DORSAL APPLICATION OF KINESIO TAPE FOR CARPAL TUNNEL SYNDROME: IMPROVING OCCUPATIONAL PERFORMANCE

A thesis submitted to the faculty at Stanbridge University in partial fulfillment of the requirements for the degree of Master of Science in Occupational Therapy.

by

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CERTIFICATION OF APPROVAL

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ABSTRACT

This was a pilot study to determine the effectiveness of kinesio tape (KT) applied to the dorsal aspect of the wrist and forearm of individuals with Carpal Tunnel Syndrome (CTS), which would improve median sensory nerve latency through repositioning to increase occupational performance. Eighteen hands were used in this pilot study to investigate the efficacy of KT on the antagonist (dorsal) surface of the wrist as an intervention to improve occupational performance and for CTS. Participants were randomly selected from the intervention group (IG) and control group (CG). The IG received KT on the dorsal surface, and the CG received KT on the volar surface of the wrist and forearms. The results suggest that KT may be associated with improvement in upper extremity function, grip and pinch strength, and median sensory nerve latency. The effect size was calculated with the type one alpha error at 20% which resulted in $\eta^2 = 0.73$ (Figure 6) (Bartko, Pulver, & Carpenter, 1988). Furthering the study is recommended to test the efficacy of kinesio tape as a conservative intervention for CTS.

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Dorsal Application of Kinesio Tape for Carpal Tunnel Syndrome: Improving Occupational Performance

Introduction

A common neuropathy known as carpal tunnel syndrome (CTS) results from compression of the median nerve in the carpal tunnel along the wrist (U.S. Bureau of Labor Statistics, 2015). Symptoms of CTS consist of numbness, tingling, burning, and pain in the hands and fingers which occurs up to three or more times daily, and lasts more than one week (Werner, Gell, Franzblau, & Armstrong, 2001). Symptoms vary from an individual in presentation and progression; however, they typically report a decrease in grip strength and function (Baker, Moehling, Desai, & Gustafson, 2013). Individuals demonstrate hyperesthesia or paresthesia in the median nerve of the hand followed by muscle weakness or atrophy of the abductor pollicis brevis and opponens pollicis (Burke, Burke, Stewart, & Cambré, 1994). Paget first discovered compression of the median nerve post distal radius fracture in 1854 (Pearce, 2009). Paget encountered compression of the nerve at Guy's Hospital as a result of the fracture being repaired by excessive new bone. The new bone instigated compression of the nerve, an ulceration of thumb, and middle digits. The patient resisted various types of treatments; however, was alleviated by binding the wrist, causing the palmar aspect to be relaxed and removing pressure on the nerve (Pearce, 2009). Putnam further identified patients with median nerve pain and paresthesia, found to inhibit occupational performance in the workplace and marketplace. Over the course of the next century, various cases of median nerve compression were found along the transverse carpal ligament which was later given the name Carpal Tunnel Syndrome in 1939 by the physician, George Phalen (Pearce, 2009).

The diagnosis of CTS continues to influence workplace occupational performance even

160 years later as the U.S. Bureau of Labor Statistics in 2015 reported incidents of 22 million individuals identified as having CTS (U.S. Bureau of Labor Statistics, 2015). Notably; of the individuals stated by the U.S. Bureau of Labor Statistics, studies have reported patient's symptoms were more prevalent during the evening and found to be slightly less troublesome during the day (Burke et al., 1994). The cause of CTS is idiopathic even after such length of prevalence; however, records have indicated that repetitive motion of the wrist links to CTS (Newington, Harris, & Walker-Bone, 2015). Newington et al. (2015) showed a direct relationship between CTS and certain occupational engagements. Certain occupations are more inclined to increase the risk of CTS in workers, in which Goldfarb (2016) identified specific occupations such as assembly line work, computer work, the use of vibrating tools and work that consists of forceful gripping, pushing, and pulling. Work is also a common place for injuries to the hand and wrist. Occupations that involve the use of heavy machinery and tools are more likely to be risk factors to the body; specifically, the fingers, hands, and wrists. Other risk factors not related to work include pregnant women, diabetics, obesity, and hyperthyroidism (Newington et al., 2015).

The positioning of the wrist during prolonged activities has also been known to correlate with CTS. Rempel, Keir, and Bach (2008) reported that increased carpal tunnel pressure was caused by non-neutral hand postures and grip forces. Also, positions of the wrist, hand, forearm, and fingers combined with fingertip force play a significant role in CTS. Positions of the wrist in flexion, extension, ulnar deviation or radial deviation outside of neutral range increased the carpal tunnel pressure. Occupations that leave the worker's wrist outside of neutral position for lengthened amounts of time are often associated with CTS (Rempel et al., 2008). According to Goldfarb (2016), employees who work over 12 hours a day for eight years or longer are at higher risk of CTS. Coggon et al. (2013) also supported these findings by including the use of a keyboard for four hours. Nurses are among occupations linked to high risks of CTS due to working long hours with computers. Of these, female nurses have been identified to be particularly at risk (Diaz, 2001).

Researchers have linked women as being the most at risk for CTS due to various occupational roles, with reports that females ages 50, and above are primary candidates (Yucel, 2015). The U.S. Bureau of Labor Statistics (2015) indicated employees; ages 45 to 54 years old with CTS having the highest amount of days away from work with 29 days per employee and 286, 000 days combined. Musculoskeletal disorders accounted for 32% of all work-related injuries in 2014. Nurse and nurse assistants have been recorded among the top six occupations where the incident rate per 10,000 full-time workers was greater than 300, with a rate of 373. Overexertion and bodily reactions accounted for 55% of those injuries and illnesses (U.S. Bureau of Labor Statistics, 2015).

Multiple interventions are used to help alleviate symptoms of CTS such as splinting, steroid injections, ultrasound, surgical release, and kinesio taping (Amini, 2011). However, many of the interventions such as surgery have proven to have a low success rate (Ehler et al., 2014). Other conventional methods such as surgical release, are more invasive and have a longer recovery time of up to one year. Ehler et al. (2014) found patients have reported that postoperative recovery is often cumbersome, lengthy, and not very beneficial for patients prone to skin breakdowns, contractures, and slower blood flow. Splinting has been widely used; however, there is poor compliance with the intervention, according to Walker, Metzler, Cifu, and Swartz (2000), 73% of their study's participants failed to follow complete compliance of splinting. Therefore, it is imperative to determine a more conservative intervention with documented success for individuals who suffer from CTS and improving occupational performance and compliance.

Kinesio Tape

Kinesio tape (KT) has been a widely-used technique for sports medicine and orthopedics and continues to emerge in the rehabilitation setting especially in occupational therapy. KT is mainly applied to the flexor muscles of the volar surface of the wrist for CTS (Kase, Hashimoto, & Okane, 1998). With the application of KT to the epidermis, compression is released on the nociceptors (pain receptors) in the subcutaneous also known as the hypodermis. Pressure to the nociceptors synapse signals of pain and discomfort which decussate on the contralateral side of the spinothalamic pathway to the brain (Lundy-Ekman, 2013). KT permits a free range of motion (ROM) of the wrist and forearm, allowing the muscular system of the affected area to heal itself bio-mechanically. KT has been indicated as a useful tool in restoring muscle function and decreasing pain. Four major functions of KT include muscle support, congestion removal to allow a flow of body fluids, activates the endogenous analgesia system, and correction of joint issues (Kase, 2003). This study investigated the effects of KT intervention for symptoms associated with CTS and the potential of increased function of the upper extremity for individuals with CTS; therefore, increasing individual compliance to facilitate occupational performance.

Electromyography

Electromyography (EMG) testing has been widely used to measure muscle response or electrical activity of a stimulated nerve within the muscle for CTS (Johns Hopkins Medicine, 2016). EMG is used in characterizing neuropathic disturbances in the carpal tunnel from distal demyelination or axonal degeneration of the median nerve (El-Emary & Hassan, 2016). The test has proven helpful in identifying proximal lesions, cervical radiculopathy or proximal median nerve entrapment that link to CTS. EMG is scientifically significant in providing evidence that KT on the dorsal side will decrease pain and increase occupational performance. An EMG procedure consists of one or more epidural needles or electrodes inserted through the epidermis into a muscle, of the abductor pollicis brevis when testing for CTS (El-Emary & Hassan, 2016). The use of EMG will detect an improvement in median nerve distal latency after applying KT on working individuals with CTS. Therefore, the use of EMG validates the efficacy of KT application on working individuals with CTS.

Statement of Problem

The wrist and hands are essential anatomical structures that allow functional performance in activities of daily living (ADL). With CTS, however, functional performance and other meaningful occupations are hindered. Occupational therapists continue to seek out the most efficient interventions with the least invasive methods used to relieve symptoms of CTS and to increase functional performance. Amini (2011) reported that the Centers for Disease Control and Prevention (CDC) declared that hand injuries are consistently ranked as the second leading injury in the workplace.

Goldfarb (2016) identified a direct correlation between CTS and work-related injuries. Finding supporting evidence that certain factors increased the risk of CTS; some of which include perimenopausal status, and rheumatoid arthritis due to joint slippage. Psychosocial factors such as fear and anxiety can cause individuals to avoid particular movements or activities such as computer work, gardening, and even assembly line work. The vibration of a jackhammer creates an impact for workers in construction that damages the joints of the wrist. Research has shown that there is an even higher risk of developing CTS with the use of a computer 12-hours per day when over a span of eight years or longer (Goldfarb, 2016). Coggon et al. (2013) documented the utilization of a keyboard for a length of even 4-hours a day also increased the risk of CTS secondary to poor posture and repetitive movements compressing the median nerve. Interventions to relieve the pressure on the median nerve are continually studied whereas the most prevalent interventions currently used are non-surgical and surgical (Johns Hopkins Medicine, 2016).

Surgical intervention has been deemed to yield higher benefits than that of a conservative path; although the efficacy has identified multiple risk factors and complications from surgical release (Ehler et al., 2014). Along with heightened risk factors and complications, surgical intervention can result in lengthy rehabilitation time, inhibiting an individual’s return to work and ADLs. Ehler et al. (2014) analyzed prognostic factors associated with postoperative outcomes and found primarily female and individuals between the ages of 60 to 94 years old, diabetic, or have thyroidal issues are less likely to see any benefit from surgical intervention. Given the population of those diagnosed with CTS, this would imply that a substantial amount of individuals will see little to no positive outcome post-surgery (Ehler et al., 2014).

According to Ehler et al. (2014), CTS required nearly double the repair time of up to five years post-surgical intervention. Therefore, the study identified a weak response to surgical intervention, and is further linked to demyelination and decreased the production of myelin proteins, reduced expression and axonal transport of cytoskeletal proteins within the peripheral nerve, as well as reduced production of neurotrophic factors in the peripheral nerve. Also, decreased blood flow along the nerve reports the arteriosclerotic involvement of the vasa nervorum. EMG found latency in adults to be significantly reduced when compared to individuals of a younger age, implying adult patients may be prone to slower postoperative recovery (Ehler et al., 2014). A longitudinal study by Weber, DeSalvo, and Rude (2010) indicated that postoperative improvement persisted up to five years later. Yucel (2015) recommended more conservative treatments to minimize patients suffering postoperative carpal tunnel release.

Significance of This Problem for OT Framework

Occupational therapists focus primarily on frameworks within their scope of practice found in the *Occupational Therapy Practice Framework: Domain and Process* (3rd ed.; American Occupational Therapy Association [AOTA], 2014). The AOTA (2014) adopted the domain and process for occupational therapists into their scope which is regularly published in the *Framework*, 3rd edition. Occupational therapists are returning to their roots of a client-centered approach where they take into account client factors, consisting of the client's body structure, mental function, and emotional capacity. OTs also consider client's pain levels, motor skills, and muscle function as it contributes to occupational performance (AOTA, 2014).

Skills are classifications of work that encompass various capacities (body functions and body structures). Performance skills are elements that can be observed in the form of actions with implicit functional purpose (AOTA, 2014). Performance skills underlie the ability to participate in occupations. Performance skills also incorporate motor skills, process skills, and social interactions skills that can provide the client with the capability to perform occupations cohesively (AOTA, 2014).

Along with performance skills are performance patterns which consist of habits, routines, and occupational roles used in the process of activities (AOTA, 2014). Habits are listed as activities performed in particular ways repeatedly with little variation (AOTA, 2014). Occupational therapists are concerned with habitual patterns in patients' lives that contribute to deficits and injuries such as CTS. A typical intervention occupational therapists suggest splinting; however, patient non-compliance is a major issue (Hall et al., 2013). Overuse of the wrist in the same position is reported to be a significant culprit to developing CTS (Coggon et al., 2013).

Patients' roles contribute directly to their habits and routines. Roles in the workplace such as long hours of computer use are documented as a leading cause of CTS. Symptoms of CTS prevent patients from fulfilling their roles at home, the workplace, school, and leisure. Among those identified as common occupations diagnosed with CTS are nurses who may be unable to document on the computer over the course of a 12-hour day, as they have been linked to high-risk occupations (Coggon et al., 2013). The AOTA (2014) suggests approaching interventions with specific strategies for evaluating, intervention planning, selection of intervention, an implementation based on the client's desired outcome, evaluating data, and evidence supporting the intervention.

Occupational therapists are concerned with the patient's outcome with emphasis on patient education in prevention, health, and wellness, quality of life, participation in occupations, competence, well-being, and improvement of occupational performance (AOTA, 2014). Occupational therapists are engaged in the overall benefit of the patient; therefore, it is imperative that occupational therapists use methods that are profitable to both the patient and the clinic while maintaining patient's compliance. Occupational therapist engagement builds rapport with patients by providing education that promotes their ability to return to work, with a better understanding of health and wellness (AOTA, 2014). Occupational therapists build rapport with the client by providing quality care such as the application of kinesio tape which provides proprioceptive stimuli alerting the patient of bad habits in posture or form.

Need for Research

Mostafavifar, Wertz, and Borchers (2012) addressed the need for additional validating KT's use in improving function, pain, and return to work. There is a lack of high-quality studies with large sample size, powered outcomes, and longer follow-up to authenticate any positive effects or lack of effects of KT; therefore, further investigation is required to produce higher levels of evidence, larger sample sizes, powered outcomes, and longer follow-up times that authenticate the positive effect or lack of KT (Mostafavifar et al., 2012). In a recent study by Ebiringah, Littleworth, and Ornelas (2016) there was firm evidence supporting the use of KT as a rehabilitation intervention for CTS. However, the study also concluded the need for further investigation to better support their findings due to sample size. Bassett, Lingman, and Ellis (2010) postulated physiological benefits of KT are only hypothetical; however, El Kosery, Elshamy, and Allah (2012) addressed in their study the use of EMG to validate the position and nerve conduction of KT with CTS. Results were an improvement in median motor distal latency at the end of the intervention program during pregnancy (El Kosery et al., 2012). More scientific evidence is needed to validate the efficacy of KT intervention for CTS, and support the physiologic benefits of KT among various populations by taking wrist position and the location of KT application into consideration.

Purpose of the Research

Walker, Metzler, Cifu, and Swartz (2000), reported only 27% of the participants showed full compliance in splinting of daytime wear for individuals with CTS. In the same study, one participant said the lack of compliance was due to the hindrance in job performance (Walker et al., 2000). The targeted population of workers with CTS is highly associated with the overuse of the upper extremities (UE). Coggon et al. (2013) found that through their study of 12,426 participants that spanned across 47 occupation groups, there was a high association between computer use and the development of CTS. Among those diagnosed with CTS, females age 50 and older are primary candidates for CTS (Yucel, 2015). Of the at-risk population, findings showed that those who used a computer at work for 12 hours a day up to eight years and are primarily nurses and office workers (Coggon et al., 2013). The purpose of this research was to determine whether using KT on the dorsal side of the wrist increased median nerve distal latency for patients with CTS. Furthermore, the purpose of this study was to seek advanced understanding in the efficacy of KT, and whether there was a reduction of symptoms for individuals with CTS to provide evidence that KT can reduce symptoms of pain, numbness, tingling and swelling in CTS.

Literature Review

CTS and Occupational Engagement

Newington, Harris, and Walker-Bone (2015) conducted a systematic review examining the relationship between CTS and occupational engagement. Limited studies have made in-depth analyses regarding movements involved in work activities, and due to time-consumption and expense, this resulted in limited participants. Therefore, exposure classification has ranged from entry-level job titles to self-reported workplace activities (e.g. repetitive bending, or straightening the wrist for one hour per day). Newington et al. (2015) concluded sufficient evidence of positive association to work and repetitive movements of the hands, as well as work associated with forceful movements of the wrist and hand. The data collected found that hand-held vibratory tools were linked to more than double the risk developing CTS. Therefore, flexion and extension of the wrist with high levels of force and repetition were reported to correlate with CTS (Newington et al., 2015).

Handwriting has been noted as one of the most common tasks in daily living and is significant to numerous occupations (Kuo et al., 2014). Handwriting skills have often been used to document at work, budget bills (checks), and other ADLs. Kuo et al. (2014) included 14 participants with CTS by a self-reported survey, sensory tests, hand strength, dexterity and handwriting tasks. Functional and biomechanical parameters were followed to determine if the participants made improvements postoperative intervention. Among individuals diagnosed with CTS, insufficient grip force was stated as a common problem. Based on the self-reported screening for handwriting, nine participants struggled with writing, and two participants said they had no handwriting difficulty. Finger dexterity showed participants had fewer pins compared to the control group. After recovering from post-surgical intervention, the participant's hand strength, sensory, and skill improved; however, findings were statistically insignificant. Countless studies have reported that handwriting performance was adversely affected in patients with CTS. More than one-third of patients have continued to experience difficulties in handwriting performance post decompression surgery (Kuo et al., 2014).

Handwriting has been recognized as a crucial task for workers that hold office and administrative positions (Kuo et al., 2014). A majority of employees who hold these positions work in suboptimal environments, which have led to various traumatic disorders, such as CTS. Tasks requiring inter-digit coordination, fine kinematic and kinetic manipulation such as handwriting, typing, and the use of touchscreen devices have few descriptive studies. Results of manual dexterity tests in earlier studies indicated that CTS patients had worse fine motor skills or less efficient performance of the hand while the focal task was increased, such as involving longer durations of bilateral hand use. This study provided clinicians a better understanding of the handwriting biomechanics and improved adaptive tools for people who perform repetitive work. However, the study's population was limited and did not look at the variability of writing performance among the participants (Kuo et al., 2014). The study also did not provide any conservative interventions to improve the functionality of handwriting.

Conservative Intervention for CTS

A systematic review by Amini (2011) relayed the effectiveness of occupational therapy interventions for rehabilitation of work-related injuries to the forearm, wrist, and hand. Amini (2011) also addressed illnesses that were reviewed as part of the Evidence-Based Literature Review Project by the American Occupational Therapy Association (AOTA). The systematic review was a comprehensive overview that analyzed 36 studies addressing multiple interventions commonly used for rehabilitation of the hand (Amini, 2011). Amini (2011) highlighted evidence related to treatments of the upper limbs that can be used by clinicians to support the common interventions used on work related injuries. Of the 36 studies, Amini (2011) included in the systematic review, 32 were level I quality, and four of them were level III quality studies. Findings were clustered into 12 areas of treatments administered (or potentially) by occupational therapists while treating work-related or otherwise acquired conditions of the hand, wrist, and forearm (Amini, 2011).

Five level I studies reviewed splinting as a conservative intervention that would deem beneficial as a preparatory technique (Amini, 2011). Two articles described splinting as a method to reduce signs and symptoms of osteoarthritis of the thumb carpometacarpal (CMC) joint, with three other reviews based on splinting for CTS. One review found limited evidence that ultrasound was an effective adjunct to treatment of CTS. Another finding that 20 sessions of ultrasound for 15 minutes with a deep pulse, decreased symptoms of CTS and sensory loss. Ultrasound also improved median nerve conduction strength. The systematic review also indicated that less than 20 sessions of sonography were ineffective. Other factors reported ultrasound conducted by healthcare providers must remain at the machine for the duration of the treatment which limited the productiveness of the clinic (Amini, 2011).

Amini (2011) stated that compared to no treatment, the development of hypertrophic scarring was reduced while the elasticity of the established scar increased. Massage to the scarred area was found to reduce itching associated with burns as well as reduced anxiety and depressed moods. However, deep transverse friction massage applied to tendonitis found no clinical benefit. Thus, KT is a favorable conservative approach to the treatment of CTS (Amini, 2011).

Walker, Metzler, Cifu, and Swartz (2000) performed a randomized clinical trial which included a six-week follow-up of all participants. Seventeen participants (24 hands) with CTS symptoms were referred to the Veterans Administration Medical Center for EMG. Two groups were used to compare the effects of night and day splinting to determine the treatment's effects on symptoms, function, and impairment of CTS. With the implementation of thermoplastic splints, Levine's self-administered questionnaire was used as a measuring factor on the severity of CTS in each participant. Both median nerve sensory and distal motor latency were measured for physiological impairments. Each measurement was applied as a baseline (pretest) and post-splint intervention (Walker et al., 2000).

Splints are based on the rationale of observations made that CTS symptoms improved during rest periods, and worsen during physical activity (Walker et al., 2000). Subsequent research has also documented that pressure of the carpal tunnel arises as the wrist leaves the reported neutral range. Walker et al. (2000) noted other factors besides wrist angles as contributory to pressure in the carpal tunnel such as the metacarpophalangeal (MCP) flexion, extension, forearm pronation, supination, finger postures, and fingertip loading. Compliance of orthotics such as splinting is reported destitute due to the hindrance of individual's occupational performance. Of the study's participants who consented strict adherence to splint wearing instructions, only 46% of the total participants complied. Incomplete compliance indicates limitations in the progression of symptomatic and physiologic improvement (Walker et al., 2000). The implementation of KT will not deter patient compliance; therefore, allowing physiological and symptomatic progression.

Overview of Kinesio Tape for CTS

Mostafavifar, Wertz, and Borchers (2012) confirmed that the use of KT for CTS improved lymphatic and blood circulation without the restriction of ROM while decreasing pain, inflammation, and recovery times. KT has been theorized to reduce pain by microscopically lifting the epidermis and improving the circulation as well as relieving pressure and irritation of neurosensory receptors (Mostafavifar et al., 2012). KT techniques also alleviated pain in the musculoskeletal region not associated with an injury (Mostafavifar et al., 2012). It has been indicated by Bae (2014) that KT may provide immediate relief of myofascial pain, with complete resolution within a few days. Evidence has also linked improvement in pain symptoms in individuals with meralgia paresthetica over the course of a short period (Lee et al., 2011). This review of KT following musculoskeletal injury suggested immediate pain relief; however, the duration may only last less than 24 hours. Furthermore, trends have suggested that KT may improve pain-related outcomes when used as an adjunctive modality to physical therapy. The results were similar whether KT was compared to a placebo intervention or other therapeutic modalities. KT has been documented to relieve pain in the first 24 hours following application, although there is insufficient evidence to support any sustained relief beyond that tie

(Mostafavifar et al., 2012). Therefore, other methods should also be considered (Mostafavifar et al., 2012).

Another benefit of KT according to Mostafavifar et al. (2012) is that function and grip have also been reported to improve with the application of KT. Functional capacity increased by providing support to the muscles without restriction. Evidence suggests that the use of KT in healthy participants might also facilitate muscle effort. Placement of KT along the forearm may enhance related or absolute force sense but did not alter maximum grip strength. Another review reported the use of KT post musculoskeletal injury did improve functional mobility; however, it was not clear whether the effects are long-term (Mostafavifar et al., 2012).

No clear evidence was found to suggest KT alone improves strength and decrease disability in comparison to therapeutic exercise (Mostafavifar et al., 2012). Acknowledgment of the effects from KT was specific to different receptors in diverse anatomical areas remain unknown; therefore, warrants further study (Mostafavifar et al., 2012). Mohammadi et al. (2014) completed a longitudinal study on the delayed effects of KT for grip. Unfortunately, scant evidence was found regarding KT and grip strength (Mohammadi et al., 2014).

Several studies investigated immediate effects of KT on maximum grip strength; however, none of them compared the three regions of the forearm such as flexors, extensors, and flexor/extensors (Mohammadi et al., 2014). Applications of KT in an I-shaped form with 50% stretch to the flexor, extensor, and flexor/extensor surface of the forearm was used (Mohammadi et al., 2014). Prior studies showed that extensor muscles stabilized grip, with the exertion compressive force on the metacarpophalangeal (MCP) and wrist joints, and balancing force on the flexors cause greater contractions to the flexor muscles by maintaining appropriate length-tension. The findings revealed significant improvement in maximal grip strength by 30-minute increments for two hours after KT applications were administered along the tri-region of the forearm (Mohammadi et al., 2014). The concluding factor recorded the greatest increase in grip strength occurred at 30 minutes of taping in males and 1.5 hours in females. Results from the current study showed that KT could effectively increase grip strength in healthy individuals with application to the extensor side of the forearm (Mohammadi et al., 2014).

A recent study by Cai, Au, An, and Cheung (2015) had a deceptive randomized trial of 33 healthy participants and were randomly assigned to three groups consisting of either true facilitator KT, inhibitory KT, or no tape. The study's objective was to use KT to alter muscle activity, both facilitatory and inhibitory. Of the listed participants, 31 out of 33 were confirmed to be uneducated in KT. No compelling differences were found in the maximum strength, EMG, or self-perceived performance between facilitatory and inhibitory KT, or tapeless conditions. KT has also been reported to be effective in pain management by inhibiting muscle activity (Cai et al., 2015). Inhibition of muscles can be accomplished by stretching the Golgi tendon organ at the distal end of the muscular fibers (Cai et al., 2015). The study results were limited due to the exclusion of unhealthy participants in determining KT as a compelling intervention for rehabilitation. Further studies are needed to determine if injured or unhealthy individuals will likely benefit from KT (Cai et al., 2015).

Wrist Position

Studies have been conducted in search of the optimal wrist position to alleviate carpal pressure while increasing the opening of the carpal canal (Burke, Burke, Stewart, & Cambré, 1994). Burke et al. (1994) compared symptom relief of individuals placed in a wrist cock-up splint of 20° extension against individuals placed in a neutral carpal tunnel wrist splint. A randomized controlled trial of 59 patients (90 wrists) with a history consistent with CTS and referred to OT for splinting. The intervention entailed custom made, thermoplastic, volar cock-up splints. Splinting was completed by alternating between a neutral position and 20° extension (Burke et al., 1994).

The use of the splint was applied to the dominant and nondominant hand (Burke et al., 1994). Therefore, splinting on the alternating wrist is neutral, the dominant hand would receive the neutral splint, and the non-dominant hand would then receive the extension splint. Patients were not notified of differences in angle. This article indicates that splint angles make a difference in symptom relief of carpal tunnel syndrome after wearing the splints for only two weeks (Burke et al., 1994). According to Burke et al. (1994), the study was the first clinical trial to indicate that the neutral angle wrist splint provided better symptom relief than the traditional 20° extension wrist cock-up splint. The study provided clinical evidence that small angle differences of the wrist allowed a more distinguishable symptom relief (Burke et al., 1994).

Rempel, Keir, and Bach (2008) also confirmed that even slight changes in the wrist’s angle provided superior relief due to the reduction of pressure within the carpal tunnel. The study found that an increase in carpal tunnel pressure was caused by a non-neutral position or grip forces. The pressure within the carpal canal is significantly influenced by the posturing of the wrist, forearm, fingers, as well as fingertip force. Rotation of the forearm into 45° of pronation increased the amount of carpal tunnel pressure along with deviation of the wrist from a neutral position (Rempel et al., 2008). Rempel et al. (2008) also found the pressure in the carpal tunnel was lowest near the neutral position of the wrist which was identified as 0° of flexion, 0° of extension, and 0° of ulnar and radial deviation. The study documented findings that pressure increased as the wrist deviated from the specified neutral position (Rempel et al., 2008).

Summary data suggested that wrist angles have a substantial impact on carpal tunnel pressure specifically during typing (Rempel et al., 2008). Data reported that the effects of both wrist flexion and extension during typing significantly increased the amount of carpal tunnel pressure. An indication of carpal tunnel pressure with an extension of 30° was profoundly greater than the pressure at 15° flexion and 0° extension using the Tukey follow-up test. A significant finding from the study concluded carpal tunnel pressure during wrist extension of 45° was at the highest peak compared to all other configurations. Researcher's findings suggested that the use of a keyboard and the type of workstation should be adjusted to avoid extension of the wrist more than 30°, and radial deviation more than 15° while using the computer for long periods. Decreasing the slope and thickness of a keyboard can reduce the angle of wrist extension. Implementing a split keyboard, forearm support surface, or raising the height of the chair relative to the keyboard have also been found beneficial. By implementing a split keyboard, the ulnar deviation can be reduced; however, a large keyboard with an opening angle may also lead to radial deviation which should be avoided. The findings of this study can be used as guidelines to keyboard console designers and clinicians for CTS management and prevention with the use of computers for long hours (Rempel et al., 2008).

EMG vs. Other Diagnostic Tools

Roll, Case-Smith, and Evans (2011) conducted a systematic review study to determine if sonography compliments electrodiagnostic testing as a screening tool for individuals with severe CTS. The results exposed profound limitations in published research that would facilitate well-documented conclusions in regards to the application of sonography to diagnose CTS. There was a broad agreement by researchers that sonography was valuable in detecting abnormalities such as bifid median nerves, persistent median arteries, secondary pathologic findings that may contribute to CTS, tenosynovitis, crystal and amyloid deposits, ganglia, and tumors (Roll et al., 2011).

Sonography was reported to be less time constraining and have better toleration from patients than electrodiagnostics overall (Roll et al., 2011). Extensive benefits set apart sonography from electrodiagnostics, however, a direct link to sonography and specific diagnostic measures for CTS are yet to be documented. A lack of standardization among researchers' methodologies, designs, variability in evaluations, and measurement protocols has led to confinement in determining the diagnostic utility of sonography. Improved association to pathology and clinical practice are further required. The conclusion of this study suggests continued research is needed to have a better grasp on sonography for diagnosing CTS (Roll et al., 2011).

Research of EMG in diagnosing CTS is limited compared to sonography which has been investigated numerous times (Roll et al., 2011). Database searches provided 582 abstracts published between 1999-2009 alone for sonography and CTS. Database searches also compiled an inclusion of 23 studies, though methodological discrepancies among the studies limited the ability to complete a meta-analysis identifying a particular diagnostic threshold. This lead to data being reviewed as a means to provide implications for the clinical utility of sonography as a screening tool, which complimented EMG, but also suggested further research. Research indicated that the largest cross-sectional region of the median nerve in the carpal canal has tremendously high potential for clinical screenings, especially in severe cases of CTS with sonography (Roll et al., 2011). The use of comparative measurements, qualitative analysis, and Doppler techniques to identify swelling of the nerve all required further investigation. However, exploration of sonography in mild cases of CTS may enhance screening protocols (Roll et al., 2011).

Another study by Visser, Smidt, and Lee (2008) proved the accuracy of sonography is similar to that of EMG. The study consisted of 207 participants with possible CTS who were referred to a neurology outpatient clinic from October 2001 to November 2004. All participants underwent high-resolution sonography as well as EMG. Motor median conduction studies were performed with the use of standard techniques of supramaximal stimulation by way of EMG (Visser et al., 2008).

The study eliminated the notion that EMG is not the only accurate assessment to confirm the diagnosis of CTS (Visser et al., 2008). Visser et al. (2008) made note that sonography may be the preferred method due to the painless and easily accessible nature. However, a limitation of the study was that participants stated they preferred sonography, yet failed to provide accurate data by only selecting a few participants (N=20) out of their entire population (N=207). It may have been best to have included all 207 participants (Visser et al., 2008).

Werner and Andary (2011) published a monograph regarding electrodiagnostics to confirm the diagnosis of CTS. The American Association of Neuromuscular and Electrodiagnostic Medicine (AANEM) used the monograph as a standard overview of EMG. The monograph addressed various techniques for EMG to evaluate the median nerve at the wrist. Limitations were also demonstrated in EMG studies, focusing on the sensitivity and specificity of EMG for CTS. References to specific populations showed disparities in normative values, and conservative cutoffs were presented. The value of electrode EMG was also examined (Werner & Andary, 2011).

Typical EMG techniques for clinical CTS were confirmed by well-documented abnormalities of the median nerve fibers that were encapsulated within the carpal tunnel (Werner & Andary, 2011). There have also been many studies that compared the sensory nerve response to be more effective than absolute median nerve latency (AMNL) in documenting median nerve abnormalities consistent with CTS. Though the monograph reported sensory fibers have larger proportions of the major myelinated fibers, which, therefore, required a higher energy requirement. Therefore, sensory fibers are more susceptible to ischemic damage. Due to focal compression, ischemic and mechanical damage to the nerve fibers will result, causing myelin dysfunction and disruption along the nodes of Ranvier (Werner & Andary, 2011).

As a result, slowed conduction velocity occurred, allowing the EMG physician to confirm abnormality of the median nerve in the carpal canal (Werner & Andary, 2011). Comparison of median sensory latency to the radial, ulnar, or median (segment outside the carpal tunnel) sensory latencies allowed the greatest accuracy for confirming the clinical diagnosis. When using comparison latency instead of absolute latency, there were more confounding factors such as age, temperature, disease (diabetes), gender, and hand size to be considered. Though motor nerve stimulation was less sensitive than other diagnostic methods, it still played a valuable role in documenting motor fiber involvement to localize lesions if the median sensory potentials were absent. Median distal motor latency (MDML) was obtained by recording over the abductor pollicis brevis (APB) by way of stimulation at the wrist (Werner & Andary, 2011).

EMG in patients with CTS has not been universally accepted and simply listed as an option in AANEM practice (Werner & Andary, 2011). During the study, EMG of the median nerve conduction was normal; there was a feeble reason to find abnormalities present on the APB. However, abnormal median nerve conduction studies (NCS) were not predicted by abnormal EMG findings. Nevertheless, EMG has added useful information to test results in many other situations. EMG is necessary for the diagnosis of cervical radiculopathy, proximal median neuropathy, and polyneuropathy as well as axonal loss in CTS (Werner & Andary, 2011).

Werner and Andary (2011) validated the efficacy of EMG by the conclusion of the monograph that the majority of cases can take into account the history of the patient and physical examinations are sufficient in making a clinical diagnosis of CTS and initial treatment. However, many patients presented multiple problems, and their presentation was atypical. In such cases, EMG can confirm a diagnosis of CTS. Coexisting or confounding diagnosis can also be ruled out through the use of EMG (Werner & Andary, 2011). Watson, Zhao, and Ring (2010) completed a study which further supported EMG. Of 140 participants, 115 patients were confirmed to have CTS through the use of EMG. The study also accounted for physician confidence in the use of EMG to diagnose CTS; EMG would be an accurate method (Watson et al., 2010). Therefore, Watson et al. (2010) stated that physicians might lack confidence in the diagnosis of CTS, EMG is a valid and accurate assessment tool to determine whether an individual has median nerve compression within the carpal tunnel.

Simovic and Weinberg (1999) researched the median terminal latency index in diagnosing CTS with the use of EMG. Participants (N=54) in the study were included based off of symptoms including numbness, tingling, or pain in the hands, and arms. Participant’s age ranged from 19 to 86 years old. The objective of the study was to evaluate the sensitivity of the median terminal latency index (MTLI) to compare with other electrophysiological methods. Nerve conduction studies were conducted by separate, blinded examiners which resulted in MTLI being useful as a parameter for CTS (Simovic & Weinberg, 1999). Median terminal latency index was calculated based on value, and there was no additional cost or time required to incorporate the data into standardized diagnostic procedures. Recorded standard values for MTLI were equal or less than 0.34 ms, and average values for MMDL were equal or less than to 4.2

ms. An abnormal value for MMDL was greater than 4.2 ms (Simovic & Weinberg, 1999).

Statement of Purpose

As occupational therapists, it is imperative to use the most evidence-based form of practice that meets the needs of the patient within the client-centered framework. Occupational therapists must consistently use the most effective, efficient, safe, and conservative intervention for CTS. The researchers; therefore, believe that KT is an efficient method compared to other traditional interventions such as splinting. Analysis of literature reviews revealed more evidence is needed to determine an effective conservative and non-surgical approach to CTS treatment to be found regarding the most effective CTS treatment, especially for a conservative non-surgical approach. As occupational therapy returns to its roots, providing evidence is necessary for supporting intervention the return occupational engagement in the workforce and marketplace.

Carpal tunnel syndrome has been the leading mononeuropathy diagnosed in the workplace (Amini, 2011). Multiple interventions have been used for the diagnosis of CTS, yet there is still debate on the efficacy of which intervention is the best. Carpal tunnel decompression (release) is the most invasive approach even though it is stated to produce favorable results. The intervention tends to have reported complications and side effects that warrant a more conservative approach (Shi & MacDermid, 2011). Conventional methods consist of but are not limited to, splinting, steroid injections, massage, and exercise therapy (Amini, 2011). Unfortunately, splinting proves to be effective but has very little patient compliance (Walker et al., 2000). Thus, further investigation has led to the use of KT for CTS. The evidence is crucial to allow KT to be recognized as an irrefutable conservative intervention by both healthcare workers and patients. Therefore, this study is to collect scientific data as evidence by the use of

EMG. A systematic review on the efficacy of kinesthetic tape for musculoskeletal conditions by Bassett, Lingman, and Ellis (2010) noted that there is a lack of research to validate the underlying physiological effect of KT application to the wrist.

Theoretical Framework

The biomechanical framework applies principles of physics in the human movement to the force of gravity. The framework targets range of motion (ROM), strength, endurance, and ergonomics (Cole & Tufano, 2008). In the context of occupations, pain, and avoidance of pain must be considered in human movement. This framework focuses on individual parts of the body that are affected; then seeks to treat the area to increase function, and decrease pain, enabling CTS. Interventions target the wrist and nerve entrapment within the carpal tunnel to relieve symptoms. The principles of this framework include management of weight-bearing against gravity; which often guide designs of splints, prosthetic devices and other adaptive equipment (Cole & Tufano, 2008).

Cole and Tufano (2008) described biomechanical principles as compensatory devices that create movement and positioning in the absence of voluntary movement or posture control. As occupational therapy returns to its roots, providing evidence is necessary for supporting interventions that assist in the restoration of occupational engagement in the workforce and marketplace. Physical agent modalities can be used to prevent limitations in ROM by accomplishing methods such as compressions, bracing, and splinting. Compressions (wrapping) reduces edema associated with limited ROM, and positioning via splints facilitates functional movement. Occupational therapists use this framework as a reference to identify body functions impacted by CTS. By evaluating patients; the conditions of CTS are determined and allow the OT to create achievable goals to reduce symptoms and increase functional performance (Cole &

Tufano, 2008). The use of the biomechanical framework in this study is to determine that KT as a physical modality is an effective conservative intervention to reduce pain and increase function for CTS patients. By implementing the framework, patient's pain levels and function can be evaluated and measured. Therefore, patients with CTS will be able to control their pain and increase their occupational performance (Cole & Tufano, 2008).

Occupation Adaptation

Schultz and Schkade (1992) suggested the occupational adaptation practice model leads therapists to new layers of intervention. This model directly affects patient's internal abilities to generate, evaluate, and integrate adaptive responses where relative mastery is experienced. The adaptation model does not disregard necessary functional skills; however, the process is directly linked to future functioning than an acquisition of specific functional skills. As described by Schultz and Schkade (1992) human beings are naturally inclined to occupation and influence their health through those occupations. Individuals also develop as a continuous process; adapting to their environment, where biological, social, and psychological factors interrupt or impair the adaptation process during random points in the life cycle. Appropriate occupational facilitation promotes the adaptive process during these pivotal points. The use of occupational adaptation theory for CTS allows the OT to look at the body function using the biomechanical framework; however, patients will be more responsive to interventions geared towards their environmental factors influencing the treatment process. The combination of applying both occupational adaptation and biomechanical framework allows the OT to use a top-down approach; providing a more congruent client-centered intervention. By addressing the biomechanical framework and occupational adaptation, treatment addresses both the physiological as well as the psychological components.

Methodology

Study design

This pilot study utilized a randomized controlled trial to investigate the efficacy of KT on the antagonist (dorsal) surface of the wrist as an intervention to improve occupational performance and median nerve latency for CTS. Consenting participants were randomly assigned to an intervention or control group by using a block strategy to recruit equal numbers of participants in each group. Participants were assigned randomly to an intervention group (IG) with KT on the dorsal surface or control group (CG) with KT on the volar surface. The IG and CG received the KT intervention for 30-minutes.

Initially, all participants completed the Numerical Pain Rating Scale (NPRS), and the Levine Questionnaire (to assess symptom severity and functional deficits in CTS). The Jamar dynamometer (to measure grip strength, functionality, and effects on ADLs), and pinch gauge was used to measure strength, and electromyography (EMG) was conducted to determine the latency of the median sensory nerve. Application of KT was then administered to participants. During the KT application, a minor cut of 2 cm in diameter on the volar side was required for the EMG to read the orthodromic and antidromic median sensory nerve latency, post-test which was conducted by a licensed EMG specialist. A post-test was conducted after 30-minutes with the same assessments (except Levine Questionnaire).

The purpose of the control group receiving KT was to eliminate the possibility of the participants becoming aware of whether they were in the intervention or control group. At the end of the study, the control group was offered the same treatment as the intervention group. The study was approved by the Institutional Review Board (IRB) at Stanbridge University. Each of the participants signed a written informed consent and were informed of their right to withdrawal from the study at any duration.

Intervention and Control Groups

Participants were recruited from multiple sites and multi-media platforms, such as, but not limited to Facebook, flyers, email, and website. Consenting participants were randomly assigned to an intervention or control group by using a block strategy to recruit equal numbers of participants in each group. All participants were over the age of 18 and had CTS signs, symptoms, diagnosis, or demonstrated positive on the Phalen's test. Individuals currently receiving treatment for their CTS symptoms, current pregnancy, history of surgical carpal tunnel release at the wrist, or under the age of 18 were excluded. Known allergies to adhesives; EMG results conclude a false indication of CTS, compromised or easily compromised skin integrity, diabetes, epilepsy, pacemakers, thoracic outlet syndrome, blood-borne pathogens or radiculopathy were also excluded. An initial baseline for grip and pinch strength for each participant was collected. A post-test was conducted 30-minutes after applying KT to both the IG or CG. Participants were then offered education and taping by a licensed occupational therapist that specializes in KT. The occupational therapy students were instructed on how to properly administer the assessments used and how to apply KT.

Outcome Measures

The Jamar dynamometer is a standardized instrument that will be used to measure the participant's functional grip strength. Testing procedures and calibration were utilized under the *Clinical Assessment Recommendations* (American Society of Hand Therapists [ASHT], 1992). A three-trial assessment was used as it has been shown to have a higher interrater reliability (Mathiowertz et al., 1985). The dynamometer is a great tool to utilize when testing functional grip strength.

According to Mathiowertz et al. (1985), the B&L pinch gauge has the highest calibration accuracy along with the Jamar dynamometer. A B&L pinch gauge was used to measure the tip, key, and palmar pinch while being held by the examiner at the distal end to prevent dropping the device. The Jamar dynamometer and B&L pinch gauge were applied, and the participants were seated with their shoulders adducted with neutral rotation. Elbows were placed in 90° of flexion, forearms in neutral, and their wrists between 0° and 20° of dorsiflexion with 0° and 15° of ulnar deviation (Mathiowertz et al., 1985). The best of the three scores were calculated.

According to Walker et al. (2000), median sensory nerve conduction studies show validity and reproducibility that confirm a clinical diagnosis of CTS with high degrees of sensitivity and specificity. EMG was used to measure improvement in median sensory distal latency after 30 minutes of KT application. EMG was conducted by a trained and licensed individual to all participants. The room temperature was adjusted to 22°C, to influence the participant's body temperature to be at 37° C during the assessment. All participants' body temperatures were within normal range of 37° C during assessment via an infrared thermometer. All participants were placed in a seated position with the affected arm exposed (El Kosery et al., 2012).

The median nerve sensory distal latencies were obtained following EMGs standard parameters found in the American Association of Electrodiagnostic Medicine (Jablecki et al., 2002). All sensory latencies were obtained at 14 cm longitudinally across the wrist with an 8 cm transverse carpal distance. The antidromic techniques were implemented for the sensory studies. The median sensory fibers were recorded from the index finger, and the ulnar sensory fibers were recorded from the small finger. The radial fibers were recorded from the thumb at 10 cm with the stimulation delivered proximally above the wrist crease. The sensory latency was measured at the peak of the negative reflection; while the amplitudes were measured from peak to peak.

All sensory latency studies were controlled for ambient temperature and mid palm skin measurements. The participants were then released for their respective KT application and returned for a repeat nerve conduction study (NCS) that repeated the pre-test procedures in the exact manner. The EMG/NCS unit used for this study was a TECA synergy unit with surface bar electrodes for recording sensory latency. Stimulation was delivered to assure supramaximal stimulation of the mixed sensory fibers. The skin temperature was recorded via a thermistor at the mid palm.

Kinesio Tape Application

The application of KT was administered by individuals educated and trained in kinesio tape application from a certified clinician. All KT application was conducted in a neutral wrist position of 0° to 20° extension. Kinesio tape was stretched to 90% elasticity, with the wrist in slight radial deviation for the first application of adhesive, followed by the hand being placed in slight ulnar deviation to administer the second application of adhesive. The intervention group received KT to the dorsal surface of the wrist in a Y formation. KT was placed on the dorsal surface, anchored at the lateral epicondyle. The tape was applied distally to the wrist crease with the bifurcated ends on the MCP to the first and fifth digits. The tape was fixed in place by a light application of pressure. The transverse carpal ligaments acquired KT on the dorsal and volar side of the wrist with small double bifurcated strips at each end. The control group received KT to the volar side similarly to the dorsal surface of the forearm in a Y formation. KT was placed medially on the forearm going distally towards the wrist crease. The tape was applied to the wrist during extension. The bifurcated ends are then placed on the thenar and hypothenar eminences for the control group. The control group received adhesive tape to eliminate the possibility of the participants identifying which group they are.

Data Collection and Analysis

An initial baseline for gross grip strength (dynamometer), pinch strength (pinch gauge), and median distal sensory nerve latency (EMG) for each participant was collected. A post-test of all assessments was conducted after application of KT. Descriptive statistics were used to summarize the study's data.

Results

A total of 15 hands were included in the analysis (Figure 1). All eight subjects, 15 hands were contacted for a 1-day-intervention and analyzed using pre and post application of KT on the dynamometer, three-jaw chuck, and lateral pinch. EMG results were used to determine if there was any improvement in median sensory nerve latency via electrode EMG. The demographics of eight participants (15 hands) with an even distribution of gender identified as 50% female and 50% male (Table 1). The employment status of the construction/laborer, nurse, hairstylist, and office worker individuals are represented. The participants' age ranges were from 24 to 92 years of age (Table 1). The baseline participant characteristics were comparable between the two groups (Table 2-5). All participants received the application of KT based on their groups (IG and CG). There were no reported adverse effects and no adjustments required.

An initial baseline for three-jaw chuck, lateral key pinch, dynamometer, and median sensory latency (EMG) for each participant was collected. A post-test of all assessments was conducted 30 minutes after the intervention. Means of each assessment for each treatment group were assessed. For the intervention group, the pre-treatment average three-jaw chuck reading was 11.67 pounds and 30 minutes post-treatment average three jaw chuck reading was 13.07 pounds (Figure 2). The pre-treatment average lateral key pinch reading was 14.98 pounds and 30 minutes post-treatment average lateral key pinch reading was 15.76 pounds (Figure 3). The pre-treatment average dynamometer reading was 40.57 pounds and 30 minutes post-treatment average dynamometer reading was 45.36 pounds (Figure 4). The pre-treatment average median nerve sensory transcarpal latency reading was 1.60 msec and 30 minutes post-treatment average median nerve sensory transcarpal latency reading was 1.66 msec (Figure 5). For the control group, the three-jaw chuck reading was 11.67 pounds and 30 minutes post-treatment average three jaw chuck reading was 13.07 pounds (Figure 2). The pre-treatment average lateral key pinch reading was 17.82 pounds and 30 minutes post-treatment average lateral key pinch reading was 18.38 pounds (Figure 3). The pre-treatment average dynamometer reading was 68.54 pounds and 30 minutes post-treatment average dynamometer reading was 80.75 pounds (Figure 4).

The pre-treatment average median nerve sensory transcarpal latency reading was 1.83 msec and 30 minutes post-treatment average median nerve sensory transcarpal latency reading was 1.79 msec (Figure 5). The effect size was calculated with the type one alpha error at 20% which resulted in $\eta^2 = 0.73$ (Figure 6) (Bartko, Pulver, & Carpenter, 1988). The descriptive data for the NPRS and Levine Questionnaire were collected and available upon request.

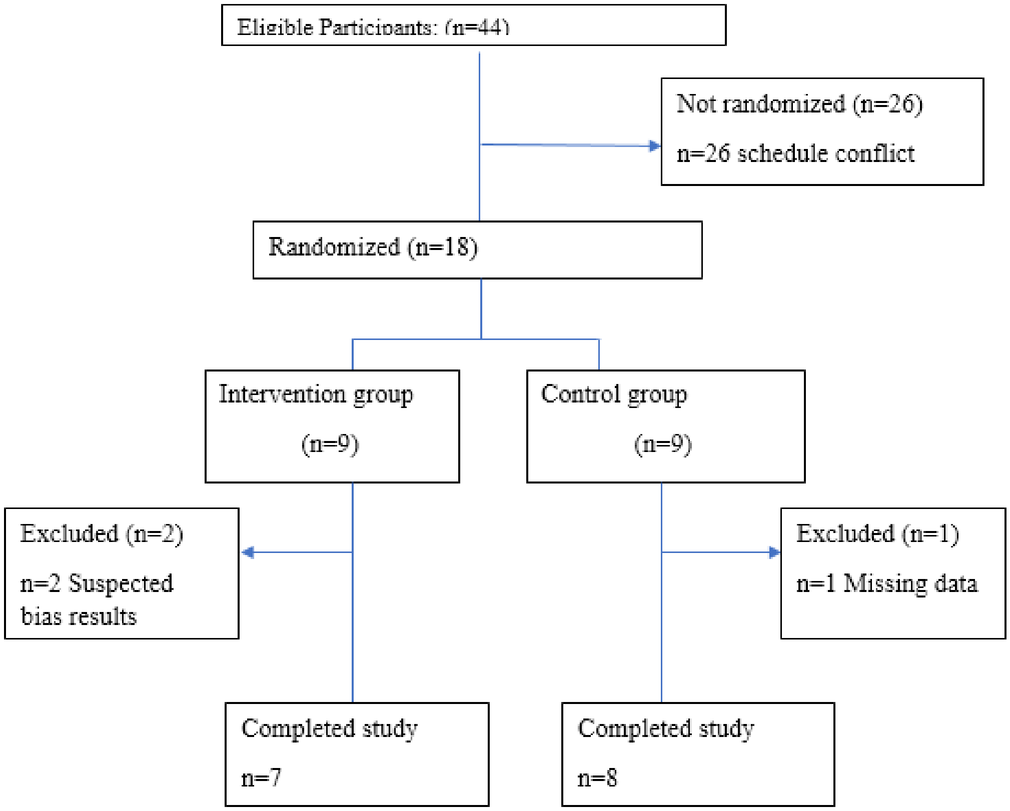

Figure 1
Identification of controlled randomized trials

Table 1: Demographic Characteristics (8 Participants)		
	Frequency (N)	**Percentage**
Gender		
Male	4	50.0%
Female	4	50.0%
Age		
18-30	2	25.0%
31-40	2	25.0%
41-50	1	12.5%
>50	3	37.5%
Career/Job		
Construction/Laborer	1	12.5%
Nurse	1	12.5%
Hairstylist	1	12.5%
Computer	2	25.0%
Other	3	37.5%

Table 2: Three-Jaw Chuck		
Intervention Group	**Pre-Tape (Average)**	**Post-Tape (Average)**
Hand 1	15.0	14.7
Hand 2	15.0	13.3
Hand 3	6.7	7.3
Hand 4	5.3	8.0
Hand 5	9.8	14.2
Hand 6	10.8	15.3
Hand 7	19.0	18.7
Control Group		
Hand 8	20.3	18.8
Hand 9	19.9	18.2
Hand 10	17.7	21.3
Hand 11	13.0	20.3
Hand 12	17.0	15.0
Hand 13	16.7	17.0
Hand 14	17.0	19.7
Hand 15	16.7	18.0

Table 3: Lateral Key Pinch		
Intervention Group	**Pre-Taping (Average)**	**Post-Taping (Average)**
Hand 1	17.0	17.3
Hand 2	17.0	17.0
Hand 3	13.0	13.3
Hand 4	7.3	6.7
Hand 5	16.8	18.3
Hand 6	15.7	19.7
Hand 7	17.7	18.0
Control Group		
Hand 8	25.7	25.5
Hand 9	24.9	24.0
Hand 10	19.7	17.7
Hand 11	13.3	16.0
Hand 12	12.9	12.5
Hand 13	11.4	11.7
Hand 14	16.7	20.7
Hand 15	18.0	19.0

Table 4: Jamar Dynamometer		
Intervention Group	**Pre-Taping (Average)**	**Post-Taping (Average)**
Hand 1	15.0	14.7
Hand 2	15.0	13.3
Hand 3	6.7	7.3
Hand 4	5.3	8.0
Hand 5	9.8	14.2
Hand 6	10.8	15.3
Hand 7	19.0	18.7
Control Group		
Hand 8	20.3	18.8
Hand 9	19.9	18.2
Hand 10	17.7	21.3
Hand 11	13.0	20.3
Hand 12	17.0	15.0
Hand 13	16.7	17.0
Hand 14	17.0	19.7
Hand 15	16.7	18.0

Table 5: EMG (Median Sensory Latency)				
Intervention Group	**Amplitude (Pre)**	**Amplitude (Post)**	**Transcarpal Latency (Pre)**	**Transcarpal Latency (Post)**
Hand 1	61.9	52.3	1.5	1.6
Hand 2	63	71.9	1.5	1.4
Hand 3	N/A	N/A	N/A	N/A
Hand 4	N/A	N/A	N/A	N/A
Hand 5	58.8	90.5	1.4	1.4
Hand 6	85.3	115	1.3	1.5
Hand 7	7	8.8	2.3	2.4
Control Group				
Hand 8	65.4	57.4	2.1	1.9
Hand 9	79.8	25.1	1.9	2
Hand 10	49.5	76.9	1.5	1.4
Hand 11	81.3	81	1.7	1.6
Hand 12	21.9	30.2	1.6	1.6
Hand 13	23.7	24.2	1.8	1.7
Hand 14	47.4	53	2.1	2.3
Hand 15	70.3	80.3	1.9	1.8

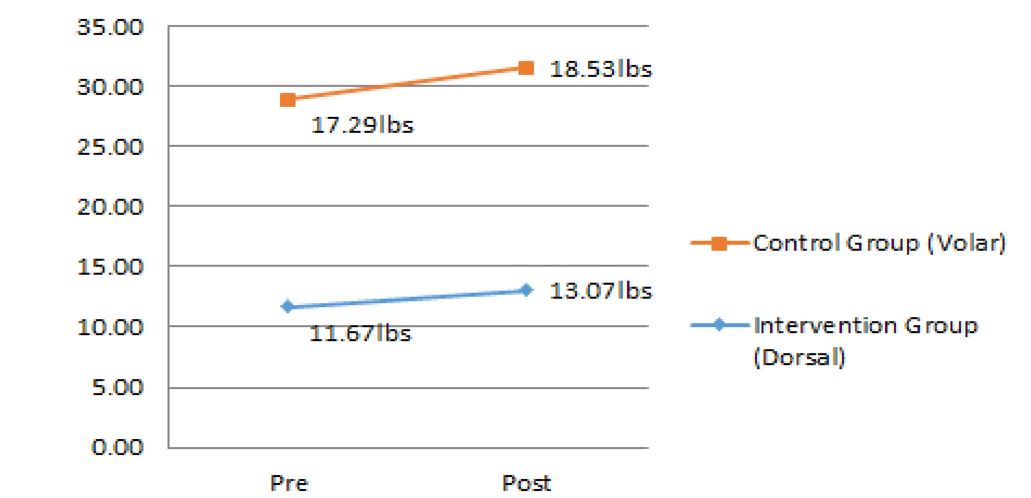

Figure 2: The mean of the pre and post test values (lbs) for three jaw chuck pinch were represented for each group.

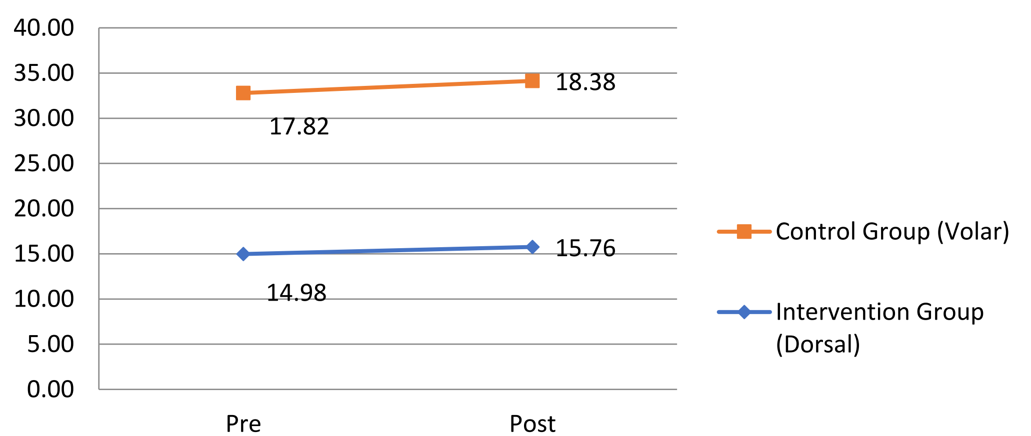

Figure 3: The mean of the pre and post test values (lbs) lateral key pinch were represented for each group.

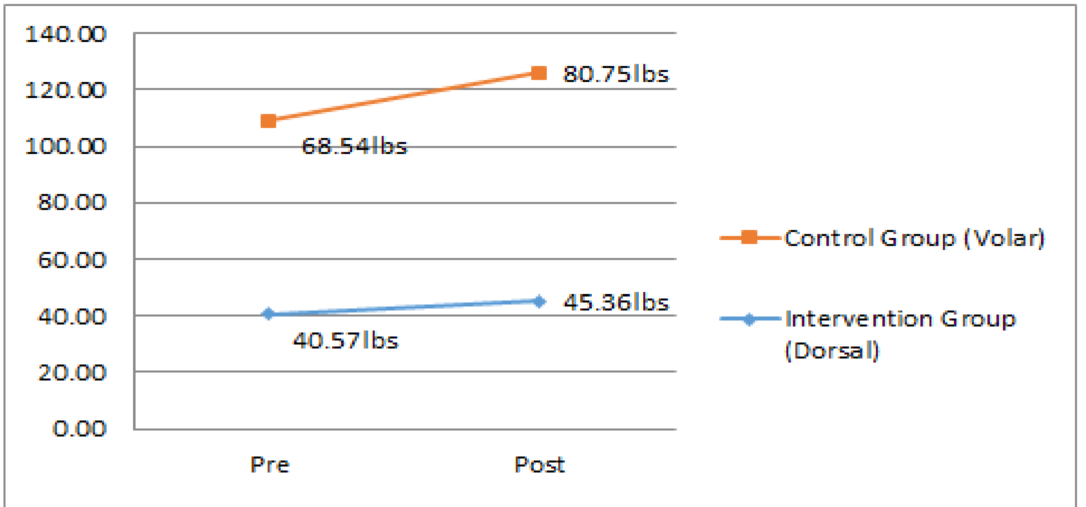

Figure 4: The mean of the pre and post test values (lbs) for power grip, with the dynamometer tool were represented for each group.

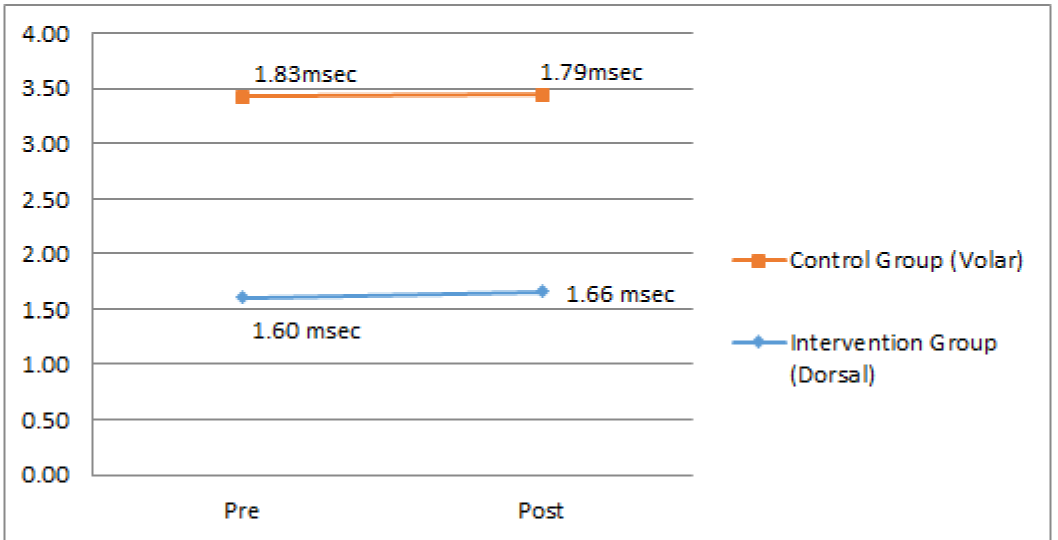

Figure 5: The mean of the pre and post test values (msec) represented the speed of median sensory transcarpal latency for each group.

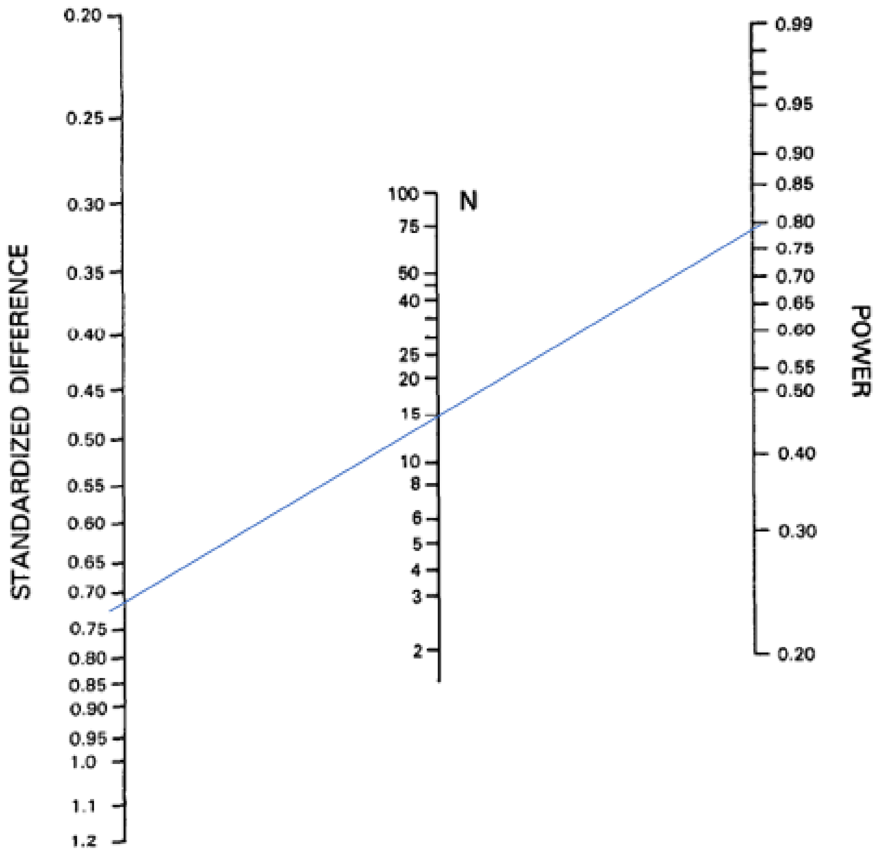

Figure 6:
Nomogram for approximate sample size N =15, statistical power of .80, and standardized difference .73.

Discussion

The findings from this pilot study were marginally significant at effect size (η^2= 0.73) which shows promise for future studies. There were fewer participants and fewer extremities in the intervention group than the control group. The difference between groups was modest with one participant with a unilateral extremity. The increased number of extremities in the intervention group may have resulted in the effect of the data analysis. To potentially correct this in future studies, it may be beneficial to have bilateral extremities as an inclusion criterion or unilateral extremities as an exclusion criterion. Majority of the group's participant's data collected were bilateral, with the exclusion of one participant being unilateral, and therefore, indicating a direct consequence of limited participants involved. One participant's data was removed from the CG due to missing data (Figure 1). Another participant with bilateral extremities data was removed due to suspected bias (Figure 1). The researchers felt it was unethical to include the data that was potentially biased as it would inaccurately promote the study's results.

To further acquire more significant data, more individuals would need to be notified of the study being conducted. Through increased efforts in advertisement and notifications to various outlets as well as a longer recruitment duration of the study, a higher significance can potentially cultivate. The results indicated that the IG with the dorsal application showed marginal improvement (figure 2-5) compared to the CG (e.g. dynamometer, pinch, and EMG). These results may be directly related to factors that were not permissible due to the limited scheduling of the researchers, EMG specialist, and participants. A factor that potentially limited the study's results is due to the study being conducted in the morning and not in the evening where individuals with a CTS diagnosis report the most discomfort. Furthermore, may also need to be considered for more significant results. Slits were needed in the KT for the EMG electrodes. It is unknown if this had any bearing on the results of the study. One participant's data did not provide any results due to the potential of severe CTS or neuropathy. The NPRS and Levine Questionnaire were implemented in the study but removed as the researchers wanted the study to be strictly quantitative.

Implication for Occupational Therapy

Occupational therapy's roots began with a holistic approach looking at the individual's specific needs and addressing them from the top-down. Keeping the focus on client-centered interventions to return the individual to their meaningful occupations and reintegrating them back into the community has always been of top priority. Clients who are unable to socially participate or perform daily routines in the workplace, marketplace, and occupational roles due to decreased function and pain may benefit from the implementation of KT to reduce signs and symptoms hindering their occupational performance. According to Walker et al. (2000), splinting proves to be an effective conservative intervention when clients are compliant with wearing the orthotic; however, many clients state they refrain from wearing orthoses due to hindrance in occupational performance or lack of comfort. KT is an alternative conservative intervention to splinting that can improve function, occupational performance, and reduction of pain, and increase proprioceptive input.

Utilizing KT to increase function, occupational performance, proprioceptive input, and reduction of pain allows patients to engage in meaningful activities. Application of KT to the dorsal side of the wrist can be used as a conservative intervention for clients with mild to moderate CTS. Clients with advanced stage CTS with uncompromising symptoms should seek further medical advice. The research that was conducted in this study will benefit the occupational therapy field by providing a new evidence-based intervention that is safe, cost-efficient and can be conducted at home through client education. The researchers hope that upon the initial evaluation to incorporate client education of KT that it will facilitate individuals to treat symptoms at the convenience of their home without invasive interventions such a surgical release. The researchers' vision for this study is to publish the results to allow other occupational therapists the opportunity to understand the benefits of using KT in CTS interventions.

Limitations of the Project

The limitations of this study included a lack of double-blindness. The control group had to be unaware of either intervention methods to maintain a reliable baseline. Recruiting participants was difficult due to the limited recruitment time for the study, resulting in a small sample size. The application of KT on the volar side required a minor cut which could limit the efficacy of the intervention. Another limitation that was not taken into account was having the CG being taped on flexor side which potentially facilitated grip strength and increased improvement. Therefore, future studies would require more torque on the dorsal application to widen the opening of the carpal canal similar to a wrist cock-up splint.

Ethical and Legal Considerations

Participants Ethics

Participants were recruited from multiple sites based on meeting both the inclusion and exclusion criteria, experiencing symptoms or a diagnosis of CTS. To minimize the risk of harm, the American Occupational Therapy Association's (2015) principles and standards of conduct were followed. The standards for professional behavior include beneficence that actions were taken to help prevent harm to the participants. Standards for non-maleficence were followed, that no harm will be placed on any of the participants. Participants' autonomy was respected, and justice allocated to both the intervention and control groups. All steps in the study were performed with veracity, to maintain a professional level of fidelity (AOTA, 2015). The standards of conduct include the studies exclusion of participants considered minors, below the age of 18, pregnant, have easily compromised skin integrity, a pacemaker, diabetes, epilepsy, blood-borne pathogens, radiculopathy, thoracic outlet syndrome, or have any known allergies to adhesives. Participants voluntarily agreed to be included in the study and were required to sign a consent form explicitly stating the intentions, potential risks and benefits, an outline of the procedure, and time commitment needed for participation in the study.

All participation was voluntary and consenting individuals were given the opportunity to withdraw from the study at any time for any reason. Voluntary participation was ensured by not giving compensation to any participants to eliminate the risk of coercion and minimize chances of undue influence. Submission of proposed research to Stanbridge University's Institutional Review Board (IRB) for approval before initiating the study assisted in identifying other potential ethical considerations that needed to be addressed. Furthermore, to maximize potential benefits to both groups participating, individuals were randomized to either the intervention or control group. To ensure equity and maintain individual justice, participants were given the option to attend a debriefing at the conclusion of the study and be informed of the study's outcomes. The initial control group was given the opportunity to receive the KT intervention on the dorsal surface of the wrist at the conclusion of the study.

Anonymity and Confidentiality

Participant anonymity and confidentiality was ensured by collected data being wiped of any personal identification and participants were assigned a numerical identifier. The key to deciphering numerical identifiers, photographs of the taping application, and collected data were secured by a biometric door and in a locked cabinet in the academic advisor's office in Stanbridge University's Occupational Therapy Department.

Conclusion

Individuals diagnosed with CTS are limited in the selection of non-invasive interventions used to decrease pain and increase function in their hands. More research is needed for a non-surgical, conservative intervention for CTS. The use of KT on improved function, pain, and performance needs to be a consideration. Grip and pinch strength were recorded upon arrival for the initial taping, and 30 minutes after the tape had been applied to these individuals. Tools used to gather the information were the Jamar dynamometer and pinch gauge, which measured the occupational performance of the individuals. The results suggest that KT may be associated with improvement of upper extremity function, grip and pinch strength, and median sensory nerve latency. However, findings of this study were marginally significant with further research to be conducted. The purpose of this study was to determine whether the application of KT on the dorsal surface would increase median nerve latency for patients with CTS. The desired outcome from the researchers was to advance the awareness in the efficacy of KT and a reduction of symptoms of CTS. By providing data supporting the efficacy of KT on the antagonist muscles clients with CTS will have another choice in interventions and possible prevention of surgical intervention; therefore, increasing client's occupational performance.

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APPENDIX A

Consent Form

Stanbridge University

STANBRIDGE UNIVERSITY RESEARCH CONSENT FORM

Researchers
Nathan Chiangi, Ryotaro Fukuda, Dorothy Ho

Research Advisor
Donnamarie Krause, OTR/L

Researcher's' Contact Information
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2041 Business Center Drive
Irvine, CA 92612
(949) 794-9090 Ext: 5526
cts.stanbridge@gmail.com

Thank you for expressing interest in our study. After an initial screening, you met the qualifications to participate in the study. Before we can move forward, please read the following information and provide us with an informed consent for your participation.
Description: You are invited to participate in a research study to examine the effectiveness of kinesio tape application on the wrist for carpal tunnel syndrome to decrease pain and increase function. The study will take place at Stanbridge University in Irvine, California with only one visit necessary. Pre- and post- assessments will be conducted during the session. You will be asked to meet the researchers for approximately three hours to receive treatment and to obtain baseline data.

Your Time Involvement: Your participation will take approximately three hours session.
Risks and Benefits: Some possible risks of this research are: participants may experience discomfort from wearing adhesive tape, and may experience fear and/or anxiety before, during, or after the procedure. Loss of confidentiality may occur if two participants know each other, sign up anonymously, and come to the study. EMG is a low-risk procedure where complications are rare; however, there is a small risk of bleeding, infection, and nerve injury where a needle will be inserted.

The benefit of this study are participants will be educated on the application of kinesio tape (KT) for carpal tunnel syndrome and potentially identify positive results for a new conservative treatment for carpal tunnel syndrome.

Payment: There will be no payment for participation in this study.
Confidentiality: All records involved with this study will be kept private. Documents that are

made public from this study will not include any identifying information about participants. A randomly chosen numerical assignment will be attached to each participant's document. All paper-collected information will be securely stored in a locked cabinet in the office of the primary researcher, during which only the researcher have access. All electronically-collected information will be stored in a drive with access only through a secure passcode. All records of personal contact information and data collection will be disposed one year after completion of the study.

Participant Rights: If you have read and signed this form you are consenting to participate in this study. Participation in this study is voluntary, and you have the right to withdraw at any point without penalty. Your alternative is to not participate in this study. You have the right to refuse to answer specific questions. Your identity will not be disclosed at any time. The results of this study may be disseminated at professional meetings or published in scientific journals.

Additional Questions/Concerns: If you have any additional questions or concerns after reading the above information, please feel free to contact one of the researchers at any time. Contact information is provided on the first page.

Independent Contact: If you are in some way dissatisfied with this research and how it is conducted, you may contact the Stanbridge University Program Director, Dr. Janis Davis: janis.davis@stanbridge.edu or 949-794- 9090.

(If applicable, complete the following)

Indicate Yes or No:

I give consent to be audio taped during this study.

_____Yes _____No

I give consent to be photographed for this study and for my photograph to be used in any materials (poster, video) resulting from this study.

_____Yes _____No

I give consent to be videotaped for this study and for my image to be used in any materials (poster, video) resulting from this study.

_____Yes _____No

I give consent for my identity to be revealed in any materials resulting from this study.

_____Yes _____No

Please keep a copy of this signed and dated consent form for yourself.

Signature____Date____________

APPENDIX B

Stanbridge University Video/Photo Release Form

Any person taking a video or still photograph for Stanbridge University related research dissemination must obtain a signed release form from all persons who are visibly recognizable in the video or photograph. Crowd scenes are exempt where no single person can be identified.

SUBJECT/PARTICIPANT CONSENT

I am 18 years of age or older and hereby grant the researcher designat**ed below from Stanbridge University** permission to photograph and/or videotape my voice and likeness and to use my voice and likeness in photograph(s)/video for publication/dissemination. I understand that my name will not be used in any publication/dissemination. I will make no monetary or other claim against Stanbridge University for the use of the photograph(s)/video.

Printed Name: **Date:**

Signature:

If Participant is under 18 years old, consent must be provided by the parent or legal guardian:

Printed Name: **Date:**

Signature:

Stanbridge Researcher (s)

Name: **Date:**

Address and Contact Information:

Signature:

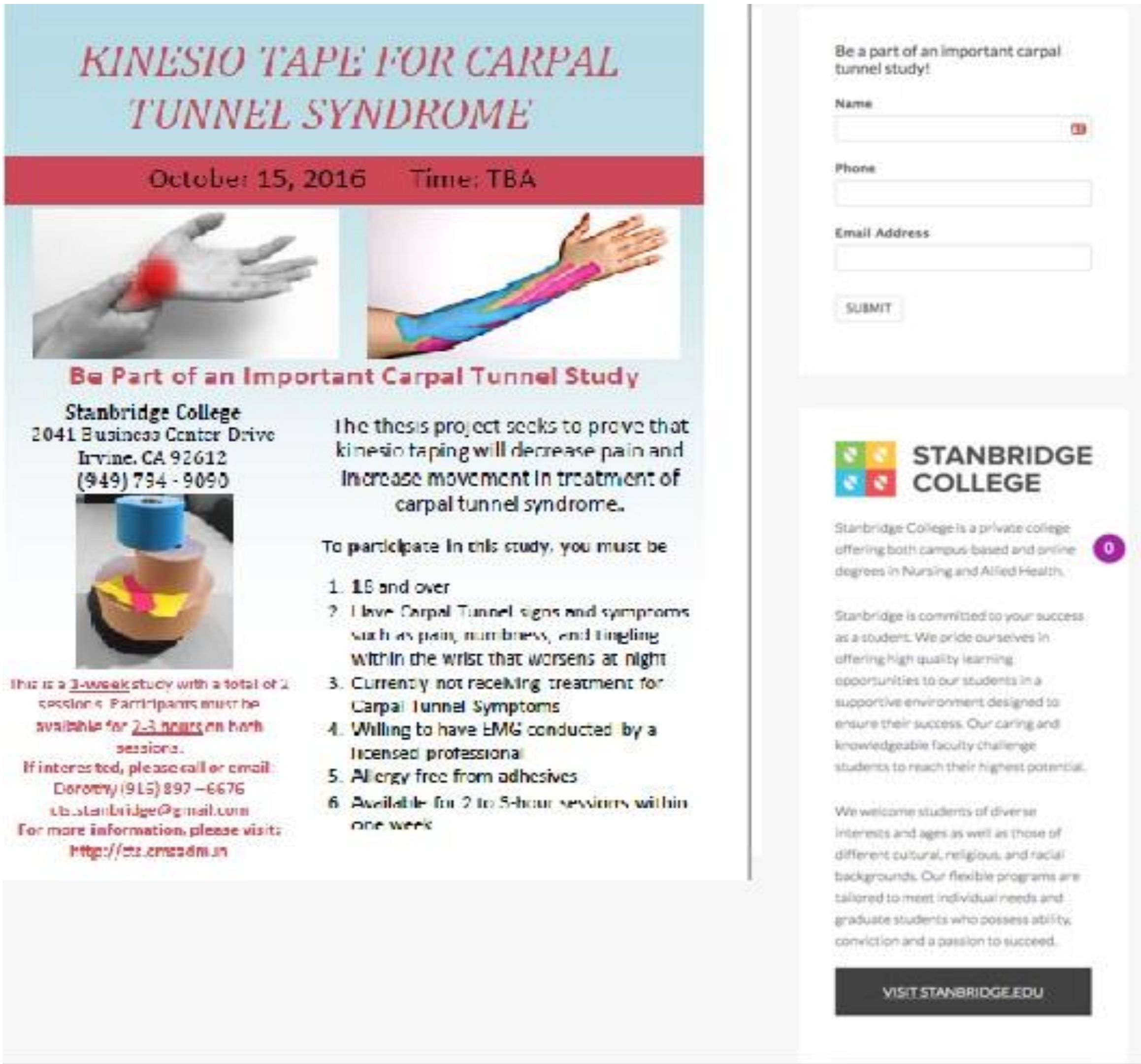
APPENDIX C

Flyers


HAVING PAIN IN YOUR WRIST?
DOES IT KEEP YOU AWAKE AT NIGHT?
February 4, 2017 Time: 9:00am- 12:00pm
Be Part of an Important Carpal Tunnel Study
Stanbridge College
2041 Business Center Drive
Irvine, CA 92612
(949) 794 - 9090
This is a 1-day study. Participants must be available for 3 hours.
If interested, please call or email:
Dorothy (916) 897 – 6676
cts.stanbridge@gmail.com
For more information, please visit:
http://cts.cmsadm.in
The thesis project seeks to prove that kinesio taping will decrease pain and increase movement in treatment of carpal tunnel syndrome.
To participate in this study, you must be
1. 18 and over
2. Experience pain, numbness, and tingling of hand and within the wrist that worsens at night
3. Currently not receiving treatment for Carpal Tunnel Symptoms
4. Willing to have EMG conducted by a licensed professional
5. Allergy free from adhesives
6. Available for a 3- hour session

APPENDIX D

CTS Website



APPENDIX E

Demographic Form

Instructions: Please provide a response for each of the following questions:

1. What is your age? ___________

2. What is your gender?

Female ○ **Male** ○ **Other** ○

3. What is your marital status?

Single ○ **Married** ○ **Separated** ○ **Divorced** ○

4. With which racial or ethnic category do you identify?

African American ○ Asian/Pacific Islander ○ Caucasian ○

Latino ○

Other: ______________________

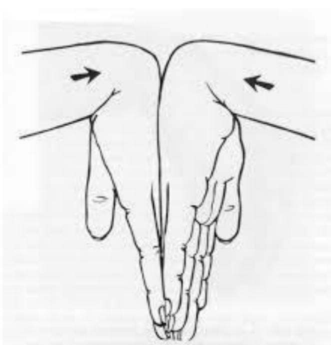
5. Career/ Job

____

APPENDIX F

Phalen's Test

Phalen's test is performed by fully flexing the wrists with the dorsum of the hands pressing against each other. The test results are positive if the client reports tingling in the median nerve distribution (thumb, index, middle and radial aspect of ring finger) within one minute (Pendleton & Schultz-Krohn, 2006).



APPENDIX G

CTS Questionnaire

CTS QUESTIONNAIRE

The following questions refer to your symptoms for a typical twenty-four hour period during the past two weeks (circle one answer to each question).

SEVERITY SCALE: 0 = None or Never; 1 = Mild; 2 = Moderate; 3 = Severe; 4 = Very severe

SYMPTOM SEVERITY SCALE

QUESTION SEVERITY SCORE 0= NONE; 4=VERY SEVERE					
1. How severe is the hand or wrist pain that you have at night?	0	1	2	3	4
2. How often did hand or wrist pain wake you up during a typical night in the past two weeks (times/night)?	0	1	2-3	4-5	5+
3. Do you typically have pain in your hand or wrist during the daytime?	0	1	2	3	4
4. How often do you have hand or wrist pain during the daytime (times/day)?	0	1-2	3-5	5+	constant
5. How long, on average, does an episode of pain last during the daytime (minutes)?	0	<10	10-60	>60	constant
6. Do you have numbness (loss of sensation) in your hand?	0	1	2	3	4
7. Do you have weakness in your hand or wrist?	0	1	2	3	4
8. Do you have tingling sensations in your hand?	0	1	2	3	4
9. How severe is numbness (loss of sensation) or tingling at night?	0	1	2	3	4
10. How often did hand numbness or tingling wake you up during a typical night during the past two weeks?	0	1	2-3	4-5	5+
11. Do you have difficulty with the grasping and use of small objects such as keys or pens?	0	1	2	3	4

FUNCTIONAL STATUS SCALE: 0 = None or Never; 1 = Mild; 2 = Moderate; 3 = Severe; 4 = Very severe

FUNCTIONAL STATUS SCALE

QUESTION SEVERITY SCORE 0= NONE; 4=VERY SEVERE					
1. Writing	0	1	2	3	4
2. Buttoning of clothes	0	1	2	3	4
3. Holding a book while reading	0	1	2	3	4
4. Gripping of a telephone handle	0	1	2	3	4
5. Opening of jars	0	1	2	3	4
6. Household chores	0	1	2	3	4
7. Carrying of grocery bags	0	1	2	3	4
8. Bathing and Dressing	0	1	2	3	4

NAME ________________________ M /F AGE________ DATE__________

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APPENDIX H

Pain Rating Scale

Pain Numeric Rating Scale

1. On a scale of 0 to 10, with 0 being no pain at all and 10 being the worst pain imaginable, how would you rate your pain RIGHT NOW.

No Worst Pain 0 1 2 3 4 5 6 7 8 9 10 Pain Imaginable

2. On the same scale, how would you rate your USUAL level of pain during the last week.

No Worst Pain 0 1 2 3 4 5 6 7 8 9 10 Pain Imaginable

3. On the same scale, how would you rate your BEST level of pain during the last week.

No Worst Pain 0 1 2 3 4 5 6 7 8 9 10 Pain Imaginable

4. On the same scale, how would you rate your WORST level of pain during the last week.

No Worst Pain 0 1 2 3 4 5 6 7 8 9 10 Pain Imaginable

APPENDIX I

Jamar Dynamometer and Pinch

Jamar dynamometer:

Pre	**Post**
1. 2. 3. AVG:	1. 2. 3. AVG:

Pinch

Pre	**Post**
Lateral Key Pinch 1. 2. 3. AVG:	Lateral Key Pinch 1. 2. 3. AVG:
3 Jaw-chuck 1. 2. 3. AVG:	3 Jaw-chuck 1. 2. 3. AVG:

APPENDIX J

EMG Record

EMG Record

PRE	POST
Amplitude:	Amplitude:
Median Sensory Latency: m/s	Median Sensory Latency: m/s