other orthopedic conditions with sleep occupation disturbance. For example, Buyukyilmaz, Sendir, and Acaroglu (2011) evaluated night-time pain characteristics and quality of sleep in postoperative Turkish orthopedic patients. This descriptive and correlational study aimed to determine the relationship between the participants' sleep quality and pain intensity. Utilization of study instruments consisted of the McGill Pain Questionnaire (MPQ) to access pain, and the Pittsburg Sleep Quality Index (PSQI) to assess sleep quality. Data analysis revealed that a correlation, within a significant level, existed between patients' pain intensity and quality of sleep.

Another example of an orthopedic sleep study included an (Alsaadi et al., 2014) investigation of the impact of sleep quality on patients' report of pain intensity within participants who were experiencing recent-onset low back pain. This study's authors suggested that pain impacts sleep. Assessment instrumentation included the Pittsburgh Sleep Quality Index (PSQI) to assess sleep quality and the numerical rating scale (NRS) to assess pain. Disability was assessed through the Roland- Morris Disability Questionnaire, depression was assessed through a Likert scale that indicated how long participants were feeling depressed. Pain persistence was

assessed in similar manner with a Likert scale. Statistical analysis showed that sleep quality and subsequent pain intensity, in patients with low back pain, are associated. This also held true while controlling for depression.

An orthopedic sleep- based study (Wong et al., 2014) investigated the use of a 20 minute educational intervention on participants' pain level, pain's impact on sleep, anxiety, and sleep satisfaction. The aim of this study was to evaluate the effects of a brief educational intervention (BEI) during participants' inpatient hospitalization, from pre- surgery to seven days post-operative, using a pretest and posttest control group design. This study concluded that BEI, which included breathing relaxation exercises, was considered pragmatic for improved sleep quality. This study informed this author's study by considering how BEI could be duplicated in an outpatient arena for CTS clients. Similar to programing within this study, programing that addresses sleep health promotion alongside functional occupations within outpatient orthopedics could prove to be very worthwhile.

A correlational study of 35 female participants with fibromyalgia aimed to explore the relationship between sleep disturbances and manual dexterity (Cerón-Lorente et al., 2013). Each participant answered demographic questions including age and Body Mass Index (BMI). Instruments used in this study were: McGill Pain Questionnaire (MPQ) to measure pain; the Hospital Anxiety and Depression Scale (HAD) to measure depression; the Fibromyalgia Impact Questionnaire (FIQ) to measure clinical variables; Pittsburgh Sleep Quality Index (PSQI) to measure sleep quality; Chessington Occupational Therapy Neurological Assessment Battery (COTNAB) to measure hand dexterity. The mean age of participants was 53 years old, and mean BMI was 29.11. Results from the FIQ revealed a mean score of 69, and results from the MPQ revealed a high presence of pain. PSQI results indicated a significant correlation between sleep

quality and manual dexterity, with latency and sleep duration being the strongest indicators of manual dexterity impact. Conclusions of this study were that a significant relationship exists between manual dexterity and sleep quality among women with fibromyalgia. Future studies could explore interventions that improve sleep quality as it is related to manual dexterity. Limitations of this study included small sample size and lack of random sampling. The study reported here was informed by this fibromyalgia study because it was found that sleep was an important indicator of clients' fine motor hand performance components.

Literature That Represents Sleep Quality and Occupational Function

Not only has sleep disturbance and pain been shown to be associated, but sleep disturbance and negative occupational function have also been shown to be associated. It has been suggested that promoting physical activity and social participation can reduce the comorbidity of pain and sleep disturbance in older people with musculoskeletal pain (Tang et al, 2015). In another study, upper extremity function using the Levine-Katz Carpal Tunnel Questionnaire's functional status scale (FSS) was used to draw connections between sleep quality and function (Patel et al., 2014). It was determined a linear decrease in the quality of sleep was linked to poor function on the FSS. It is fair to say that sleep disturbance has been shown to be connected to occupational functional disturbances.

Summary

There is a limited amount of studies that research the connection between sleep and hand function within CTS clients. However, there are a number of studies that have been conducted with non-CTS orthopedic conditions that have shown a relationship among sleep, pain, and function. The time is now to inform occupational therapy practice that sleep quality is closely connected to most of function, specifically including hand function in CTS.

Section 3: Methods

Participants

This study included 53 adults who were diagnosed, through Electromyography (EMG) at an orthopedic outpatient practice in Southern Arizona, with carpal tunnel syndrome. Inclusion criteria included being 18 years of age or older and the ability to understand and respond in English. There were 17 male participants and 36 female participants, ranging from 30 to 86 years of age, with a mean age of 58.42, and standard deviation of 14.74. The participants were recruited, August to November of 2015, through convenience sampling.

Project Design and Measures

Project Design

This study's project design incorporated a cross-sectional survey research method. Participants provided data regarding factors surrounding hand function, sleep quality, and pain level. Survey methodology was used because it was the most fitting for this study given surveys are a "method of inquiry characterized by collecting data using structured questions to elicit self-reported information from a sample of people" (Forsyth & Kviz, 2006, p. 91). Furthermore, according to Creswell (2014), a survey design provides a quantitative or numeric description of trends, attitudes or opinions of a population by studying a sample of that population.

At this time, a small-scale single time point study was appropriate in increasing existing knowledge in order to inform future research that will be more costly and time-intensive. Prior to this study, a larger-scale study might be considered premature.

Measures

The survey instruments that were used in this study were Manual Ability Measure-20 (MAM-20), Pittsburgh Sleep Quality Index (PSQI), and the Visual Analogue Scale (VAS) for

pain. Electromyography (EMG) was used to determine CTS diagnosis and CTS severity level. Demographic information was collected from each participant including his or her age and gender. The data collection instrument used for the assessment of hand function was the Manual Ability Measure-20 (MAM-20). One of the aims of this study was to incorporate occupation-based practice principles within the current CTS and sleep quality body of knowledge. In doing so, it was imperative that the assessment of hand function was not based solely on biomechanical dimensions such as strength, range of motion, or grip, but rather on a client's ability to use his or her hand to complete everyday occupations. The MAM-20, an occupational therapy assessment, consists of a rating scale that surveys clients' ease or difficulty in completing a series of everyday hand tasks. Examples of such hand tasks included using a spoon or fork, zipping a jacket, cutting meat on a plate, and wringing a towel. The MAM-20 rating scale ranges from 1-4. Easy is assigned to 4, a little hard is assigned to 3, very hard is assigned to 2, and can't do is assigned to 1. This assessment was shown to have greater than acceptable psychometric properties as an outcome measure within clients with a range of clinical diagnoses (Chen, Palmon, & Amini, 2014). A current study showed that the Manual Ability Measure-36 had good reliability and validity in hand function during everyday tasks (Poole et al., 2015).

The instrument used to assess sleep was the Pittsburgh Sleep Quality Index (PSQI). It was described (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) as a self-rated survey in which participants are asked to measure their sleep patterns and quality of sleep. The participants score their sleep in seven areas: sleep latency, subjective quality of sleep, habitual sleep efficiency, sleep duration, sleep disturbance, use of sleeping medication, and daytime dysfunction over the past month. A Likert scale from 0 to 3, is used to score each of the above seven areas. The score of "3" denotes the highest level of sleep disturbance. Test-retest reliability

of this instrument has been determined to be good, and the validity has been determined to be high (Backhaus, Junghanns, Broocks, Riemann, & Hohagen, 2002).

The Visual Analog Scale (VAS) was used to gather participants' pain level. This scale consisted of 10 cm straight line. The scale started with 0 and ended with 10. Under "0" the words "no pain" were written, and under "10" the words "worst pain" were written. The participant was asked to mark his or her hand pain from 0 to 10.

Nerve Conduction Studies and Electromyography (EMG) the "gold standards" were used to detect CTS and CTS severity. The nerve conduction test quantifies the speed at which impulses move along the median nerve. Delayed conduction velocity indicates poor nerve function. The needle (EMG) portion of the examination evaluates for evidence of denervation (nerve blockage) in the muscle innervated by the median nerve (Weiss, 2013). This data indicates the severity of the nerve damage caused by compression. In Mild CTS, the sensory latency 14 cm across the wrist, is greater than 3.7 milliseconds; In Moderate CTS, the sensory latency 14 cm across the wrist, is greater than 3.7 milliseconds, and the motor latency 8 cm across the wrist is greater than 4.2 milliseconds; In Severe CTS, the sensory and/or motor responses are absent, or there is evidence of denervation seen on the needle EMG portion of the study (Weiss, 2013).

Setting

This study took place at an outpatient orthopedic practice in Southern Arizona. This setting is made up of a practice of 30 physicians, including four full- time hand surgeons, and one full-time physiatrist who accounted for the majority CTS- EMG referrals.

Ethical Considerations

Institutional Review Board (IRB) approval was attained through Eastern Kentucky University. Informed consent from each participant was obtained prior to participation.

Data Collection Procedure

The participants were asked to complete both the MAM-20 and the PSQI surveys. The clients were approached directly after CTS diagnosis confirmation through EMG testing, and were asked to complete a short survey verbally. This procedure included the following steps: 1. EMG testing was conducted by a physician, 2. Clients were identified by EMG findings as having a positive CTS diagnosis, 3. Permission and informed consent were obtained to conduct the surveys, 4. Participants completed the MAM-20, PSQI, and VAS. Data was collected and stored in a secure and locked file to protect the confidentiality of the data.

Data Analysis

Descriptive statistics for all continuous variables included mean, standard deviation, and range. Descriptive statistics for categorical variables included frequencies, percentages, and chi-square tests. Independent samples t-tests were used to assess sex differences on sleep and CTS measures. Pearson correlations were used to assess the association between measures. Hierarchical multiple regressions were used to test the association between measures after controlling for the influence of other variables. The SPSS 23 program was used for data analysis.

Section 4: Results and Discussion

Results

The sample was predominantly middle-aged (M = 58.42, SD = 14.74). There were significantly more female (69.8%) than male participants, χ^2 (1) =8.321, p = .004. While there were fewer participants with mild CTS (n=12, 22.6%) than moderate (n=20, 37.7%) or severe (n=21, 39.6%) CTS, this difference was not significant, χ^2 (2) =2.755, p = .252. See Table 1.

The mean Rasch-derived manual ability was 62.76 (SD=12.11). The mean pain level as assessed by VAS was 5.96 (SD=2.1). When present, EMG sensory latencies were a mean of 4.33ms (SD=0.69) and EMG motor latencies were a mean of 5.88ms (SD=1.69). The mean PSQI score of 10.15 (SD = 4.53) was above the cutoff score of 5 for detecting disturbed sleep. Participants reported an average of just under six hours of sleep per night in the past month (M=5.94, SD=1.53). See Table 2.

Male participants had higher CTS severity (M=2.50, SD=.63) than female participants (M=2.03, SD=.80), t (51) =2.10, p=.041. Male and female participants did not significantly differ in terms of sleep disturbance, manual ability, pain, EMG sensory latency, or EMG motor latency. See Table 3.

Sleep quality as assessed by the PSQI was significantly negatively correlated with manual ability such that greater scores on the PSQI were associated with lower manual ability, r (53)=-.459, p = .001. Sleep quality as assessed by the PSQI was significantly positively correlated with the VAS of pain such that greater scores on the PSQI were associated with greater pain, r (53) =.364, p = .007. See Table 4.

With the exception of a marginally significant positive correlation between sensory EMG latency and pain (r [33] =.306, p=.073), neither EMG sensory or motor latencies were significantly correlated with sleep disturbance, manual ability, or pain, p's > 0.3. See Table 5.

Both sleep disturbance and sleep quantity were negatively correlated with manual ability, such that more disturbed sleep and shorter sleep duration were associated with lower manual ability, r's=-.354 and -.276, p's=.009 and .045 respectively. Both sleep disturbance and sleep quantity were positively correlated with pain, such that more disturbed sleep and shorter sleep duration were associated with greater pain, r's=.378 and .278, p's=.005 and .044 respectively.

Neither sleep disturbance or sleep duration were associated with CTS severity or EMG sensory or motor latencies, p's>.10. See Table 6.

In a multiple regression analysis, sleep disturbance was significantly associated with manual ability after controlling for sleep duration. After controlling for sleep disturbance, however, sleep duration was not significantly associated with manual ability. See Table 7.

In a multiple regression analysis, sleep disturbance was significantly associated with pain after controlling for sleep duration. After controlling for sleep disturbance, however, sleep duration was not significantly associated with pain. See Table 8.

In a multiple regression analysis, sleep quality was significantly associated with manual ability after controlling for CTS severity and pain. Scores on the PSQI accounted for a unique 12.7% of the variance in manual ability. See Table 9 for regression statistics and parameter estimates. See Figure 1 for the association between PSQI and MAM.

Discussion

To the knowledge of this author this is the first study to investigate in CTS clients the association of sleep occupation quality using the PSQI, and occupation-based hand function using the MAM-20, while controlling for reported pain level and CTS severity based on EMG latencies. Improved knowledge of the association of sleep occupation quality and hand function can empower both the client and healthcare provider. Client education for improved sleep occupation quality encourages health promotion, an action-plan intended to keep people well.

Discussion as Related to Study's Objectives

The objectives of this study were met, and the results of this study agreed with the hypothesis: Sleep quality is associated with hand function above and beyond the association of pain and CTS severity to hand function in CTS clients. It was found that a significant negative

correlation existed between PSQI and MAM-20. Hence the higher the score on PSQI, meaning the higher the sleep disturbance, the lower the MAM-20 score, meaning lower the hand function. While associations were found for sleep quality, none were found for CTS severity. Sleep disturbance was found to be positively correlated with pain level. This means that CTS clients are more likely to have a higher pain level when sleep disturbance is higher. Disturbed sleep and shorter sleep duration were both associated with lower hand function and higher pain, however the findings of this study imply that sleep quality is more strongly linked to hand function and pain level than sleep duration. The objectives to assess sleep occupation in a fresh study participant group, and to implement an occupational therapy frame of reference during this study were both achieved.

An occupational therapy frame of reference was implemented in this study through the choice of terms and instrumentation. For example, what studies outside of occupational therapy practice would value for hand parameters might include hand dexterity, instead this study valued hand parameters that included occupation-based hand function. Hand function was measured through the examination of an occupational therapy derived instrument of manual ability, the MAM-20.

Implications for Public Health and Work Place Health Promotion

It was found in this study that male participants had higher CTS severity than female participants. Male and female participants did not significantly differ in terms of sleep disturbance, manual ability, pain, EMG sensory latency, or EMG motor latency. From this study, we learned that the CTS participants mean pain level was 5.96, MAM-20 score was 62.76, PSQI score was 10.15, and hours slept were 5.95 hours. The CTS participants reported pain level that was 5.96 units above the no pain marker, and their manual hand ability was 37.24 units below

high ability, their sleep disturbance was 5.15 units above the cutoff for non-disturbed. They reported sleeping between 1.04 and 2.04 hours less than recommended by Centers for Disease Control and Prevention ("Sleep," 2013). It was also learned that for each one point increase in the PSQI rendered a decrease of 1.026 on the MAM-20. If these participants are representative of the greater CTS population, then there are clearly public health implications.

The Healthy People 2020 (Health People 2020, 2015) sleep health goal states: "Increase public knowledge of how adequate sleep and treatment of sleep disorders improve health, productivity, wellness, quality of life, and safety on roads and in the workplace." This study's findings can be applied to this Healthy People 2020 goal, by increasing the knowledge of CTS clients of the benefits that improved sleep quality has in relation to improved occupation-based hand function.

A useful way to establish priorities in public health is to examine the price an injury or condition imposes on society. According to Safety, Health Assessment, and Research for Prevention (SHARP) research indicates that workers' compensation costs for CTS were some of the largest of all injuries or illnesses. CTS clients who have worker compensation claims have more than triple the workers' compensation days of paid time-loss in comparison to upper extremity fracture claimants ("Economic Burden," 2015).

Knowledge gained from this study has the potential to enhance functional outcome-based treatment for CTS so that early and safe return to work roles can be achieved. One way in which work place health is promoted, according to the CDC (2013), is by creating "sustainable worksite programs in communities across the country." Such programs for CTS workers should include the emphasis of the importance of healthy sleep occupation for the successful return to occupation-based function, including hand-based tasks necessary for job performance. Such

programming could include patient education which helps CTS clients develop healthy sleep preparation and sleep participation patterns.

Implications for Occupational Science

Occupational science is best described by two of the leading occupational science institutions, Eastern Kentucky University and University of Southern California**.** Eastern Kentucky University Department of Occupational Science and Occupational Therapy describe occupational science as:

> The study of human occupation — how we occupy our time through activity, organize ourselves by activity patterns and habits, and create meaning through occupation. Occupation is essential to a healthy and satisfying life. Occupational science is an evolving social science that studies occupation, how and why people engage in occupations, the context in which occupations occur, and the occupational performance that results (http://ot.eku.edu/bs-occupational-science-program-0).

In the case of this study, the application of the study of occupation was through the study of sleep occupation; the context in which sleep occupation occurred was assessed through the PSQI; and the application of occupational performance was assessed through the MAM-20.

Occupational science was also described, by the University of Southern California Division of Occupational Science and Occupational Therapy, as a science of everyday living, focusing on the benefit of occupations while identifying "how engagement in occupation can address global health concerns of the 21st century by promoting health, well-being and quality of life across the lifespan" (http://chan.usc.edu/about-us/our-name). In the case of this study,

occupational science could be interpreted as identifying how engagement in the occupation of sleep can address a global health concern, such as CTS. The findings of this study suggest that the occupation of sleep is strongly associated with hand function and pain level in CTS clients.

Implications for Occupational Therapy and Practice Areas

Within AOTA's scope of practice it has been established that occupational therapy practitioners complete **"**Evaluation of factors affecting…and intervention… to promote… "activities of daily living (ADLs), instrumental activities of daily living (IADLs), rest and sleep, education, work, play, leisure, and social participation" (AOTA, 2014, p.2). Rest and sleep, according to AOTA (2014) include "activities relating to obtaining rest and sleep, including identifying need for rest and sleep, preparing for sleep, and participating in rest and sleep" (p.4). This study's focus was clearly bound to AOTA's scope of occupational therapy practice, through its investigation of sleep. Furthermore, the findings of this study suggest within CTS clients that evaluation of sleep occupation is necessary in the promotion of hand function. In addition to evaluation of sleep occupation within CTS clients, treatment to promote sleep quality should be devised. Such treatment could include: occupations and activities, preparatory methods and tasks, and education/training. Two practice areas which this study notably informed were occupation-based hand therapy and work rehabilitation.

Occupation-based hand therapy was informed by the findings of this study. It was determined that sleep quality is linked to hand function; and that pain level is linked to hand function for CTS clients. The occupation-based hand therapist, based on these findings, should initiate an initial evaluation that includes sleep quality and pain levels as baselines for treatment.

Treatment for the promotion sleep quality and pain reduction could include educating the CTS client regarding proper bed positioning, sleep preparation routines, and proactive pain control.

Work rehabilitation occupational therapy was informed by this study through learning that the common work-linked condition of CTS is impacted by sleep occupation health and client pain level. Hand function that is often necessary for return to work is linked both to sleep quality and pain level in CTS clients. Work rehabilitation occupational therapy practice can use this information for the individual client as well as the entire workplace. Entire workplace CTS programming could include sleep promotion through education in reduced caffeine intake, smoking cessation, or pain management. For the individual CTS client, the work rehabilitation occupational therapist could create a treatment plan that included sleep hygiene routine, bedroom environmental modification, bed positioning, bedroom temperature regulation, and bedroom noise modulation (AOTA Sleep Fact Sheet, 2012).

Implications for Occupational Therapy Practice Client-Centered Outcomes

It was published recently in "People's Values, Needs are Met by Occupational Therapy" by AOTA (2015) based on the *Journal of the American Medical Association* (JAMA) article entitled "Value-Based Payments Require Valuing What Matters to Patients" (Lynn, McKethan, & Jha, 2015) that occupational therapy practice's focus on what clients' value is integral to our ever changing health care system. It was stated that a movement in the health care system exists for payers to incentive quality and client-based value over volume. Jerosch-Herold (2008) showed that the CTS client value sleep quality, pain reduction, and function to complete meaningful activities from treatments. In addition, this study revealed within CTS clients that sleep quality is linked to function and pain level, thereby it only makes sense that OT treatment would focus on sleep quality and pain levels. This would ensure that client-centered outcomes

are promoted, while at the same time ensure that steps were being made towards value-based payments.

Project Limitations

This study had several limitations. First, the use of convenience sampling verses probability sampling was a limitation of this study. Only evaluating participants at one time point, and the lack of prospective or objective measures of hand function or sleep were also limitations of this study. It is not too surprising to find two self-report symptom measures like PSQI and MAM to be correlated. This is referred to as "method variance," in which relationships can be overestimated due to using the same method (e.g., self-report) for both constructs.

Future Research

The strongest quantitative research involves multiple types of measurement, large samples, and multiple time points, but that research is always preceded by smaller studies with fewer measurements at one time point. To strengthen future research, a researcher could use additional measures beyond the self-report instruments used in this study, such as objective measures including actigraphy or polysomnograms for sleep; or hand dynamometer measure for hand strength. Duplicating this study in a larger sample of participants over more than one point in time would strengthen future research. Other interesting ways to extend future research would include adding to the broad investigation of sleep quality through the PSQI by including additional measures that tap specific sleep disorders. For example other measures could include: the STOP BANG, an eight-item questionnaire that provides screening for sleep apnea; the insomnia severity index (ISI), a short seven-item measure that screens for insomnia. By adding these measures to future research would not only reveal the broad measure of sleep quality's impact on hand function, but also more distinctively specify the association of sleep apnea and

insomnia to hand function. Another way to extend this study would be to look at prospective data through sleep diaries. The present study investigated only the retrospective data taken from the PSQI. Prospective sleep journaling would allow this research to be extended in a way that could look at bidirectional impact of sleep quality on hand function. An example of a question regarding bidirectional impact would be: Does Monday's night of high sleep disturbance impact Tuesday's day of hand function in CTS clients?

Extending this research to examine sleep occupation's association with hand function in high risk work force areas including those who enter data on computers such as secretaries or data entry clerks, those who work in meat packing, or aircraft assembly could specifically add knowledge to the occupational therapy work rehabilitation practice area. A study designed to examine CTS clients' hand function outcomes after participation in occupation-based hand therapy that included sleep occupation quality promotion verses participation that did not include sleep occupation quality promotion would extend knowledge in both occupational therapy practice client-centered outcomes and occupation-based hand therapy domains.

Summary

It was found in CTS clients that sleep quality is strongly associated with hand function even when controlling for pain level and CTS severity level. Sleep quality was significantly negatively correlated with manual ability, meaning the higher the sleep disturbance was, the lower the manual ability. It was also learned for each one point increase on the PSQI rendered, a decrease of 1.026 on the MAM-20 was rendered.

Findings from this study support public health and work place initiatives that include the promotion of sleep quality for CTS clients. Occupational science was informed by this study through its investigation of the occupation of sleep which revealed its strong link to hand

function and pain within CTS clients. Occupational therapy practice, occupation-based hand therapy practice, and work rehabilitation occupational therapy practice can all be informed by the findings of this study. Across all these domains it should be ensured that CTS care includes evaluation and treatment of sleep quality for the promotion of hand function outcomes. Finally, this study supports the usefulness of a health care payer system that incentivizes client-based value over volume. This study provided a better basis of understanding for CTS client-centered outcomes.

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Appendix A

IRB Permission Documents

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NOTICE OF IRB EXEMPTION STATUS
Protocol Number: 16-024
Institutional Review Board IRB00002836, DHHS FWA00003332

Principal Investigator: **Angela Goorman** Faculty Advisor: **Dr. Colleen Schneck**

Project Title: **The Relationship between Occupational Function and Sleep Quality in Carpal Tunnel Syndrome**

Exemption Date: **8/28/15**

Approved by: **Dr. Rachel Williams, IRB Member**

This document confirms that the Institutional Review Board (IRB) has granted exempt status for the above referenced research project as outlined in the application submitted for IRB review with an immediate effective date. Exempt status means that your research is exempt from further review for a period of three years from the original notification date if no changes are made to the original protocol. If you plan to continue the project beyond three years, you are required to reapply for exemption.

Principal Investigator Responsibilities: It is the responsibility of the principal investigator to ensure that all investigators and staff associated with this study meet the training requirements for conducting research involving human subjects and follow the approved protocol.

Adverse Events: Any adverse or unexpected events that occur in conjunction with this study must be reported to the IRB within ten calendar days of the occurrence.

Changes to Approved Research Protocol: If changes to the approved research protocol become necessary, a description of those changes must be submitted for IRB review and approval prior to implementation. If the changes result in a change in your project's exempt status, you will be required to submit an application for expedited or full IRB review. Changes include, but are not limited to, those involving study personnel, subjects, and procedures.

Other Provisions of Approval, if applicable: None

Please contact Sponsored Programs at 859-622-3636 or send email to tiffany.hamblin@eku.edu or lisa.royalty@eku.edu with questions.

Appendix B

Tables

Table 1

Descriptive Statistics for Categorical Variables

	Number	Percent	χ^2	p
Severity			2.755	0.252
Mild	12	22.60%		
Moderate	20	37.70%		
Severe	21	39.60%		
Sex			8.321	0.004
Female	37	69.80%		
Male	16	30.20%		

Table 2

Descriptive Statistics for Continuous Variables

	Mean	SD	Range
Age	58.42	14.74	30-86
Sensory	4.33	0.693	4-6
Motor	5.88	1.685	4-10
Pain	5.98	2.1	0-10
MAM	62.76	12.11	41.1-100
PSQI	10.15	4.53	1-18
Subjective	1.66	0.92	0-3
Sleep latency	1.42	1.1	0-3
Sleep duration	1.49	1.09	0-3
Sleep Efficiency	1.4	1.2	0-3
Sleep disturbance	1.81	0.71	0-3
Sleep Medication	1.25	1.41	0-3
Daytime dysfunction	1.3	1.2	0-7
Hours of sleep	5.94	1.53	3-10

Table 3

Sex Differences in Sleep and CTS Measures

	Sex			
	Male	Female		
	M (SD)	M (SD)	t	p
PSQI	11.00 (4.93)	9.78 (4.37)	0.895	0.375
MAM	64.04 (11.84)	61.78 (12.25)	0.900	0.372
Pain	5.38 (2.39)	6.24 (1.94)	-1.39	0.17
CTS severity	2.50 (.63)	2.03 (.80)	2.10	0.041
Sensory	4.63 (.75)	4.23 (.661)	1.42	0.166
Motor	6.24 (1.67)	5.73 (1.69)	0.99	0.328

Table 4

Correlations between Sleep Quality and CTS Measures

	PSQI
MAM	-.459**
Pain	.364**
Sensory	-.010
Motor	-.052

* p < .05, ** p < .01, *** p < .001

Table 5

Correlations between EMG Sensory and Motor Latencies and Subjective Variables

	Sensory latency	Motor latency
PSQI	-.010	-.052
MAM	-.185	.040
Pain	.316 †	.001

† $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$

Table 6

Correlations between Sleep Disturbance and Quantity and CTS Measures

	Sleep Disturbance	Sleep Duration
MAM	-.354**	-.276*
Pain	.378**	.278*
CTS severity	-.185	.013
Sensory	.287	.113
Motor	-.186	.040

* p < .05, ** p < .01, *** p < .001

Table 7

Multiple Regressions Testing the Association between Sleep Disturbance, Sleep Duration, and Manual Ability

	Statistical significance			Parameter Estimates			
	F	p	ΔR^2	B	Beta	t	p
Intercept	-	-	-	75.102	-	16.971	<.0001
Sleep duration	4.205	0.045	0.076	-2.089	-0.187	-1.377	0.175
Sleep Disturbance	4.804	0.033	0.081	-5.093	-0.298	-2.132	0.033

	Statistical significance			Parameter Estimates			
	F	p	ΔR^2	B	Beta	t	p
Intercept	-	-	-	75.102	-	16.971	<.0001
Sleep Disturbance	7.299	0.009	0.125	-5.093	-0.298	-2.132	0.033
Sleep duration	1.896	0.175	0.032	-2.089	-0.187	-1.377	0.175
Overall model $F(2, 50)=4.66$, $p=.014$, $R^2=.396$							

Table 8

Multiple Regressions Testing the Association between Sleep Disturbance, Sleep Duration, and Pain

	Statistical significance			Parameter Estimates			
	F	p	ΔR^2	B	Beta	t	p
Intercept	-	-	-	3.714	-	4.878	<.0001
Sleep duration	4.271	0.044	0.077	0.352	0.181	1.347	0.184
Sleep Disturbance	5.792	0.020	0.173	0.962	0.324	2.407	0.020

	Statistical significance			Parameter Estimates			
	F	p	ΔR^2	B	Beta	t	p
Intercept				3.714	-	4.878	<.0001
Sleep Disturbance	8.514	0.005	0.143	0.962	0.324	2.407	0.02
Sleep duration	1.814	0.184	0.03	0.352	0.181	1.347	0.184
Overall model $F(2, 50)=5.232$, $p=.009$, $R^2=.416$							

Table 9

Multiple Regression Testing the Association between Sleep Quality and Manual Ability after Controlling for CTS Severity and Pain.

	Statistical significance			Parameter Estimates			
	F	p	ΔR^2	B	Beta	t	p
Intercept	-	-	-	80.618	-	11.689	<.0001
Severity	0.150	0.700	0.003	-0.13	-0.008	-0.067	0.947
Pain	6.688*	0.013	0.118	-1.197	-0.208	-1.557	0.126
PSQI	8.305*	0.006	0.127	-1.026	-0.384	-2.882	0.006
Overall model $F(3, 49)=5.387$, $p=.003$, $R^2=.498$							

Figure 1

The Association between Sleep Disturbance and Manual Ability